The effect of switching costs in the Peruvian mobile phone market

Universidad de Piura
Preliminary version

Tilsa Oré Mónago *

Abstract

Based on a game theoretical model I previously developed and using consumer panel data, I present some evidence of the effect of the unlocked-handset policy (a reduction on switching costs), recently implemented in Peru, on demand and prices. Average prices declined since mid 2014, and the switching rate rocketed since the implementation of the policy in January 2015. To retain consumers and attract rival's consumers, companies responded also with very low on-net prices through their "private network" with unlimited minutes, which may have increased the network effects in the market.
From my estimation, I found a significant negative effect of switching costs on demand for voice traffic (which suggest a positive effect of the unlocked-handset policy on demand) and positive network effects on the demand. The policy, by reducing consumer switching costs, would have generated an increase of 39.7% in the minutes consumed by switchers. Moreover, any change of consumer status (company or consumption plan) is associated with 31.2% increase in minutes consumed. I also found that, with lower significance level, the policy would have induced a reduction of per-minute prices by 9.4%.

Keywords: Switching costs, unlocked-handset policy, network effects, mobile telecommunications, number portability.
JEL Codes: L11, L12, L13, L41, L42

1 Introduction

Mobile phone users, across the world, still have to deal with high transaction costs when they want to switch providers: phone numbers and phone sets are, in many cases, locked to certain network and/or subject to the exclusivity of certain provider's service. Moreover, if there is a distinctive on-net and off-net call pricing scheme, consumers may also prefer to stay in the larger network. Number portability became popular as recipe for enhancing market efficiency, but at what extend such policy reduce switching costs and what else the regulatory agencies should target to increase efficiency when implementing such policies, are some of the questions that can be better addressed by knowing the nature of switching costs. Empirical research on estimating the effect of switching costs in network industries is highly relevant considering the policy implications.

*This research paper is part of my doctoral dissertation. I would like to thank Claudia Barriga, Jose Carlos Aguilar and Jorge Trelles from OSIPTEL, to Gonzalo Ruiz (former President of OSIPTEL), Manuel Cipriano, and Javier Alvarez (from IPSOS Peru) for their valuable cooperation; also I thank Wilmer Cordoba and Carlos Ireijo for their insights about the market. My deepest gratitude to the NET Institute, `www.netinst.org`, for funding this research project. All the errors are my own. My e-mail address is tilsaore@gmail.com .

Many countries already implemented-number portability policies.[1] However, there are still places where handsets are locked to a provider and usually their purchase is tied with an exclusive contract for certain term. If consumers want to switch to another provider, they face costs (time or money) for "unlocking" her handset or just buy another with the new provider. Countries such as Chile implemented, in 2012, a policy that bans the practice of telecommunications providers to sell locked handsets and/or impose consumers to a exclusive contract with them.

These regulatory changes aimed to reduce, exogenously, switching costs in the mobile telecommunications markets, and provides with a good opportunity to test theoretical predictions and find evidence of the impact of switching costs in market outcomes and consumer welfare. In particular, Peru implemented number portability in 2010, but contrary to expected, the effect was marginal compared to neighbor countries such as Chile the implemented such policy around the same time. Recently, in 2015, the unlocked handset policy was implemented and switching rate of subscription lines among providers increased rapidly.

Based on a game theoretical model I previously developed, I empirically test my model predictions using Peruvian consumer panel data. My theoretical model, briefly presented in section 2, accounts for two types of switching costs, switching fees (also known as endogenous switching costs and constitute transfers from consumers to providers) such as the early termination fees (ETF) and individual/idiosyncratic switching costs (e.g. psychological costs, laziness level, which are exogenous to the providers). The model predicts that first period prices are decreasing in individual switching costs, while second period prices are increasing in them. The presence of switching fees only intensifies the intertemporal price compensation and leaves multiperiod payoffs unaffected. Multiperiod consumer surplus are decreasing in exogenous switching costs.

Ale (2013) addresses a similar problem for Chilean market, but the author restricted his analysis to information given by one firm only on its customer base, so the analysis could not cover the entire market. Weiergraber (2014) estimates both the switching costs and the network effects for the US mobile industry using a structural discrete choice model. The author identifies the network effects from the comparison of different dynamics of local markets. The study uses firm-level data that contains mainly operational and accounting information, and a consumer survey of cellphone users. However, unlike Weiergraber (2014), in my chosen market I additionally have an exogenous change on switching costs, which helps to identify the switching costs effects. The other advantage is that in my selected market, there is explicit price discrimination on and off network, and additionally I have information on the network used by household members, which helps to control for network effects.

At this stage of my research, I provide some evidence based on market analysis and reduced form empirical methods. In particular, I use instrumental variables to test the effect of the unlocked handset policy on prices and demand of mobile calls service. I analyzed the market based on the available information and descriptive statistics, and as second step I estimate the switching cost effects on market outcomes. My testable hypothesis is that a reduction in individual switching costs (unlocked handsets policy) led to lower average prices and higher higher demand for the service. Even though my objective is to estimate the effect of the reduction of switching costs, I also take into account the network effects, because in the Peruvian case,

[1] The UK and the Netherlands in 1999; Spain in 2001; Germany and Italy in 2002; the USA, France and Finland in 2003; Slovakia in 2004; Mexico and Brazil in 2008; Ecuador in 2009, Argentina and Peru in 2010; Colombia in 2011; Chile in 2012, among other countries.

these seem to be stronger due to a common practice of explicit price discrimination between off-net and on-net minutes. Section 3 and 4 present the relevant details about the industry and the Peruvian mobile phone service market.

In general, it is observed that the proxy price variable, implicit price ('per-minute average revenue'), declined since the second quarter of 2014 (when a first regulation – the paperwork reduction regulation of number portability – was implemented), and continued such trend during 2015. [2] In particular, the switching rate rocketed with the implementation of the unlocked handset policy in January 2015. It is important to acknowledge that the unlocked handset policy was announced in November in 2014, but firms would know about the intended change since the end of 2013. Likewise, lower average per-minute prices are related to lower off net and on net prices, however to retain consumers and attract rival's consumers, companies offered very low on-net prices through their "private network' with unlimited minutes, the premium of off-net per minute price over this private-network price became larger.

For the empirical estimation, explained in sections 5 ad 6, I used longitudinal consumer survey data (for the period 2013-2015) enriched with firm-level information for the demand estimation, and I built a different 'long' providers panel data (for period Q1 2008-Q4 2015) based on the available operational and financial quarterly information of providers for the supply estimation. Thus, I estimated a demand and a supply equations to test the effect of exogenous switching costs on demand and prices. I relied on the instrumental variables method with fixed effects for the estimation of the demand equation, and with random effects for the estimation of the supply equation.

After controlling for network effects and market entry, I found a significant negative effect of exogenous switching costs on demand of voice traffic (minutes), implying that a reduction on switching costs (unlocked-handsets) led to an improvement of consumers who increase their demand for the service. In particular, my results indicate that the unlocked handset policy reform –an external reduction of exogenous switching costs– implemented in Peru in 2015 would have induced an increase of demand of minutes of 39.7% for consumers that switched providers. Furthermore, given that 61% of the consumers do not change their choice status (plan type and company), the estimation suggests that, in addition, any change in consumers' *status quo* would have increased their demand for mobile services by 31%.

On the other hand, my relevant findings also include a positive and significant positive impact of network effects on demand. Specifically, network effects coming from the existing off-net and on-net price discrimination positively impact the demand for minutes; thus, a 1% increase in the premium of off-net calls over on-net private-network calls would have increased demand for minutes by 4.9%, which would be mostly comprised by on-net minutes.
From the supply estimation, a highlighting result is given by the negative and significant effect of change in switching rate (ratio of ported-out lines out of total lines), an increasing switching rate would induce prices to decline. Likewise, despite its low statistical significance level, I found that the reduction of (exogenous) switching costs (individual costs of switching efforts) given by the implementation of the unlocked-handset policy would have led prices down by 9.4%, which supports my theoretical prediction of reduction of prices due to reduction in exogenous switching costs. This last result give some empirical evidence to my theory, but

[2]The implicit price is the per-minute average revenue, and it is calculated by dividing the provider's reported revenue by the total minutes traffic reported to OSIPTEL for each period (quarter). The implicit price for the market is the weighted sum of the implicit price of the largest three operators, using the market share over voice traffic as weights.

I have to acknowledge its statistical significance may be limited due to data size. This also suggests that a better estimation model that exploit the dynamics of the game using the largest longitudinal data set is needed. Given that this is an on-going research project, I aim to provide later with an estimation of a dynamic demand model.

1.1 Motivation: Unlocked handsets policy and number portability

The mobile industry is among many, the most dynamic in terms of innovation. In few decades the range of services has been vastly broadened, providing from purely voice service to text messaging, video calls, internet access (WiFi, 3G, 4G) etc, while the prices have been declining and becoming broadly accessible to everyone.

In mobile telecommunications industry, switching costs can be showed explicitly as form of exclusive contracts and early termination fees ETF, and also in the form of lack of number portability. Less explicit are the switching costs associated with the paperwork involved in porting phone numbers from one provider to another, and increasing difficulty in comparing among each time many price menus, adding to the search an learning costs.[3] Additionally, it can be argued that network effects added to switching costs may cause stronger consumers' inertia.

As a response, telecommunication regulatory agencies across the world have been implementing number portability policies to reduce switching costs and increase competition. Previous empirical studies show evidence that supports the predicted adverse effects of switching costs in competition. According to Viard (2003) and Lee et al. (2006), number portability policies in countries such as the USA and Korea, respectively, indeed lowered the existing switching costs and led firms to reduce their prices improving competition conditions. Lee et al. (2006) find that 'having to buy a new phone' was the second highest switching barrier for consumers.[4]

In Peru, the number portability reform was implemented in 2010 after being announced in 2007.[5] This reform allowed consumers to keep their phone number, restricted the paperwork duration to five business days and reduced forced contract duration. Similar reforms were implemented in Brazil and Mexico two years earlier, and big impact was expected. The number of switched lines were minimal; by 2014, in more than three years of the regulation, only about 269 thousand mobile lines switched operators out of 29 million active lines in Peru, whereas in Chile and Colombia, where the policy was implemented later, the figure was around 2.5 million and 1.3 million in 2.5 and 2 years of implementation of the same regulation, respectively.[6] [7]

In July 2014, OSIPTEL, the telecommunications regulatory agency in Peru, mandated to reduce the paperwork time to port numbers from 5 to 1 business day. In November of the same year, the regulatory agency announced its new policy, which would be implemented since Jan-

[3] According to Grzybowski and Liang (2015), European consumers face between 26 and 46 price schedules to choose one in the fixed-mobile bundles. In Peru, by September of 2014, there were around 368 price schedules for the postpaid type of service, 186 and 127 offered, respectively, by Movistar and Claro the largest companies.

[4] Both Viard (2003) and Lee et al. (2006) estimate static models, while the first uses a difference in difference method, the second uses a random coefficient discrete choice model.

[5] First Number portability reform was announced by Law 28999 in April 2007.

[6] El Comercio, *"Portabilidad en celulares solo es usada por el 1% de usuarios"*, September 04, 2014. Available at https://elcomercio.pe/economia/peru/portabilidad-celulares-usada-1-usuarios-176472.

[7] By the end of 2014, the number of subscription lines in Colombia was of 55.3 million (Colombian population is around 48.3 million inhabitants), Chile's was of 26.7 million, and Peru's was 30.3 million.

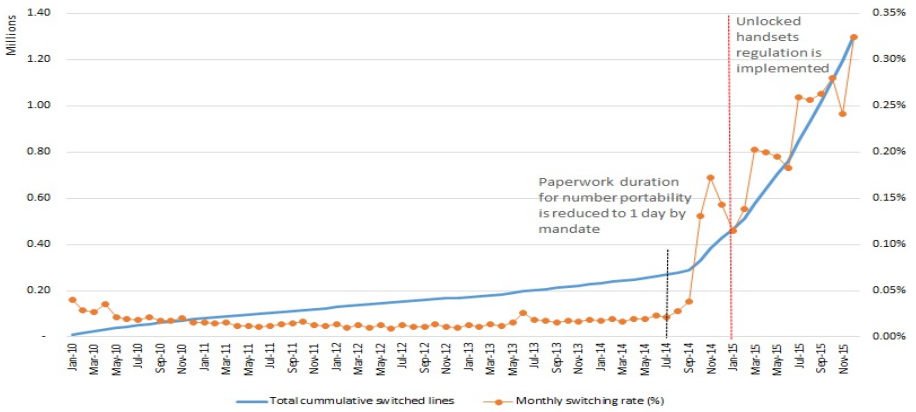


Figure 1: Peru: Switched mobile lines and monthly switching rate (2010-2015)

Source: OSIPTEL- Telecommunications Regulatory Agency

uary 2015, to reinforce number portability: only unlocked handsets would be commercialized (firms had to unlock existing handsets), firms were banned to offer contracts of forced duration as only option. [8] Only in 2015, around 877 thousand lines switched providers, and around 1 million since the unlocked handset policy was announced. Figure 1 shows the drastic change in the cumulative number of ported subscription lines and the monthly switching rate (monthly ported lines over total subscription lines). There is an increased switching behavior after the reduction of portability paperwork duration and a striking change after the implementation of the unlocked handsets' policy.

Peru, Colombia and Chile have similar markets, being Chile (with a population of 17.6 million people) the smallest among these three and the one that has promoted more competition in the market; and the one that leads the major regulatory changes in the region. Chile started the implementation of its number portability policy late in 2010, strengthened it by banning lock-phone sales in 2012, and allowed the entry of MVNOs in 2012.[9] Colombia did the same in the mid of 2011, at the beginning of 2012, and 2013 respectively. It took 5 years to Peru, to implement the second step of number portability policy, and the entry of MVNOs recently was allowed in 2016. The delayed of the second step of number portability policy in Peru may explain the differences in switching behavior.

These recent regulatory changes that exogenously reduced switching costs emphasize the importance of individual (exogenous) switching costs. Number portability was allowed since 2010, but it was not until handsets were unlocked and the paperwork reduced to observe significant changes in switching providers.[10] This observation also rise questions about the market features in Peru. The market structure was basically duopolistic: by the end of 2014,

[8] *Resolucion 166-2003-CD/OSIPTEL* in December 2013 to be implemented in 2014, and *Resolucion de Consejo Directivo 138-2014-CD/OSIPTEL* in November 2014 to be implemented in January 2015.

[9] Law 20471, in force since December 12, 2010. Decree 379 in force since March 25, 2011; and Resolution 5400 enacted on September 29, 2011 and implemented on January 2012 (all available at http://www.portabilidadnumerica.cl/normativa/.

[10] This is a standard practice around the world, so is the concern about its role in the telecommunications industry, thus the OECD also showed interest to better understand the different mobile handset acquisition models and to analyze the different prices (OECD, 2013).

two out of four companies concentrated 94% of the market share despite the entrance of the fourth at the end of 2014. The two largest players kept their position, so a year later, in 2015, the share of these two was still above 87%.

In addition, the Peruvian market presents stronger network effects than other mobile communications markets, because firms explicitly discriminate between on-net and off-net calls, moreover, they created a "private-network" within their on network, and price accordingly. Also calls between mobile networks and fixed-line networks are marginal, therefore the market is basically restricted to mobile-to-mobile communications.

This mobile telecommunications market seems to have the features to analyze the impact of switching costs on market equilibrium outcomes and test the theoretical predictions.

2 Theoretical Framework

2.1 Switching costs

Switching costs can be understood as additional (real or perceived) costs that users or consumers incur to change or switch providers. These costs can be derived from learning costs, transaction costs, informational costs, searching costs, shopping costs, contractual or pecuniary switching fees,even psychological costs (Farrel and Klemperer, 2007; NERA, 2003).[11] Thus, we can classify switching costs as endogenous when they are set by firms (switching fees) and directly affect firm's profits, and exogenous switching costs that can be idiosyncratic and specific to consumers.

Under the presence of high switching costs, consumer inertia may increase causing demand to be more inelastic. Thus, markets can be split into those that are already established consumers and those that are new consumers, and firms can easily discriminate among them. For the consumer side, switching costs implies that individuals do not take one-time decision any more, but a life-cycle decision, for the current and future periods. Therefore, these costs shift competition from one period transaction to a long-term relationship (Farrel and Klemperer, 2007).

These special characteristics allow firms to reinforce their market position in future periods. For that reason firms may have the incentive to lower prices to attract consumer in the initial periods and once they are "locked-in", they would be tempted to raise prices and take advantage from those consumers. In fact, that is the reason why firms may be more interested in market shares than in short-run profits, they would fiercely compete to secure a large number of consumers, therefore increase their market share, which will allow them to increase their later profits (Farrel, 1986; Klemperer, 1987a,b, 1988; Beggs and Klemperer, 1992). This behavior is broadly know as "bargaining-then-ripoff" strategy.

However this last approach assumes consumers are naive, so, if rational consumers with expectations over future prices are assumed, then firms may not enjoy so much discretionality. Consumers may realize that price cuts will not last all the periods, and that firms with lower prices may be more likely to raise prices in the following period, therefore will be more reluctant to price cuts and switching costs indeed increase prices (Klemperer, 1987a; Farrel and Klemperer, 2007).

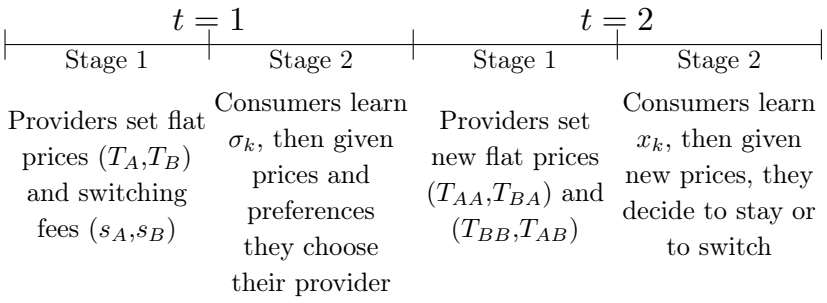
[11] Psychological switching costs refers to those "costs" of trust, this happens with those goods where the quality is perceived after its consumption for several periods (medical services), and quality is taken on trust (NERA, 2003).

2.2 Model on switching costs

In a previous study (Ore, 2017), I modeled a game theoretical model in which I distinguished the effect of exogenous and endogenous switching costs on market equilibrium in subscription markets where there are introductory offers. Following a two period game, in which two competitive firms set period flat prices (T_i in the first period , T_{ii} in the second period to loyal consumers, and T_{ij} to newcomers switchers from firm j) and switching fees (s_i).

A continuum of consumers have same constant valuation for the service v (assumed to be big enough, such that the market is covered at all periods) and not only face s_i but also a 'exogenous' and heterogeneous (idiosyncratic) switching costs $x_k \sim U[0, \omega]$ (for consumer k) revealed in the second period, and an idiosyncratic relative taste shock for provider A over B, $\sigma \sim U[0, \theta]$, revealed in the first period and by which they choose providers in the first period.

Both, firms and consumers, have the same discount factor δ and consumers have rational expectations. Firms do not know the idiosyncratic values of consumers but they know their distribution.
The timeline of the game is:



Using backward induction, I found that there are symmetric subgame perfect equilibria in pure strategies that lead to a unique equilibrium outcome: providers split the market equally in the first period, and the ability of setting switching fees only intensify the inter-temporal price compensation such that multiperiod payoffs are unaffected; on the other hand exogenous switching costs affect consumer welfare. [12]

Second period prices are increasing in the individual (exogenous) switching cost parameter, first period prices are decreasing in exogenous switching costs, and the upper bound of switching fees (endogenous switching costs) decreases with exogenous switching costs.

The equilibrium prices and payoff are summarized below, $\forall i, j \in \{A, B\}$:

$$T_i^* = 2\theta - \delta(\frac{\omega}{3} + s_i)$$
$$T_{ii}^* = \frac{2}{3}\omega + s_i$$
$$T_{ij}^* = T_{ji}^* = \frac{\omega}{3}$$

[12] For detailed explanation on the model setting and solution, please review Ore (2017) or click `here`.

and switching fees are such that

$$-\frac{5\omega}{9} \leq s_i^* \qquad \text{thus}, \pi_{2i} \geq 0$$
$$s_i^* \leq v - \frac{11\omega}{18} \qquad \text{thus}, E[R_{2i}] \geq 0$$

Multiperiod profits are:

$$\pi_i^* = \frac{\delta\omega}{9} + \theta \quad \forall i \in \{A, B\}$$

and are unaffected by the ability of introducing switching fees, but profits are increasing in ω and the relative taste parameter θ for provider A over B. Consumers' multiperiod payoffs are

$$R_i = v(1+\delta) - \frac{5\omega\delta}{18} - 2\theta \quad \forall i \in \{A, B\}$$

This also suggests that regulatory agencies should target reductions on exogenous switching costs rather than reduction of switching fees. The recent regulatory changes in the mobile telecommunications market of Peru, offers a natural experiment to test and quantitatively measure the welfare gains of a reduction of switching costs.

2.3 Switching costs and network effects: an approach

My theoretical model does not include network effects, but it considers a relative taste parameter, which is individual specific to consumers (realized only in the first period when choosing providers) and contain such effects. In the second period, consumers only choose to switch or to stay with their first period provider. Therefore, in the second period decision variable is the exogenous idiosyncratic switching cost.

Given the unnavoidable presence of network effect in mobile telecommunications, I also based my testable hypothesis on the existing theoretical literature such Klemperer (1987a), Farrel and Shapiro (1988) and particularly on Doganoglu and Grzybowski (2004). The latter shows a theoretical model of competition with switching costs and network effects is developed. This model considers only interaction between existing firms, discarding any potential entry. This is consistent with the telecommunications industry where there are important entry barriers, such as radio spectrum allocation and important sunk costs, that hinders rapid entry in the market. Their model considers a two-stage duopolistic price competition under Hotelling setting. Among the main findings derived from this dynamic model are the following:

- Although switching costs and network effects have different and opposite impact on the demand (the first makes demand more inelastic, while the latter, more elastic), the coexistence of these two feature, seem to reinforce the incentive to rise prices in the second period to take advantage of lock-in consumers, particularly in large network firms.
- In the equilibrium, both firms will split equally the market in both periods, prices and profits in the second period are positive and decreasing in network effects.
- Given first period equilibrium prices depend negatively on network effects, and are independent on switching costs; first period stage will exhibit intensive competition, and this will be lessen in the second period (which agrees to what is found in other models).

Finally, the testable hypotheses are the following:

(i) A reduction of individual switching costs reduces second period prices, therefore increases demand for the service/good.

(ii) Network effects affect negatively second period prices, therefore influences positively to demand.

3 The mobile phone telecommunications industry

Mobile phone calls services can be characterized as experienced goods, in the sense that consumers will know about the service once they consume it. Additionally, mobile phone service cannot be stored. These characteristics of the service add dynamics to the decision making of consumers, who make choices at every period based in their past experiences.

In Latin America, the mobile telecommunications market has expanded rapidly during the last decade; one favorable factor was the number portability policies and the entry of the Mobile Virtual Network Operators in many countries (like Mexico, Chile and Colombia). However, few operators still remain as the largest. In Chile, 3 out of 13 operators accounts for 96% of the market share; in Colombia, 3 out of 4 operators account for 99% of the market share; while in Peru, 2 out of 4 keep the 90% of the market share. In terms of profitability, the average revenue per user ARPU (more specifically, per subscription line) in the region declined to USD 10.7 in 2014 from its level of USD 11.7 in 2012 (which still are above the USD 6.8 observed in the developing world). Likewise the average effective price per voice minute in the region fell from USD 0.11 to USD 0.06 between 2008 and 2013 (GSMA, 2014). In Peru, considering the ARPU of the two largest network providers, the market's ARPU decreased from USD 9.1 to USD 8.8 from 2013 to 2014; these levels are below the region's average and might reflect the high share of prepaid subscriptions (72% in 2014).

Mobile services are usually provided under two plan types, pre-paid and post-paid. Within each type each company offer several consumption plans with different characteristics each (minutes for on-net calls, off-net calls, SMS, data availability, contract length) that may include a locked telephone set at cheaper price (companies state they sell at subsidized price) to be paid along a contract duration (usually 12 to 18 months).[13] The plans have certain valid period, but then new plans are created to keep the choices diverse. Although an extensive range of consumption plans are good since it provides consumers with a variety of options, benefits would be reduced with too many and changing consumption plans that may be seen as confusing and would prevent consumers to optimally take a choice.[14] Handsets are still sold locked in many countries, and although unlocked handsets are available, these also sold

[13] By comparing import prices, and handsets' prices offered by companies under postpaid plans, prepaid and unlocked, OSIPTEL found that there is almost no subsidy. Handsets imported at cheap price were sold by the companies up to 112% higher than their import value, premium that would reach 325% for the selling price of unlocked phones. In the case of modern smartphones of high import value, they were offered up tp 29% of the import price when offered under a consumption plan, such premium would reach 36% if offered unlocked. I also could compare prices of smartphones and catalog prices, and found a similar premium between 30% to 47%. The study, that also supported OSIPTEL' mandate, found that in 2014 mobile operators directly imported 75% of the total ammount of imported handsets, which imported mostly cheap handsets (47% of the handsets have value below USD 33.00. The smartphones of highest import value accounted only for 2.5% of all the imported quantity.

[14] According to Grzybowski and Liang (2015), European consumers face between 26 and 46 price schedules to choose one in the fixed-mobile bundles. In Peru, by September of 2014, there were around 368 price schedules for the postpaid type of service, 186 and 127 offered, respectively, by Movistar and Claro the largest companies.

at higher price.

Being subject to a service contract and owning a locked handset prevent switching to another company due to the costs involved. Switchers may need to spend time and also money, perhaps on ETF, but also to 'unlock' the handset or to buy another locked phone from the new provider. Currently, ETF is observed in service contracts given by the largest provider, but it is absent from the service contracts of other providers. Such coexistence of zero and positive switching fees in the Peruvian market supports also my theoretical predictions about switching fees, all network providers not need to apply switching fees, doing it so would only intensify inter-temporal price compensations.

The recent policy implemented in Peru to reduce exogenous switching costs may have allowed increasing switching behavior. Moreover, the two regulatory changes imposed exogenous shocks on switching costs which makes the analysis of the market attractive. The government allowed for number portability in the telecommunications sector in 2010 to enhance competition by reducing switching costs; however other very relevant switching costs such as the locked handsets and lengthy number portability procedure remained until early 2015, when a new regulation was implemented.

Following my theoretical model, an anticipated reduction of a exogenous switching costs would have led to lower prices and profits, and increased consumer surplus. Based on the assumption of uniformly distributed mass of consumers, my model predicts that switching rates do not depend on exogenous switching cost parameter. This basically because any anticipated change would drive firms to act strategically, using different period prices to inter temporally compensate consumers. Thus, acknowledging a future reduction of exogenous switching costs, firms would increase current prices and later reduce prices to compensate their loyal consumers and become attractive to rival's consumers in the following period.[15] Consumers that have lower idiosyncratic exogenous switching costs and small relative preference between providers will still switch, but switching will happen at the same rate.

After the number portability reform in 2010, many expected a decreased in prices, but that did not happen. Price stay almost flat. This may be related to consumer heterogeneity in terms of exogenous switching costs. A lengthy portability process may have prevented consumers with low time availability to switch. A speedy process and the availability to carry the same handset from a provider to another may have allowed those consumers to switch after the second reform in 2015. Prices would later fall in the race for keeping and attracting rival's consumers.

The low switching rate in Peru may be explained by the current structure of handset acquisition. Although companies have more flexible service contracts, they still tie handset sales to consumption plans. Given that the average income in Peru is around 1600 PEN (USD 550 aprox) consumption plans that allows the acquisition of handsets in installments are attractive for mobile consumers. Another explanation for low switching rates is related to the increasing premium between off-net price and private-network price (calls within the network cheaper than on-net prices). Since late 2014, the large mobile operators set same off-net and on-net prices, but offered very low-price or unlimited private-network minutes. Moreover, given the increasing rate of smartphone adoption in Peru (which reached 29% by the end of 2015, 10 percentage points higher than in 2014), mobile operators are competing in data prices: the

[15] This regardless of the existence of switching fees, which my model predicts to have no effect in multiperiod payoffs

national average price for one MB fell from 2.18 PEN and to 0.23 PEN, between 2013 and 2015. [16]

3.1 Peru's mobile phone market

In Peru by the end of 2015, there were four mobile providers (two of them also provide fixed-line services), from which two accounted for around 90% of the national market since 2010 (only in 2015 the joint share of two big providers was 87%). The industry was privatized in early nineties, and at that time companies showed to aggressively compete against each other. However, as time passes concerns about competition impediments has arisen (switching costs are one of them), as well as consumers' dissatisfaction increased.[17]

The market is characterized for having a pays-who-calls price scheme, only call makers pay for the calls they make. That is why people have incentives to get a phone only to stay connected and to receive calls. Indeed, still around 68% of mobile line subscriptions were prepaid by the end of 2015.

Mobile-to-fixed calls are subject to a different regulation, which has derived in higher prices than mobile-to-mobile calls within a network. There is also an explicit price discrimination between on-net and off-net calls, being the later charged up to 67% more than the former one in some consumption plans, particularly in the case of small companies or prepaid consumption plans. Therefore consumers are driven to keep their calls within their network and mostly use the service to communicate to another mobile phone. This is one of the reasons why still 76% of the outbound traffic calls are associated to mobile on-net calls.

It is worth mentioning that Peru and Colombia are some of the few countries where on-net and off-net price discrimination exist. In Chile that changed since 2014 where such discrimination practice was banned. However, unlike Colombia, Peru does not only keep the same network price discrimination practice, but may be the unique case in Latin America where price discrimination is also practiced within each network (unlimited talk is allowed only for a subset of subscription lines within the same network, otherwise a discounted price still applies). Indeed, after averaging the per-minute price offered by the most popular consumption plans, the premium of off-net calls over this private-on-network calls reached 110% in 2013, peaked over 290% in 2014 and remained in 70% in 2015. [18]

On the other hand, the argument behind the service contract is associated to the provision of subsidized handsets. These subsidized handsets' prices are consistent with the idea of firms to get as much consumers as possible and then 'lock them in' to extract rents. Unlike the theoretical models where lower prices in a period are followed by higher prices in the following periods once the consumers are 'locked in', in the Peruvian mobile industry case, telecommunication service's keep the price steady and it may be even the case that they do not transfer any cost savings to consumers (in the form of lower prices) as it would happen in the absence of switching costs. Taking into account the information contained in ITU (2014), which rank

[16] To calculate this average price, I used the prices given in the most popular consumption plans per year per company per plan type provided by the Peruvian Regulatory Agency.

[17] Almost 50% of all the consumers' complaints on telecommunications services were related to mobile communications. Share that increased from 10% in 2010.

[18] I could obtained the name of the plans of the most popular plans (name of plans that have together at least 50% of subscriptions) per type of plan per company for years 2013 to 2015 from the Peruvian Regulatory Agency. The characteristics of the plans and prices are available in other database of the Peruvian Regulatory Agency called SIRT.

166 countries according to the affordability of a Mobile-cellular sub-basket, Peru is one of the countries with expensive cellular service. In terms of the ranking, Uruguay gets the highest position among South American Countries with the 66th position; Chile gets the 75th position; Peru, the 87th; and Colombia, the 102nd. For all those cases, such mobile-cellular basket represents 1.67%, 1.98%, 2.43% and 3.35% of their per capita GNI respectively.[19]

Moreover, handset prices may not be subsidized as argued. In fact, the Colombian Telecom Regulatory agency (*'Comision de Regulacion de Comunicaciones'*) found that only one specific Samsung handset, offered by the mobile companies' plans, was actually cheaper than an external or direct provider (CRC, 2013). In 20114, by comparing import prices, and handset's prices offered by companies under postpaid, prepaid plans and unlocked, OSIPTEL found that there was not almost no subsidy (with an exception of the small operators). Cheap handsets (up to an import value of USD 33.0) were sold by the companies up to 112% higher than their import value, premium that would reach 325% for the selling price of unlocked phones. In the case of modern smartphones of highest import value, they were offered up to 29% of the import price when offered under a consumption plan, such premium would reach 36% if offered unlocked. I also compared prices of smartphones and catalog prices and found similar premiums that range from 28% to 47% for unlocked handsets. It is important to mention that mobile operators directly imported 75% of the total handsets, which were mostly low-value handsets (47%), while high-value smarphones only accounted for 2.5% of the imported quantity. [20]

4 Market analysis

The mobile phone market in Peru is supervised by the government, and regulated only at the level of interconnection fees (termination rates charged by the companies for incoming calls from different network) under a price cap regulation.

In 2015, the mobile phone market in Peru accounted for 34.2 million active mobile line subscriptions, which implies a mobile density of 114.9 (lines per 100 inhabitants). Nonetheless, these mobile lines belonged to 19.7 million people older than 11 years old, 25% higher than in 2013 (ERESTEL, 2013, 2015). However, according to the ERESTEL in 2015, only 4.6% of the population owned more than one phone number and 4% owned more than one handset.[21]

The market has rapidly expanded during the last decade; only in five years (2005-2010) the number of mobile subscriptions increased almost six times its level of 5.5 million lines in 2005.[22] Nonetheless, until the third quarter of 2014, three were the mobile network operators; the two largest companies –Telefonica Moviles (Movistar) and Americal Movil (Claro)– consistently concentrated 95% of market share (55.3% for Movistar and 39.6% for Claro). Currently,

[19] The mobile-cellular sub-basket consists of prepaid service prices of 30 calls and 100 SMS from the largest mobile operator.

[20] In 2014, taking a random handset from many of the smarthphone offered by a Peruvian company, the 'Motorola X' was offered at $812 and $565 in the prepaid and postpaid consumption plans, and it was sold by $883 if the consumer wants it unlocked; while the price of this same unlocked handset at Amazon was $350, and even if import tariffs and taxes were added, the handset price would have still be around $500. [Note: I took a smartphone model from the mobile catalog from Claro (www.claro.com.pe), accessed on 24 Apr. 2014.]

[21] On the other hand, smartphone adoption expanded since 2012 and significantly increased in 2015 (see Figure 6 in the appendix)

[22] According to the ITU, the number of mobile subscriptions in South America grew by 344% between 2004 and 2014. In Peru itself, this number grew by 679% in the same period. The mobile teledensity in South America reached in 2014 ranges from 96 to 158, Peru is only above Bolivia and Venezuela (GSMA, 2014).

there are four operators: the acquisition of Nextel by the Chilean firm Entel and the entry of Viettel at the very end of 2014 have impacted the market; the joint market share of this two companies increased from 6% to 12%, between 2014 and 2015, driven mainly for an increase of Entel subscriptions (see figure 5).

4.0.1 The supply: Mobile network operators

The mobile service network infrastructure is displayed over the country, and by the end of 2014, 1825 out of the existing 1833 counties were covered by the service. It is worth mentioning that only the two largest mobile operators have almost full coverage, so they both compete in most of the counties. Likewise, Entel (Nextel) the third operator that was highly specialized in mobile services to business until before its expansion, competed only in 14 out of the 24 regions of Peru by the end of 2014.

By 2015, 68% of the mobile phone lines were under the prepaid plan, 15.5% under the postpaid plan, and 16.3%, under control/hybrid plan. [23] In average, a Peruvian mobile user is a prepaid consumer. Movistar has the largest share within prepaid service (12.4 million subscriptions), prepaid subscriptions accounted for 69% of its total subscriptions in 2015, figure that was 74% in 2013. Hybrid subscriptions are next in order, and at last are postpaid subscriptions. In contrast, Claro, the stronger rival, strictly limits its offer of hybrid plans and depends mostly on prepaid and postpaid line. Claro is the leader in the market of postpaid service (4 million subscriptions out of 5.3 million total postpaid subscription), and second in terms of market share in prepaid subscription. Figure 7 (in the appendix) shows the evolution of number of line subscriptions by service type by company; although prepaid lines are superior in number, it is clear an increasing trend of postpaid lines, which can be explained by the popularity of smartphones that are mainly obtained through contracts within postpaid (and hybrid) contracts.

Providers offer different consumption plans: the prepaid plan, which charges per-minute price; the postpaid plan, which charges a monthly fixed fee (which includes an allowance of minutes) and a per-minute price for additional minutes; and the control/hybrid plan, which charges a fixed fee (with allowance of minutes included) but charges prepaid prices for additional minutes. Firms tend to explicitly discriminate between on-net, off-net and to-fixed-line calls; off-net prices can be 50% greater than the on-net prices. Table 11 (shown in the appendix) shows 6 different price menus out of the 313 offered by the largest two companies by September 2014, where such characteristics can be observed.

Likewise, using the information of around 15 most popular consumption plans for each year, I constructed average prices for each type of call per plan type (postpaid/hybrid and prepaid) per company by the end of each year. [24] The total average per minutes prices per type are

[23] A control/hybrid plan consist of a mobile phone consumption plan for which consumers signed a contract and are charged a flat monthly fee for a consumption package of certain amount of services (voice minutes, SMS, data, etc.), after the consumption of the services reaches its quota, additional service can be consumed using prepaid phone cards or recharging methods.

[24] Each consumption plan, may include 10 variations with different fixed fee level, it also includes allowance of minutes off-net, on-net, and private network. They may include allowance for data and SMS as well. However, those varieties of the same consumption plan shared same prices for overage consumption. To find the average price for each type of call and MB of data consumption I averaged overage prices with the implicit paid price within included allowances, dividing the fixed fee by the minutes included, thus I found implicit price per minute (SMS or MB). For cases with unlimited minutes (postpaid and hybrid plans) I considered a maximum number of 50000 minutes, and I restrict my sample of plan variations to those below the fixed fee value of 130 PEN, given that according the ERESTEL, the average postpaid mobile consumer spends 60 PEN per

	Average of monthly Fixed fee	Average per minute price on-net calls	Average per minute price off-net calls	Average per minute price to fixed-line calls	Average per minute price Private Network calls	Average price per SMS	Average price per MMS	Average price per MB of data	Average price per SMS internati onal
Prepaid									
2013	5.80	0.90	1.19	1.08	0.18	0.14	0.41	0.40	0.25
2014	5.80	0.62	0.78	0.73	0.18	0.11	0.36	0.18	0.24
2015	2.25	0.50	0.62	0.60	-	0.10	0.40	0.22	0.23
Postpaid									
2013	74.71	0.69	0.69	0.65	0.27	0.34	0.49	2.70	-
2014	58.99	0.57	0.63	0.63	0.19	0.28	0.56	0.39	0.50
2015	69.46	0.28	0.33	0.34	0.05	0.13	0.34	0.24	0.37

Table 1: Average per unit price (in Peruvian soles - PEN) of popular plans by type of plan

Notes: 1/ Prepaid plans have and average fixed fee because some providers require consumers to purchase prepaid card of minimum value from time to time. Recharge value/prepaid card ranged from 3 to 10 PEN.

Source: OSIPTEL - SIRT, Consumption mobile plans

shown in the table 1.

From the table, we can observe that prepaid consumers face higher per unit prices than post-paid consumers. Another observation is that per minute prices decreased between 2013 and 2015, and the fall in prices is sharper between 2014 and 2015 in the case of postpaid/hybrid consumers. Let's recall that the main switching cost policy was implemented starting 2015. Likewise, it is worth noting that the average price per MB (data consumption) significantly fell since 2013. This may be explained for an increased smartphone adoption and data demand (that includes access to social networks such as Facebook and Whatsapp), and stronger competition in prices to capture the high-value consumers (postpaid users).

Figure 2 shows the implicit price, a weighted average of the calculated revenue per minute of mobile call and the market concentration index (HHI). [25] [26] It can be observed a pronounced decrease in this implicit price since the second quarter of 2014 (when the paperwork reduction regulation of number portability was implemented, but further changes were expected), which continued during 2015. The unlocked handset policy was announced in November in 2014, but firms would know about the intended change since the end of 2013. Since the second quarter of 2014, the implicit price declined from above USD 0.06 to around USD 0.04. On the other hand, the market concentration index slightly decrease in the last quarter of 2014, stabilizes and falls in the mid of 2015.

A decreasing HHI reflects the increasing role of Entel as the third player; the company left the

month(the median was 50 PEN) in the service.

[25] I use the revenue per minute of call as a proxy of the per-minute price of the companies. I took reported revenues for the three operators corresponding from mobile phones services (these exclude the income from handset sales) and divided by the total voice traffic (outbound and inbound voice traffic). Following the same criteria of OSIPTEL, then I obtained the implicit price as the weighted average of such per-minute prices per company, and use the market share of total subscription lines as weights.

[26] A previous version of this paper, showed the analysis using a per-unit price called 'effective price' taken from GSMA Intelligence, however later, I found that the data for this constructed variable was not reliable. I took then the approach used by the regulatory agency, OSIPTEL.

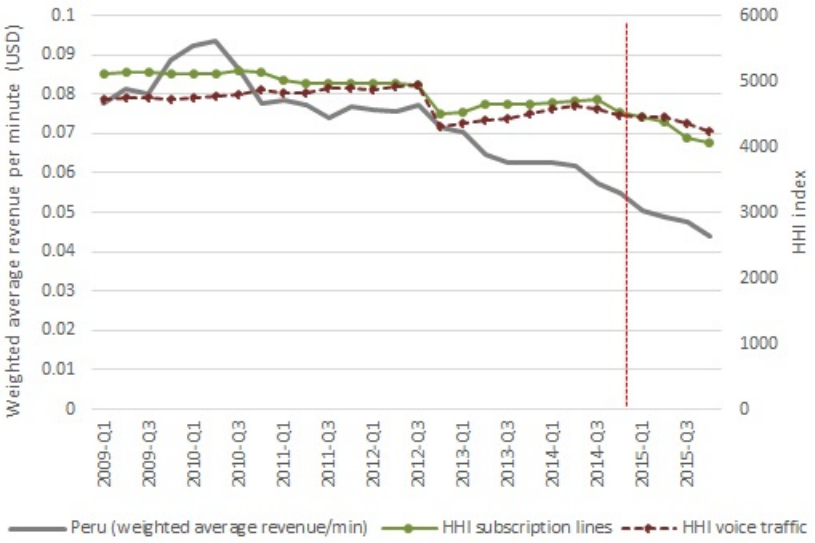


Figure 2: Peru: Implicit price per minute in USD and Herfindahl-Hirschman Index

Source: OSIPTEL; Quarterly Financial reports - Telefonica Moviles, America Movil, and Entel/Nextel

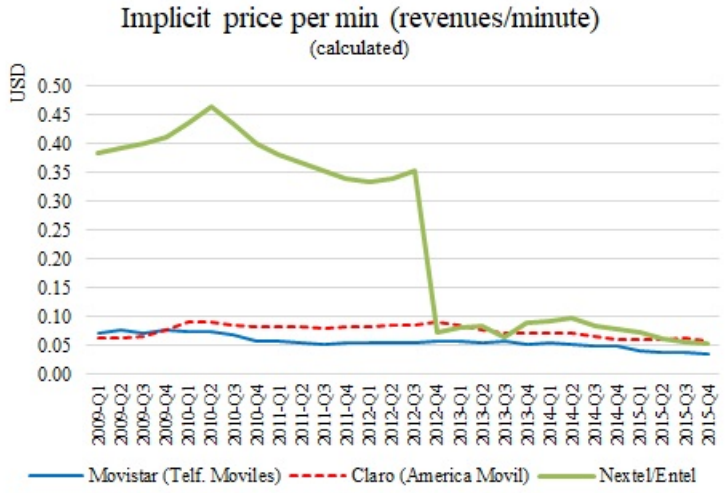


Figure 3: Implicit price per minute (USD) per company

Source: OSIPTEL; Quarterly Financial reports - Telefonica Moviles, America Movil, and Entel/Nextel

previous practice of focusing only in a small type of users (businessmen and corporations) and expanded its service to prepaid consumers; it also expanded its presence across the country. The impact of Bitel's entry in the market has been small; after a year of operation, it captured 3.5% of the market and competed mostly for prepaid consumers. However, it is relevant to notice that Bitel although it initially attracted consumers, these then switched to bigger operators, so Bitel did not gained from net ported lines. Until mid 2015 Bitel lost rather than gain ported lines (see figure 8 in the appendix).

A closer look into the calculated implicit per-minute prices of the companies (see figure 3) shows Entel/Nextelwith the highest price until late 2012, then its price plummeted and closed the price differential with the competitors. As noted before, since mid 2013, the acquisition of Nextel by Entel led to an aggressive change of business focus from corporate to personal services, which explains the onward price decline. Among the biggest players, Claro's per minute price tends to be consistly higher than Movistar's – in particular after the third quarter of 2010 when the first regulation was implemented–, which may be due to its a larger share of postpaid subscription line. Claro kept its slightly declining trend in prices since mid 2013, and Movistar seemed to wait until 2015 to start reducing its price. shows that Claro has a consistent higher price per minute than Movistar – in particular after the third quarter of 2010 when the first regulation was implemented– that can be explained by a larger share of postpaid subscription line in Claro than in Movistar.

In term of voice traffic, the information show a sustain increase in minutes of call, however, since the policy implementation, inbound traffic increase at positive and increasing growth rates, pushing all traffic to grow at positive rates particularly after mid 2015 (see figure 11 in the appendix). Additionally, table 2 shows the increasing average monthly consumption of mobile services between 2013 and 2015 for the surveyed population, which doubled between 2014 and 2015.[27] We also can observe that the minimum consumption level increased by 2015, which suggest an increase in demand for all consumers in the sample.[28].

Table 2: Monthly minutes of call consumed by user (PEN) (2013-2015)

Year	Max	Mean	Min	Median	N obs.
2013	389.0	31.7	0.0	13.6	2081
2014	623.6	51.5	0.0	32.3	2859
2015	1195.3	102.2	3.0	55.6	2495
Total	1195.3	63.0	0.0	30.6	7435

Notes: Consumption calculated from the reported individual monthly expenditure in mobile services and the average price calculated from price menus of popular plans for each provider.

Source: ERESTEL Panel Sample 2013-2015

Moreover, distinguishing such information by providers, we can observe a clear increase in the consumption of minutes of the typical consumers of the three biggest players (see table 3). A remarkable increase in minutes consumed is observed for Claro's consumers, provider that keeps the largest share of postapid lines and offers more data services to its consumers.[29] On the other hand, a typical consumer of Bitel (the newest and smallest provider) shows a decrease in its consumption of minutes between 2014 and 2015. being the smallest network

[27]It is worth mentioning that this variable minutes consumed per individual is absent in the consumer panel data information, and it is constructed from the monthly expenditure in mobile services and the average price from popular plans, assuming consumers use mobile service only for voice services.

[28]Individual consumption of mobile services are measured as minutes of call per consumer, obtained by dividing the declared monthly expenditure in mobile services and the calculated average price per plan per company

[29]Let's recall that the constructed variable "minutes" assumes all mobile expenditure corresponds to voice minutes. The big jump on minutes of use, may be reflecting the increase of usage of Data (MB). Claro did not only focus on providing postpaid services, but also on being the first on providing the largest 3G and 4G network across the country.

Table 3: Average monthly minutes of call consumed by user by provider (PEN) (2013-2015)

Year	Movistar	Claro	Nextel/Entel	Bitel
2013	32.75	27.34	114.69	
2014	56.90	37.56	158.22	71.43
2015	89.21	118.50	222.45	67.77

Notes: Consumption calculated from the reported individual monthly expenditure in mobile services and the average price calculated from price menus of popular plans for each provider.

Source: ERESTEL Panel Sample 2013-2015

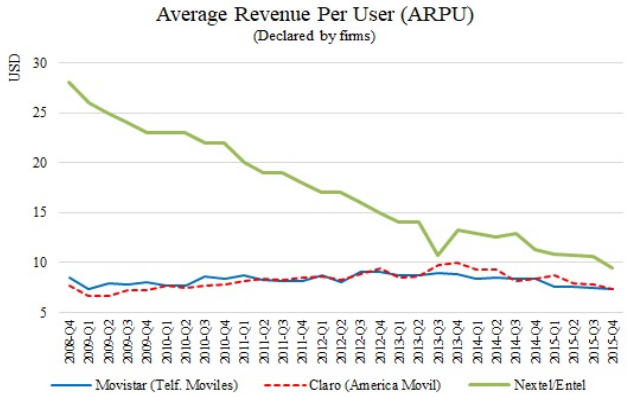


Figure 4: Average Revenue Per User by company

Source: Financial reports - Telefonica Moviles, America Movil and Nextel/Entel

implies that most of the minutes traffic is comprised by outbound traffic, which mean higher costs due to interconnection costs and therefore make prices less competitive.

Switching behavior seemed to strengthen competition in prices. Figure 9 (in the appendix) shows that the accelerated decline of the weighted implicit prices also coincide with a sharp increase of switching lines, in particular after the second mid of 2014 where a switching paperwork reduction was mandated and continued after the regulatory policy was implemented in 2015.

Given the pays-who-call pricing structure and the explicit price differentiation between on-net and off-net calls, on-net mobile-to-mobile calls made around 88% of the total outbound call traffic in 2013, whereas the mobile-to-mobile off-net calls only represented 8.5%.[30] Likewise, as expected, Movistar and Claro concentrate more than 90% of all the outbound traffic of mobile calls. An important observation is that by the end of 2015, small players Entel and Bitel that compete in the market and have smaller networks presented large share of on-net mobile-to-mobile calls, 53% and 66% respectively, of their total outbound traffic. (see Figure 12 and 13 in the Appendix).

The two-part tariff theoretical models predict firms to set zero per-unit price and extract the

[30]Since 2005, the outgoing on-net call traffic increased by 18 percentage points, while the outgoing off-net call traffic decreased by 3.5 percentage points

consumer surplus by setting a fixed fee equal to it. When there are two consumer types, the high type would have a positive consumer surplus, while the firm extracts all low-type consumer surplus and provides less quantity. In this market the prepaid consumers constitutes the low-type consumers as opposed to the postpaid consumers. Figure 4 show the monthly average revenue per user (ARPU) of the largest three operators, according to what is declared in their financial reports. Unlike Nextel/Entel that shows a clear decreasing trend of its ARPU until mid 2013, the ARPU for the other two operators were slightly increasing until 2014; during 2013 teh ARPU was higher in the case of Claro (America Movil) compared to Movistar(Telefonica Moviles).

In the case of Movistar, for which the revenue data were dis-aggregated by type of charge –revenue from calls and from fixed fee– and by type of service plan (prepaid and postpaid lines) until mid 2014, I could construct the ARPU and the average revenue per minute of call (ARPM) for the prepaid and postpaid case. Using these variables as proxies of the prices, as shown in figures 10a and 10b, we can see that the per-minute price for postpaid consumer (high-type) is almost zero while it is higher for the prepaid consumer. On the other hand, the ARPU of postpaid consumer is higher than the prepaid ones.

4.0.2 The demand: Mobile phone users

Most of the information shown in this section is based on the National Survey on the Demand of Telecommunications Services and Characterization of the users - ERESTEL, which consists of cross-sectional survey data collected by the Peruvian Regulatory Agency OSIPTEL since 2012.

Based on the survey data 2013 and 2015 from OSIPTEL, the share of mobile phone user population (in age to get a mobile phone) increased from 64% to 75% between those years. Most of the users (83% of mobile phone users) live in urban areas. Nonetheless, the mobile phone usage increased in rural areas: in 2013 only 49% of rural population owned a mobile phone, in 2015, that figure rose to 62%. Peruvian mobile phone users are still call-receiver type as opposed to call-makers (the percentage of the share of call-receivers remain around 58% between 2013 and 2015. That explains the high share of prepaid phone users, 68% against to 32% of postpaid/hybrid plans. Movistar remains as the company with largest share of the users(59% in 2015, three percentage points below the figure reached in 2013).

It is worth mentioning that most of the users in 2013 made mobile-to-mobile calls to communicate with family and friends (see table 16 in the appendix); this shows an important network aspect present on mobile communications. Additionally, only 21% of the total mobile users has a smarthphone, and most of them are subscribed to a postpaid/control plan. In 2013, almost 50% of the postpaid/control users had basic service such as voice and SMS,and 42% also had internet. In 2015, postpaid/hybrid consumers would prefer internet over SMS availability, 39% of the consumers would have plans that offer voice and internet only, and 10% would get internet only. Claro and Nextel/Entel have large share with users where their plan package includes data service (see Table 12 in the appendix)

Prepaid plan users have lower average monthly income and are relatively younger than postpaid/control plan users; likewise, those who own a smartphone have higher income than those who do not (see Table 14 (in the appendix) that contains information of 2013).[31] The willingness to pay of postpaid users without smartphone for a phone set is higher than those that already own one, showing the effect of newness of smartphones among those who do not

[31]This information was not available for following waves, but it is relevant.

Table 4: Number of mobile users that switched companies

	2013			2015		
	Prepaid	**Postpaid/Control**	**Total**	**Prepaid**	**Postpaid/Control**	**Total**
Has ever switched to another company?						
NR	0	2,289	2,289			
	0	0.07	0.01			
No	12,140,561	3,366,891	15,507,452	12,177,770	5,571,546	17,749,316
	98.05	96.87	97.79	95.81	90.97	94.24
Yes	240,940	106,675	347,614	532,704	552,771	1,085,476
	1.95	3.07	**2.19**	4.19	9.03	**5.76**
Total	12,381,501	3,475,854	15,857,355	12,710,474	6,124,318	18,834,792
	100	100	100	100	100	100

Note: Number of subscribers are calculated using the expansion factors.
Source: ERESTEL 2013, 2015

have one. The willingness to pay for a handset under the prepaid plan is high for users that already own a smartphone, this would be showing perhaps certain dissatisfaction from the first acquired smartphone.

Regarding the switching behavior, an increase on it is observed between 2013 and 2015. By 2015, around one million users switched companies, whereas in 2013 only 347.6 thousand people switched companies, this despite the implementation of number portability three years earlier. Thus, the switching rate increased from 2.19% to 5.7%, which can be related to the unlocked handset policy. As shown in Table 4, switching rate among prepaid consumers doubled and the switching among postpaid consumer tripled between 2013 and 2015.

Table 5 shows the number of switchers from/to each company. Consumers mostly switched between the two larger networks (Movistar and Claro), which reflects the duopolistic structure of the market. The smallest networks Nextel/Entel and Bitel attracted switchers mainly from Movistar; compared to 2013, Entel was more effective to attract consumers (see Table 13 in the appendix). On the other hand, an important change observed between 2012 and 2015 is that among the reasons that led to such switching decision, poor quality of service rose as the main reason followed by price differences; this in contrast to the high share of 'family and friends in the new network' as leading reason found in 2012. This may imply that the decision to switch may have become less sensitive to network effects (see Table 6 and 15).

As for consumption, based on ERESTEL 2015, 74% of mobile users would make less than 5 daily calls; and almost all (97%) talk less than 10 minutes per call made.

Finally, the average switcher in 2015 in the Peruvian market can be described as a middle age and mate person, who works, has higher income, spends more in mobile services, and is slightly more call-maker than receiver, it is marginally a postpaid/hybrid (see Table 17 in the appendix). Relevant information about smartphone usage in Peru is also provided in the appendix.

Table 5: Number of mobile phone users switched from/to each company

Current company	Switched from				Total switchers
	Movistar	Claro	Nextel	Bitel	
Movistar	0	202,457	8,820	3,784	215,061
Claro	291,403	0	13,060	1,353	305,816
Entel (Nextel)	142,109	112,901	0	1,229	256,239
Bitel	65,780	19,034	4,073	0	88,887
Total	499,293	334,392	25,953	6,366	866,003
Movistar (%)	0	94.14	4.1	1.76	100
Claro (%)	95.29	0	4.27	0.44	100
Entel (Nextel)(%)	55.46	44.06	0	0.48	100
Bitel (%)	74	21.41	4.58	0	100
Total (%)	57.65	38.61	3	0.74	100

Note: Number of subscribers are calculated using the expansion factors.
Source: ERESTEL 2015

Table 6: Reasons for switching companies

Reason to switch providers	Current mobile company				Total	
	Movistar	Claro	Nextel	Bitel	%	N°
Price differences	23.6	19.0	35.2	36.8	26.8	227,646
Bad service quality	49.4	63.1	50.2	44.5	54.0	459,426
Sales / Promotion	7.3	3.0	7.1	8.8	5.9	50,118
Other	2.8	2.0	1.7	1.8	2.1	17,617
Network effects (family/friends in new network)	16.9	12.8	5.9	8.2	11.3	96,360
Total	100	100	100	100	100	851,166
	214,709	298,507	253,298	84,653	851,166	

Note: Number of subscribers are calculated using the expansion factors.
Source: ERESTEL 2015

5 Empirical Model

Aiming to show that a reduction on exogenous switching costs affects market equilibrium outcome, I restrict my analysis to test the hypothesis that a reduction in exogenous switching costs (unlocked handset policy) led to lower average prices, therefore to an increase in the demand for minutes. To show some empirical evidence that supports my theoretical model, I perform a reduced form model estimation to find evidence of a negative relationship of exogenous switching costs and the demand for mobile phone services, and a positive relationship between exogenous switching costs and prices.

$$u_{ijt} = v_{ij} + (X_{it}^1 + X_i^2)\gamma^i + k(M_{it} + NS_{jt} + pr_{jt}^n) + \alpha_1 p_{jt} + s_t(\alpha_2 + \alpha_3 * 1\{d_{it}\}) + \varepsilon_{ijt}$$

where,

- $v_{ij} = v + \sigma_{ij}$, where v indicates the value of the service constant across consumers (the value to be communicated), and $\sigma_{ij} \sim N(0, var(\sigma))$ is the idiosyncratic relative taste of a consumer of a initial provider over the other, assumed to be time invariant.
- X_{it}^1 and X_i^2 includes all the observed time variant and invariant demographic characteristics.
- k denotes the importance of network size for consumers
- M_{it} denotes the share of mobile users within household of individual i
- NS_{jt} denotes the network size of firm j
- pr_{jt}^n denotes the premium charge for off-net calls over private network calls of the most popular consumption plans for firm j.
- p_{jt} denotes the average revenue per minute of call of the mobile telecommunications service of firm j, the implicit price per minute.
- d_{it} is a dummy variable the equals 1 if the individual switched to another company in the previous year, and 0 otherwise.
- s_t denotes the extra cost of unlocking a handset (measured by the average premium of unlocked handset over the locked one) that may affect to every consumer i, and in particular, this cost is incurred when switching providers.
- ε_{it} is an i.i.d. shock to individual consumer i that captures all the unobserved factors that add to the exogenous switching costs that each individual face at time t.

The demand equation

Taking into account such utility function, I write the aggregated demand of minutes (calls) – measured as the log of minutes consumed by individual i, from provider j at period t, $ln(q_{ijt})$– as shown in equation (1).

$$\begin{aligned} ln(q_{ijt}) =& \alpha_i + \beta_1 ln(p_{jt}) + \beta_2(X_{it}^1 + X_i^2) + \beta_3(M_{it} + NS_{jrt} + pr_{jt}^n) + \beta_4 I_{ijt} + s_t(\beta_5 + \beta_6 * 1\{d_{it}\}) \\ &+ \beta_7 * Entel + \beta_8 * Bitel + \epsilon_{ijt} \end{aligned} \tag{1}$$

To capture the invariant unobserved individual-specific characteristics, I use α_i, which would refer to the idiosyncratic taste shock in the theoretical model, assumed to be totally random here. X_{it}^1 and X_i^2, time variant and time invariant demographic characteristics, include age, sex (female=1), ever married dummy variable (1 if ever married), maximum level of education, geographic area of residence (coast, highlands and amazon forest), log of monthly household income per household member, mobile service tenure (1=less than a year, 2= 1∼2 years, 3=

2∼3 years, 4= more than 3 years), working status (1=working), user type (1=call receiver, 2=call maker), dummy variable for who pays for the mobile service (1=herself), dummy variable for owning more than one handset and another for owning many phone numbers, dummy variables for having taken promotions/sales, for having internet service at home and for being an internet user.

To control for the network effects, I use three control variables: M_{it} that denotes the log of share mobile users within each household, NS_{jrt-1} the lagged market share of each company j in each region r of Peru (there are 24 regions), and the variable pr^n_{jt} that shows the premium of average per-minute price of off-net minutes over average per-minute price of on-net-private-network minutes. Likewise, to control for the effect of the expansion policy of Entel(Nextel) and the entry of the fourth company (Bitel) to the market, I use a dummy variables *Entel* and *Bitel*.

To capture the effect of the reduction of switching costs (unlocked handset policy), I use variable the average premium of the price for getting an unlocked handset over a locked one s_t; this term enters to the equation directly and through an interaction with d_{it}, which equals one if a change of providers is observed between years.[32] Additionally, I add a variable *inertia*, I_{ijt}, which equals one if the consumer kept her same plan and provider from previous period.

The supply equation

The equation I estimated is the following

$$\begin{aligned} ln(p_{jt}) =& \gamma_0 + \gamma_1 * ln(qm_{jt-2}) + \gamma_2 * ln(MS_{jt}) + \gamma_3 * U_t + \gamma_4 * ln(Portout_{jt-1}) + \gamma_5 * ln(C^{int}_{jt}) \\ &+ \gamma_6 * Q_{3Y12} + \gamma_7 * NewEntel + \gamma_8 * EntryBitel + \eta_{jt} \end{aligned} \tag{2}$$

where,

- $ln(qm_{jt})$ is the natural logarithm of the total traffic (inbound and outbound) of minutes of provider j in quarter $t-2$, this considering that prices (or price menus) are not adjust immediately, but with some lags.
- $ln(MS_{jt})$ is the natural logarithm of the total market share in subscription lines of provider j in quarter t, which will control for network effects.
- U_t is a dummy variable that changes from 0 to 1 when year is 2015.[33]
- $ln(Portout_{jt-1})$ denotes the natural logarithm of the share of ported out lines of provider j, which is lagged one period.
- $ln(C^{int}_{jt})$ is the natural logarithm of a proxy for interconnection costs of providing the service, in this case we will use the share of off-net outbound traffic to all outgoing traffic lagged by one period.[34]

[32]The information on premium of unlocked handsets was gathered taking into account price catalogs of companies (such as Claro) and the premium calculated by OSIPTEL for the years 2013 and 2014, from 2015 on this premium was just zero.

[33]I was unable to use the average premium of unlocked handset over locked ones, since this information was not available at the required frequency, quarterly.

[34]Although I got information on the number of base stations per provider, such information corresponds to years 2013, 2014 and 2015, using it would significantly reduce the sample size compromising the estimation results.

- Q_{3Y12} is a dummy variable for third quarter of 2012, period in which a massive disconnection of inactive lines happened in the largest two providers.

- $NewEntel$ is a dummy variable to indicate the change in Entel/Nextel's business model by which it became an aggressive competitor. The variable equals one starting from the first quarter of 2014, ans zero otherwise.

- $EntryBitel$ is a dummy variable to indicate the entry of Bitel (the fourth operator) which started operations in the third quarter of year 2014, thus the variable equals one since then, and is zero otherwise.

- η_{jt} is an i.i.d. shock to provider j that captures all the unobserved factors that influence provider j at time t when setting prices.

According to the theoretical predictions, a reduction in exogenous switching costs leads to a decline in prices, therefore there is a positive relationship between prices and exogenous switching costs. In terms of the variables described above, we should expect that the unlocked-handset policy (U_t) impacts negatively in prices, thus
$\gamma_3 < 0$. On the other hand, to retain consumers once switching is observed, we should expect a decline on prices of providers, therefore we must expect $\gamma_4 < 0$.

6 Data

To analyze the effect of the unlocked handsets policy on the market, I gathered information on many sources. The most important source of information is the Peruvian Telecommunications Regulatory Agency (OSIPTEL for its name in Spanish), which supervises the companies and gets very detailed firm-level information from them at monthly or quarterly basis. OSIPTEL has also implemented a national level survey about telecommunication services consumption, which is yearly conducted since 2012. This survey includes panel data since 2013, which is available under request.

I obtained consumer panel-data from the National survey on the demand of telecommunications services and characterization of the users - ERESTEL (in Spanish) [35]. This longitudinal data contains information of around 1200 households, and 3800 individuals, from which 2800 are mobile phone owners and are older than 11 years old for the years 2013-2015. The data set contains information at household and individual level on all the telecommunications services (fixed-line, mobile, internet, public telephone service, and paid-TV) and include demographic information such as age, sex, personal income, household expenditure, working status. [36] I also used the cross-sectional data from the same survey to get some descriptive information from the waves 2012 to 2015. This database is publicly available and contains information of 11255 to 15128 households. The survey is conducted at the end of each year. For 2014, the survey was collected between October and November.

I complemented the consumer level information with firm-level information associated to the number of mobile phone subscriptions by type of service (prepaid or postpaid), by region, per company from the regulatory agency. The data are also available for traffic calls (minutes),

[35] *Encuesta de Demanda de Servicios de Telecomunicaciones y Caracterizacion de los Usuarios - ERESTEL* in Spanish

[36] Additionally, I got data for a smaller consumer survey on 'Habits, uses and attitudes towards mobile phone services' conducted by a private consulting firm, IPSOS for the year 2014. The dataset contains socio-economic information and focuses in the habits and preferences of people when using smartphones.

dis-aggregated by type of service, destination, and region, at the firm level. Likewise, I also obtained data on number portability, the number of lines switched among providers (inter firm switchers) from January 2010 onward, in a monthly basis. In terms of infrastructure investment, I collected quarterly data on the number of base stations per company per region. Detailed information on characteristics of mobile consumption plans are also published by the regulatory agency. In addition, I was provided with the list of the names of the most popular consumption plans (those that jointly get 50% of each company's subscribers) per company per type of service per year for 2013, 2014 and 2015. This information is helpful to focus the gathering of relevant average plan characteristics and price differentials between on-net, off-net and private-network minutes.

In order to check locked and unlocked handsets prices, I gathered information on imported quantity and price of handsets by importer for the period between Jan. 2014 to Dec. 2015 from the Customs Office of Peru (The Tax and Customs Administration Office (SUNAT for its name in Spanish), through their ADUANET service.

Finally, I collected quarterly financial information from companies' financial reports provide, mainly on revenues and earnings' margins. From that information, data of the Average Revenue per User (ARPU) for mobile service provision and Average Revenue per Minute (ARPM) of mobile communications are constructed. I have collected quarterly data from 2008 to 2015 of revenues corresponding to mobile subscribers and voice traffic for the three major companies, and for the largest company, I got such information by type of service (postpaid and prepaid). To complement this information, I also obtained partial information from GSMA intelligence regarding revenues of the fourth operator (Bitel).

Based on all these sources, I built a longitudinal data set for 5464 individuals during 3 years, from which 1382 are mobile phone consumers along the three years. Table 7 shows the summary statistics of the main variables of mobile phone users that I use for the model estimation, in particular, for the demand estimation (equation 1). The variable minutes consumed per individual (absent in the consumer panel data information) is constructed assuming consumers use mobile service only for voice services.[37] Thus, I used the monthly expenditure on mobile services reported by the consumers, and the prices –which I collected from the popular plans (as representative prices for prepaid and postpaid plans) by provider and for each year – to get the monthly quantity of minutes consumed.[38] These average per minute prices I constructed also allow me to calculate the premium of per-minute price of off-net calls over "private-network"-on-net calls.

From the data, a typical Peruvian mobile phone user is an adult of around 38 years old, who works as employee or auto-employee, consumes 63 minutes of call per month, has been engaged in a romantic relationship, lives in the coast of the country, has some secondary level education, and is also an internet user. More than half of the consumer' household member are also mobile users, and uses the mobile services three to more years; and between 3 to 4% of the mobile users own more than one phone number or handset. Around 60% of the mobile users in the data set remain with same consumption plan and the same company, 20% would take advantage of the "on sale" promotions of the network providers, around 22% are observed

[37] Peru has a pay-who-calls system, so that the variables minutes consumed refers to minutes each user paid for starting a call. In the aggregate, these minutes comprises the outbound minutes traffic.

[38] I also used the share of on-net and off-net calls per provider to construct a more accurate per provider per plan average per minute price.

Table 7: Summary statistics for mobile users

Variable	Mean	Std. Dev.	Min.	Max.	N
Individual information					
Minutes consumed per month	62.962	92.353	0	1195.26	7435
Inertia	0.613	0.487	0	1	3859
$(1\{plan * company_{t-1} = plan * company_t\})$					
Switched companies (=1)	0.219	0.414	0	1	3859
Share of mobile users within household	0.693	0.255	0.1	1	7564
Age (years)	38.199	16.006	12	96	7564
Female (=1)	0.491	0.5	0	1	7564
Ever married (=1)	0.654	0.476	0	1	7564
Geographical location (Coast=1, Amazon=3)	1.555	0.689	1	3	7564
Household monthly income per member (PEN)	663.680	584.358	5	8600	7344
Maximum education level (max 11 years)	6.482	2.244	1	11	7564
Working status (working=1)	0.654	0.476	0	1	7564
Student (=1)	0.167	0.373	0	1	7564
User type (call receiver=1, call maker=2)	1.399	0.49	1	2	7552
Tenure mobile service (1 if <1 year, 4 if > 3 years)	3.232	1.054	1	4	7552
Many handsets (yes=1)	0.029	0.167	0	1	5439
Many phone numbers (yes=1)	0.039	0.193	0	1	5439
Mobile paid by herself/hsh member (=1)	0.986	0.117	0	1	7550
Promotions/sales taker (=yes)	0.205	0.404	0	1	6538
Internet at home (=1)	0.527	0.499	0	1	7047
Internet user (=1)	0.528	0.499	0	1	7563
Firm-level information					
Average per-minute revenue implicit per-minute price (PEN)	0.176	0.078	0.121	1.263	7551
Share of installed base stations per region	0.403	0.132	0.094	0.581	7385
Share of ported-out lines	0.012	0.015	0.001	0.154	7546
Market share of lines per region$_{t-1}$	0.544	0.17	0	0.817	7446
Premium of unlocked handset	0.522	0.375	0	0.795	7547
Premium off-net over private network per-minute price	8.102	24.891	0.893	326.816	7546

Notes: Information given for around 2576 individuals across 2 to 3 years.
Source: ERESTEL Panel Data 2013-2015, OSIPTEL, and financial reports of companies.

to switched providers between periods.[39] From the firm-level data, the premium of the price of an unlocked handset over a locked one is in average 54%, and the premium of the per-minute price of off-net calls over private-network calls is found to be huge, around 810%.

[39]This variable equal one when the reported provider of the consumer in the period t is different from the one in $t-1$.

Table 8: Summary statistics of network providers

Variable	Mean	Std. Dev.	Min.	Max.	N
Average per-minute revenue implicit per-minute price (PEN)	0.415	0.393	0.114	1.843	102
Total voice traffic (bill. minutes)	2.432	2.219	0	8.571	116
Subscription lines market share	0.316	0.216	0.002	0.577	114
Share of ported-out lines	0.004	0.005	0	0.027	77
Total outbound off-net voice	0.216	0.197	0	1.295	116
Share off-net outbound traffic to all outbound traffic	0.236	0.234	0.035	0.768	114
Smartphones adoption rate	0.081	0.096	0	0.33	97
Housing price (constant PEN of 2009 per m^2)	3493.98	1056.163	1819.941	5094.139	144
GDP annual variation (%)	5.685	3.118	-0.807	11.439	144
Gross Value Added volume (index 2007=100)	125.744	17.052	93.543	155.63	144

Source: Quarterly financial reports of companies, OSIPTEL, Central Bank of Peru BCRP, and National Institute of Statistics and Information INEI.

On the other hand, taking the information collected from operational and financial quarterly reports of the mobile service providers and OSIPTEL, and complementing it with data on macroeconomic indicators, I built another panel data set for the period 2007 to 2015. Thus, I got information for 36 quarters for the three major companies, and 6 quarters for the latest operator that entered in the third quarter of 2014. Table 8 show the main descriptive statistics of the main variables that are used to estimated the supply equation 2.

6.1 Estimation strategy and results

I estimate the demand equation (1) using the instrumental variables approach; I control for demographics characteristics, and include control variables for switching costs and network effects. To control for endogeneity in the demand equation and identify the parameters, I use instruments (supply shifters) for the variable per-minute price. More explicitly, I instrument price variable using information I got from the companies, specifically: the lagged share of installed base stations in each region and the lagged log of the share of ported-out lines per company. To conduct this estimation, I used the unbalanced panel data, consisting on 3133 datapoints, corresponding to information of 2217 individuals during a one to two years period.[40]

Likewise, for the estimation of the supply equation (2) I relied on the operational and financial quarterly firm-level information I collected for the period 2007-2015. Thus, I obtained a small panel data and I also used the IV method. Thus, I used demand shifters to control for endogeneity and to identify the supply equation and the effect of the reduction of switching costs. In particular I instrument the quantity of voice minutes by four variables that serve as proxies of demand shifters: the rate of smartphone adoption per company per quarter (information retrieved from GSMA intelligence), the housing price per square me-

[40] Given that I use the variable Inertia (based on the observed changes on provider or consumption plan from one period to another), and also I use the dummy variable d_{it} from observed changes on providers, I necessarily lost information of a year for the estimation.

ter in the Peruvian Capital City (at constant national prices of 2009), the annual variation of the GDP, and the index of physical volume of the Gross Value Added (with 2007 as base year).

To perform the estimation and to secure I have stationary variables, I de-trended the variables of equation (2) using the Hodrick-Prescott filter, and found no significant seasonality in the variables. In addition, for those variables that did not pass the unit root test –mainly the share of ported out lines– I used the variables in their first differences.[41] Thus, the supply equation I estimate is the following, and due to limited information, I could only use 69 datapoints corresponding to information to the three largest providers, and 23 quarters.

$$\begin{aligned} ln(p_{jt}) =& \gamma_0 + \gamma_1 * ln(qm_{jt-2}) + \gamma_2 * ln(MS_t) + \gamma_3 * U_t + \gamma_4 * \Delta ln(Portout)_{jt} + \gamma_5 * ln(ShareOutq^{ofn}_{jt-1}) \\ &+ \gamma_6 * Q_{3Y12} + \gamma_7 * NewEntel + \gamma_8 * EntryBitel + \eta_{jt} \end{aligned}$$

Results

Demand estimation: Following the IV method with random effects on panel data, I estimated the equation (1); the results are shown in Table 9. The table also reports estimated coefficients of the fixed effect and first difference models to show robustness of the estimates. Although the model specification relies on random effects, according to the Hausman test I reject the null hypothesis that such random effects model provides consistent estimates. Thus, I use the fixed effects coefficients for the analysis.

As expected, the results give a negative and significant relationship between per-minute price and voice traffic (minutes consumed), moreover the coefficient indicates that the demand for voice-mobile services is price elastic and the price demand elasticity is -2.5. A key finding is given by the observed significant negative effect of consumer inertia on demand; in fact the estimate indicates that any change of the current state (consumption plan or company) would increase the demand for minutes by 31.2%.[42]

Moreover, as predicted by the model, the results give evidence of a negative effect of exogenous switching costs in demand –this, according to my theory, would be related to the positive relation between prices and exogenous switching costs–. Specifically, the indicator of the exogenous switching costs (the unlocked handset premium combined with switching behavior) shows a statistically significant negative coefficient implying that the policy (a reduction of the exogenous switching costs associated to the extra costs of owning an unlocked handset) would have generated an increase of 39.7% of the demand for minutes for switchers. Higher exogenous switching costs prevent consumers to benefit from better offers from other providers, and lock them to same provider even though prices are higher. Such prices, also would limit the voice traffic. Let's recall that the typical Peruvian user is a call receiver and as a prepaid user (that face higher per minute prices), she may be reluctant to make calls, moreover considering the who-call-pays regime in the market.

On the other hand, despite not being consistent, the estimated coefficient of the effect of the handset policy (the unlocked handset price premium) in the random effects model may suggest

[41] To test for unit root existence, I used the Fisher-type unit-root test based on the augmented Dickey-Fuller test. Before running the regression with the de-trended variables, I found that only the variable share of ported out lines would barely pass the unit test with 5% of significance level at most. Thus, in a preventive way, I used the variable in first differences to control for any non-stationary problem.

[42] The calculation comes from $100 * (e^{-0.375} - 1)$.

Table 9: Demand estimation: log of quantity of minutes consumed as dependent variable

Variables	Random Effects (1)	Fixed effects (2)	First differences (3)
ln(per minute price)	-2.539***	-2.451***	-2.451***
	(0.144)	(0.283)	(0.285)
Inertia	-0.249***	-0.375***	-0.375***
	(0.036)	(0.06)	(0.06)
Premium off-net to private-net per-minute price	0.06***	0.048***	0.048***
	(0.007)	(0.01)	(0.01)
Premium unlocked handsets*switch	-0.267***	-0.506***	-0.506**
	(0.071)	(0.12)	(0.121)
Premium unlocked handsets	0.684***	-	-
	(0.116)		
Ever married	-0.05	-0.302*	-0.302
	(0.049)	(0.184)	(0.185)
ln(household monthly income per member)	0.255***	0.179***	0.179***
	(0.027)	(0.047)	(0.048)
Maximum level of education	0.046***	0.236**	0.236**
	(0.008)	(0.103)	(0.104)
Working status	0.104***	0.173**	0.173**
	(0.037)	(0.079)	(0.08)
User type	0.485***	0.458***	0.458***
	(0.031)	(0.051)	(0.051)
Use of internet	0.305***	0.16**	0.16**
	(0.038)	(0.07)	(0.07)
Many phone numbers	0.489***	0.497***	0.497***
	(0.116)	(0.168)	(0.169)
Entel dummy	2.063***	1.703***	1.703***
	(0.15)	(0.295)	(0.298)
Bitel dummy	-14.069***	-10.847***	-10.847***
	(1.865)	(2.589)	(2.612)
Mobile service tenure	0.047**	-0.129*	-0.129*
	(0.022)	(0.077)	(0.077)
Promotions/sales taker	-0.198***	-0.091	-0.091
	(0.034)	(0.056)	(0.057)
Constant	-5.079***	10.462**	-0.335*
	(0.492)	(5.31)	(0.174)
R^2 overall	0.48	0.01	0.148
R^2 between	0.494	0.01	0.148
R^2 within	0.412	0.434	-
Std. dev. α_i	-	6.416	1.498
Std. dev. ϵ_{ijt}	-	0.691	0.965
N. obs	3133	3133	916

[a] ***, **, * denotes statistic significance at 1%, 5% and 10% level respectively. Robust errors are given in parentheses for all columns.

[b] $ln(p_{jt})$ is instrumented by the lagged log of share of installed base stations, and lagged log of share of port-out lines.

[c] Region fixed-effects are used in column (1) and omitted from the table, as well as other 9 regressors. Given the rejection of the Hausman test, the fixed-effect model, column(2), is the consistent estimator.

that all consumers would have benefited from the existence of such premium due to possible compensation in the form of subsidies given by companies; the estimate would indicate that

the handset policy reform may have reduced such benefit.[43]

From the variables used to control for network effects, only the premium of the per-minute price off-net over private-network calls is found to be highly significant. The estimation shows that, as expected, network effects coming from this off-net and on-net price discrimination positively impact the demand for minutes. In particular, a 1% increase in the premium of off-net calls over on-net private-network calls would increase demand for minutes by 4.9%, which would be comprised by on-net minutes.

Among other significant findings, the demand for minutes increases with income, level of education, working status, being a declared call-maker user, ownership of many phone numbers, and decreases with mobile service tenure. Also, being an internet user would increase the demand for voice traffic, this may reflect that heavy users of internet are usually those that demand more from mobile phone services. Likewise, it is noteworthy that the demand of minutes increases with for consumers of Entel(Nextel), which started a fierce competition in prices. The effect of the entrant (Bitel, the smallest player) in the demand for minutes of its consumers is found negative; as mentioned before, this can be explained by the marginal impact Bitel has had in terms of building a network and a consumer base during the observation period; being a small network, the costs of providing the services are much higher due to the interconnection fees, and therefore their prices would not be as competitive as the bigger networks.

Supply estimation: The results of the supply estimation are summarized in Table 10. Despite of the small size of data used for the analysis, we still could get some insights. As observed, a positive relationship between price and voice traffic supply is found, which gives us the expected sign despite of being statistically insignificant.[44] The coefficient of the market share of subscription lines that capture the effect of network size on prices, although statistically insignificant, shows to positively impact prices. This may suggest that as companies expand their network they would increase prices to extract more from consumers. The variable that capture interconnection costs, the share of off-net outbound traffic in total outbound traffic, shows a highly significant positive effect on prices; the higher the interconnection costs the higher the prices.

A key result is that – as predicted by my theory – a reduction of exogenous switching costs (implementation the unlocked-handset policy) shows to have had a negative effect on prices; in particular, with a statistical significance at 10% level, such policy would have led to an average reduction of 9.4% in prices of mobile services (per-minute price). Moreover, larger changes in the switching rate (the share of ported-out lines) are found to drive prices down.(he coefficient is negative and significant at the 1% level).

Given the estimation results, and contrary to the intuition, the expansion of Entel and the entry of Bitel did not contribute to a reduction of prices, only the entry of Bitel is found to have a positive impact (statistically significant at 5% level) on average prices. According to the market analysis, implicit per minute prices declined during 2014, particularly after the second mid of the year (which coincides with Bitel's entry). It could be argued that the effect

[43] According to the specification test, random effects estimates are not consistent, but a naive interpretation of such results would indicate that the policy would have caused an reduction of 98% ($100 * (e^{-0.684} - 1)$) in the demand for minutes (mobile services).

[44] Let's recall that these estimation results rely on small data size, only 69 data-points, which constrains the observed variation. Monthly data would be desirable, however, providers only report quarterly revenue data.

Table 10: Supply estimation: log of implicit price (revenue per minute) as dependent variable

Variable	Coefficient	(Std. Err.)
Log of total minutes traffic$_{t-2}$	0.241	(0.548)
Log of total market share$_t$	0.019	(0.665)
Unlocked handset policy (=1)	-0.099*	(0.056)
Δ Share of ported-out lines	-0.017***	(0.006)
Log of share off-net outbound traffic to all outbound traffic	0.391***	(0.129)
Q_{3Y12}	0.176*	(0.107)
New Entel dummy	0.036	(0.060)
Entry Bitel dummy	0.077**	(0.039)
Constant	-0.012	(0.026)
R^2 overall	0.220	
R^2 between	0.338	
R^2 within	0.226	
Std. dev. η_{jt}	0.217	
$\chi^2_{(1)}$	15.01	
N. obs	69	

[a] ***, **, * denotes statistic significance at 1%, 5% and 10% level respectively. Robust errors are given in parentheses for all columns.

[b] $ln(qm_{jt-2})$ is instrumented by the lagged log of the rate of smartphone adoption of company j, log of housing price, log of GDP percentage variation, and log of GVA volume. share of installed base stations, and lagged log of share of port-out lines.

[c] Given the non-rejection of the Sargan-Hansen test of overidentifying restrictions and the Hausman test, the random effects model is the consistent and efficient estimator.

on price reduction is already explained and captured by the changes in switching rate,[45] which outweighs the effect to increase prices. However, this debatable result leaves the opportunity to improve the model specification or use a richer model that exploit the dynamic structure of the game.

7 Conclusions

In this paper I present the Peruvian mobile phone industry, where recent regulatory changes exogenously reduced exogenous switching costs (unlocked handset policy and reduction of paperwork duration of number portability to one day). Theoretical models, in particular my model on exogenous and endogenous switching costs predicts that a reduction of exogenous switching costs (like the ones affected by the Peruvian regulatory policy) lead to lower second period prices and increased consumer utility.

The market is an attractive case study because the regulatory changes offered the opportunity of having a quasi-natural experiment of the reduction of switching costs, it is also an interesting market to research about network effects given the existing explicit off-net and on-net price discrimination.

[45] Certainly, switching rates increased for all companies since June of 2014.

The average price (implicit price) declined since the second quarter of 2014 (when the paperwork reduction regulation of number portability was implemented, but further changes were expected), and continued such trend during 2015. In particular, the switching rate rocketed with the implementation of the unlocked handset policy in January 2015. It is important to acknowledge that the unlocked handset policy was announced in November in 2014, but firms would know about the intended change since the end of 2013. Likewise, lower average per-minute prices are related to lower off net and on net prices, however to retain consumers and attract rival's consumers, companies offered very low on-net prices through their "private network' with unlimited minutes, the premium of off-net per minute price over this private-network price became larger.

Using microdata for the mobile telecommunications industry in Peru, consumer panel data enriched with firm-level information, I present some empirical evidence that supports some of my theoretical predictions. I estimated a demand and supply equation to test the effect of exogenous switching costs on demand and prices. For that purpose, I used consumer panel data set and a firm panel data set to perform the estimation of the equations.

From the supply estimation, I found that such reduction of switching costs (implementation of the unlocked-handset policy) would have led prices down by 9.4%. Moreover, larger changes in switching rates (ported-out lines) significantly reduced prices.

From the demand estimation, and after controlling for network effects and market entry, I found reduced-form evidence of the negative and statistically significant impact of exogenous switching costs on consumers' demand for mobile phone service (minutes of call). A reduction of exogenous switching costs indeed increased demand for the service. More precisely, the results from the demand estimation indicates that the unlocked handset policy reform –an external reduction of exogenous switching costs– implemented in Peru in 2015 would have induced an increase of demand of minutes of 39.7% particularly for those that switched providers. Furthermore, given that 61% of the consumers do not change their choice status (plan type and company), the estimation suggests that any change in consumers' *status quo* would increase the demand for mobile services by 31%.

Finally, the estimation results from the demand equation show that, as expected, network effects coming from the off-net and on-net price discrimination positively impact the demand for minutes. In particular, a 1% increase in the premium of off-net calls over on-net private-network calls would increase demand for minutes by 4.9%, which would be comprised by on-net minutes.

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Graphs and tables

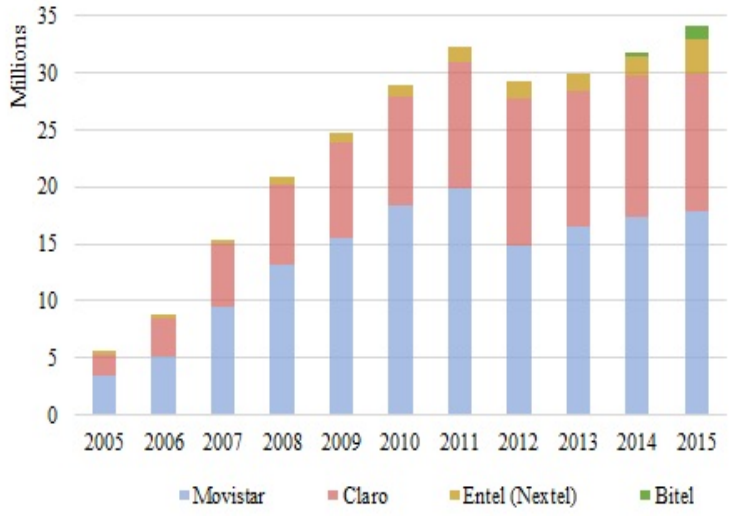


Figure 5: Mobile phone services expansion and market shares

Source: OSIPTEL

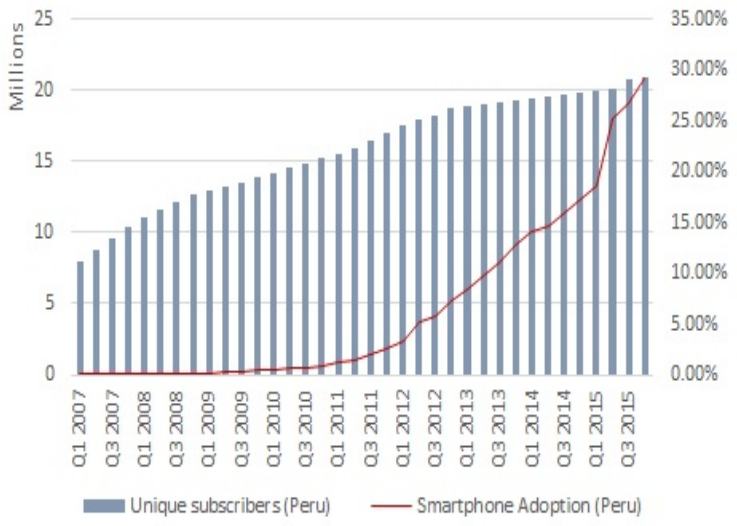


Figure 6: Mobile phone unique subscribers and smartphone adoption (%)

Source: GSMA Intelligence

Table 11: Price menus of prepaid, postpaid and control service plans

		Prepaid		Postpaid		Control/Hybrid	
		Movistar [1]	Claro [2]	Movistar [3]	Claro [4]	Movistar [5]	Claro [6]
Additional							
Per minute price (USD)	On-net	0.17	**0.48**	**0.24**	**0.14**	Prepaid prices	Prepaid prices
	Off-net	0.17	**0.80**	**0.36**	**0.24**		
	To fixed line	0.17	0.69	0.29	0.14		
Other services (USD)	SMS Domestic	0.03	0.03	0.08	0.07	Prepaid prices	Prepaid prices
	SMS Int.	0.09	0.08	0.08	0.07		
	MMS	-	0.26	0.17	0.17		
	1 MB	0.17	0.17	0.18	0.32		
Fixed monthly fee USD		-	-	18.04	24.02	20.94	31.12
Allowance (minutes included)	Minutes fixed line	-	-	150	97	85	122
	Minutes on-net	-	-	150			222
	Minutes off-net	-	-	75		70	106
	Minutes to own private network	-	-	100	200	300	-
	SMS	-	-	30	200	225	190
	MB	-	-	-	450	50	300

Note: I took the most popular plans by Sep. 2014, which are 1/ Tarifa Unica; 2/ Plan Juerga; 3/ Movitalk Univ. Basico; 4/ Smart Total HC i69; 5/ Control RPM 59.9; 6/ Plan de Datos 89
Source: OSIPTEL- Mobile Phone Companies

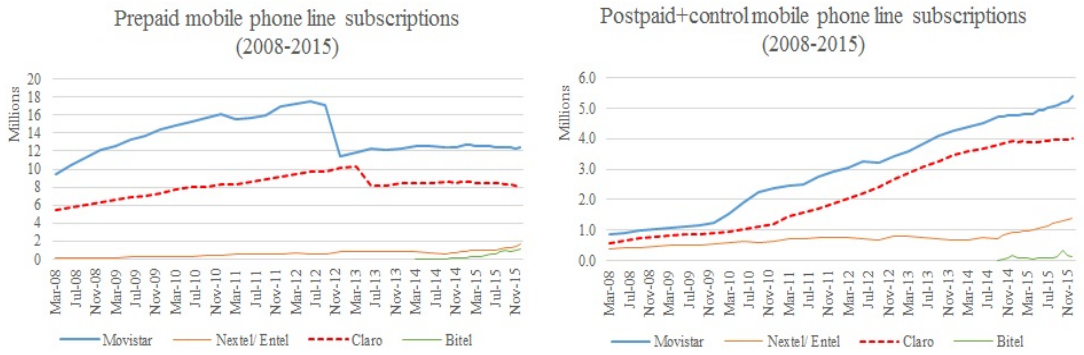


Figure 7: Mobile phone lines by service plan and company

Source: OSIPTEL

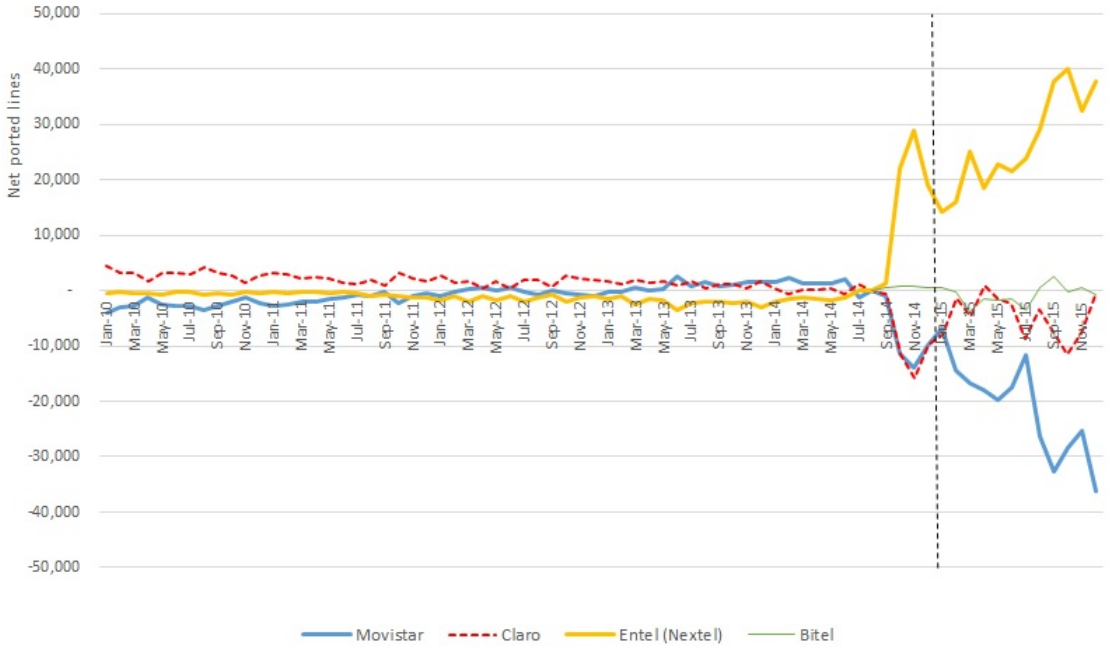


Figure 8: Net ported lines by company per month (Jan 2010 - Dec 2015)

Source: OSIPTEL

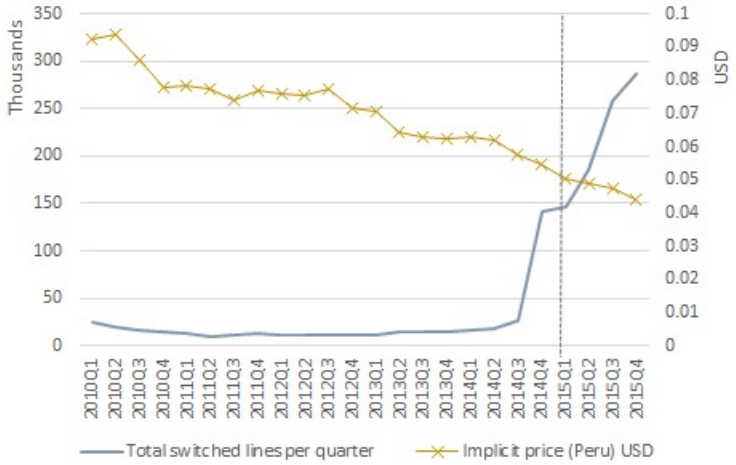
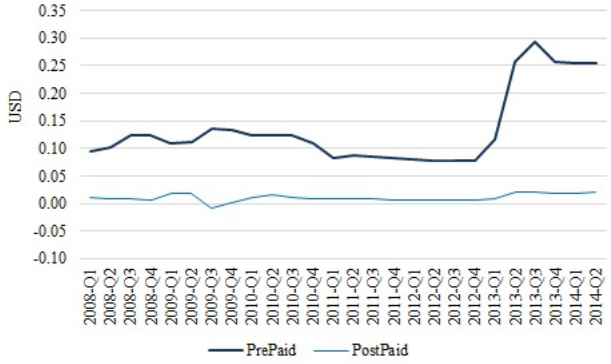
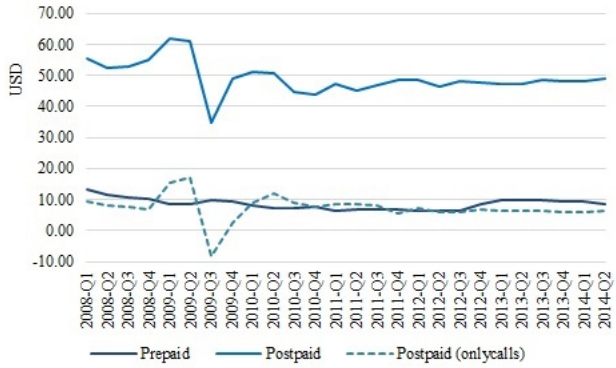


Figure 9: Quarterly switched lines and Aggregate implicit price per minute

Source: OSIPTEL and Quarterly Financial Report from companies

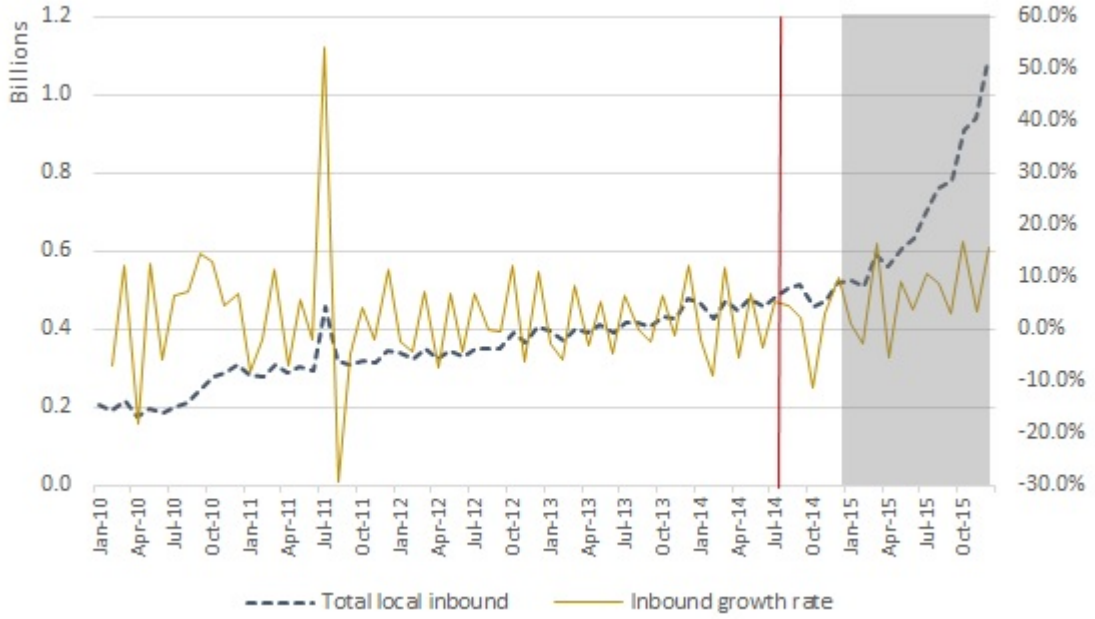


(a) Movistar: Average Revenue Per Minute of call

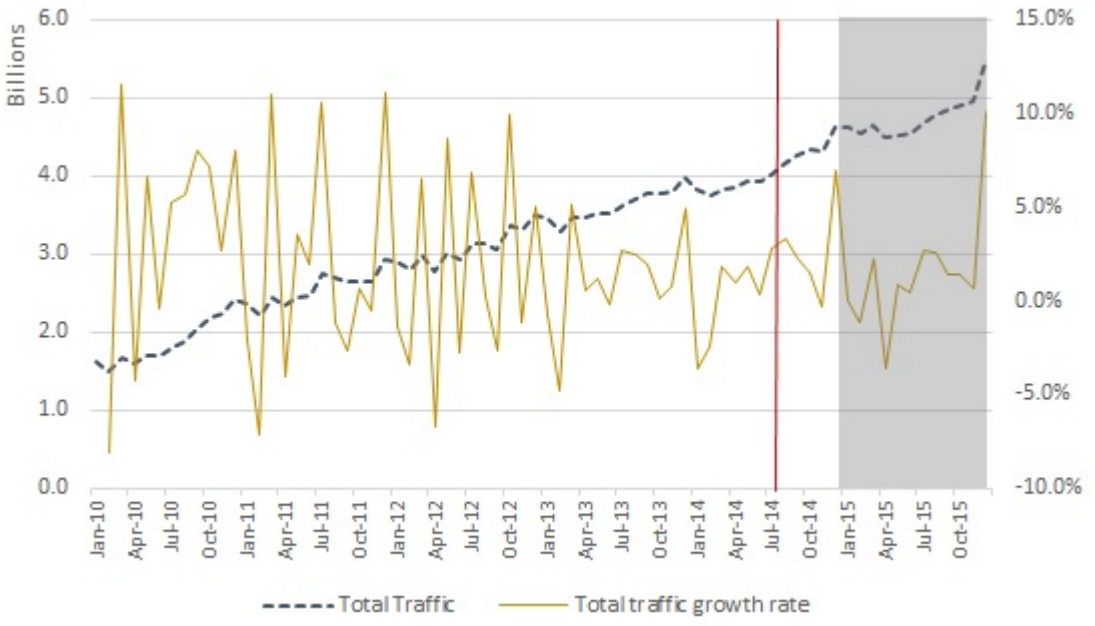


(b) Movistar: Average Revenue Per User

Figure 10: ARPU and average revenue per minute by type of service
Source: Telefonica Moviles - Financial reports



(a) Inbound voice traffic (minutes) and growth rate (%)



(b) Total voice traffic (minutes) and growth rate (%)

Figure 11: Voice traffic level and monthly growth rates (Jan 2010 - Dec 2015
Source: OSIPTEL

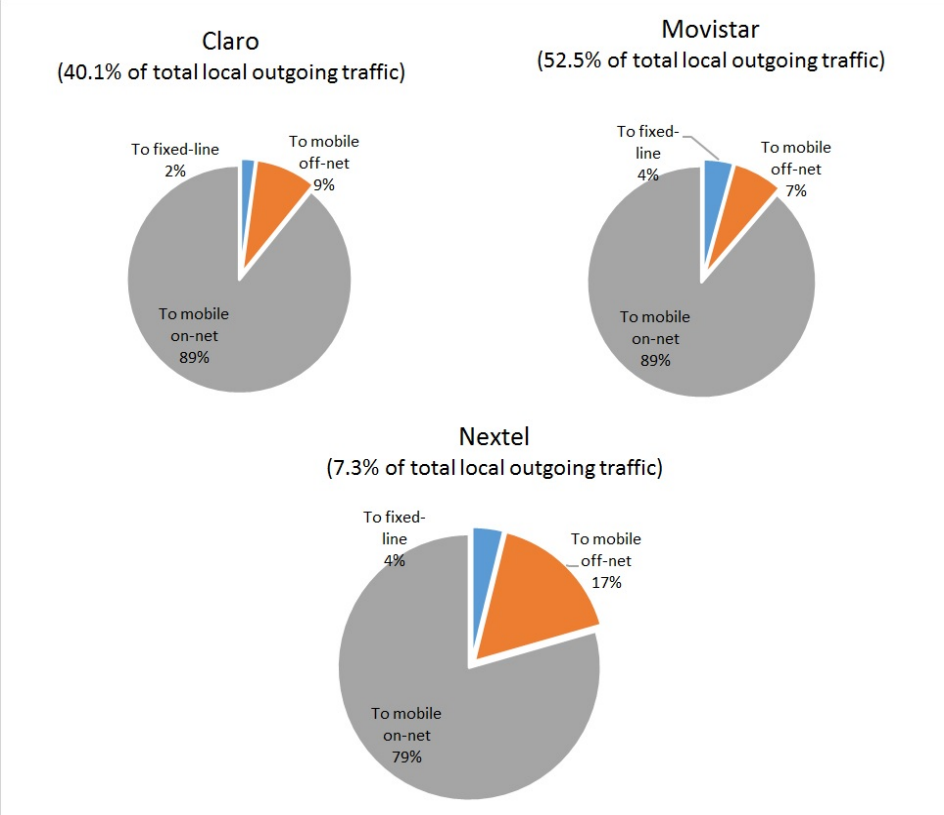


Figure 12: Outgoing local calls' traffic by destination and company (2013)

Source: OSIPTEL

Table 12: Services provided to postpaid/control plan users by company

	2013				2015				
	Movistar	**Claro**	**Nextel**	**Total**	**Movistar**	**Claro**	**Nextel**	**Bitel**	**Total**
Your plan includes:									
NR	0.39	0.95	1.06	0.6	7.07	4.06	2.87	3.58	5.68
voice	9.63	7.6	18.27	9.21	16.65	10.51	4.76	6.55	13.5
voice+SMS	55.25	37.17	29.85	**48.13**	5.76	2.84	0.98	1.19	4.34
voice+SMS+internet	34.73	54.28	50.82	**42.06**	23.64	28.56	32.25	32.24	**26.09**
voice+internet					37.39	41.63	42.5	38.12	**39.24**
SMS+internet					0.49	0.92	3.48	3.19	0.91
Only SMS					0.17	0.04	0.62	0.81	0.17
Only Internet					8.83	11.44	12.55	14.32	10.08
Total	100	100	100	100	100	100	100	100	100
	2,153,298	1,209,536	113,020	3,475,854	3,700,783	2,184,625	526,039	76,271	6,487,718

Note: Number of subscribers are calculated using the expansion factors.
Source: ERESTEL 2013, 2015

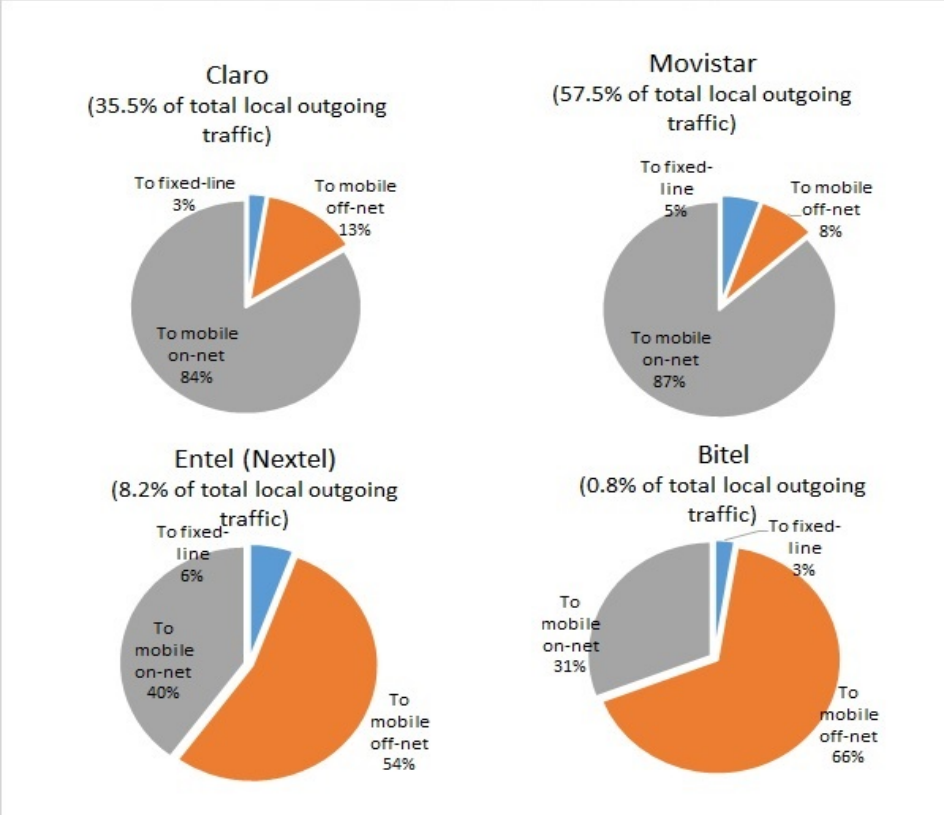


Figure 13: Outgoing local calls' traffic by destination and company (2015)

Source: OSIPTEL

Table 13: Number of mobile phone users switched from/to each company

Current company	Switched from				Total switchers
	NR	Movistar	Claro	Nextel	
Movistar	3,770	30,694	143,399	9,017	186,881
Claro	0	124,050	17,521	5,430	147,002
Nextel	0	9,930	3,802	0	13,732
Total	3,770	164,674	164,722	14,448	347,614
Movistar (%)	2.02	16.42	76.73	4.83	100
Claro (%)	0	84.39	11.92	3.69	100
Nextel (%)	0	72.31	27.69	0	100
Total (%)	1.08	47.37	47.39	4.16	100

Note: Number of subscribers are calculated using the expansion factors.
Source: ERESTEL 2013

Table 14: Willingness to pay for service and handset per type of plan

	Without smarthphone				With smartphone			
	Avg WTP for phoneset (PEN)	Avg WTP phone service (PEN)	Avg monthly income (PEN)	Avg age	Avg WTP for phoneset (PEN)	Avg WTP phone service (PEN)	Avg monthly income (PEN)	Avg age
Prepaid								
Movistar	57.7	12.3	1,140.1	39.1	**78.4**	28.2	1,377.1	29.0
Claro	76.2	11.0	1,166.2	38.9	**109.7**	8.1	1,542.8	29.1
Nextel			1,130.4	38.7			1,443.3	31.5
Postpaid								
Movistar	**105.7**	21.3	1,591.6	42.0	95.1	19.5	2,050.6	33.2
Claro	**83.6**	18.8	1,577.0	40.1	51.7	28.9	2,173.7	32.4
Nextel	200.0	20.0	2,222.8	39.8			2,305.6	35.7

Source: ERESTEL 2013

Table 15: Reasons for switching companies

Reason to switch providers	**Current mobile company**			**Total**	
	Movistar	**Claro**	**Nextel**	**%**	**N°**
NR	0.0	6.0	0.0	3.0	8,696
Price differences	17.5	24.9	0.0	21.0	61,669
Bad customer services	15.3	8.3	0.0	11.8	34,563
Coverage/Mobile signal	20.5	**36.2**	34.8	**28.3**	82,976
New company has digital services	0.0	0.7	0.0	0.3	998
Better and advanced phone sets	2.5	1.4	0.0	1.9	5,629
Induced (gifts)	9.2	9.1	0.0	9.1	26,689
Network effects (family/friends in new network)	**31.8**	12.3	**65.3**	**22.4**	65,711
Other	3.3	1.2	0.0	2.2	6,528
Total	100	100	100	100	293,458
	147,873	144,033	1,553	293,458	

Note: Number of subscribers are calculated using the expansion factors. This information is absent for the year 2013.

Source: ERESTEL 2012

Table 16: Percentage of mobile users by destination of calls and company

	Movistar	Claro	Nextel	Total
Mobile phone calls destination by				
NR	0.01	0.01	0	0.01
Fixed line	4.9	4.79	1.93	4.82
Mobile	94.81	94.98	98.07	**94.92**
LD	0.28	0.22	0	0.26
Total	100	100	100	100

	Movistar	Claro	Nextel	Total
Calls to communicate with:				
NR	0.15	0.12	0	0.14
Family/friends	81.08	82.23	62.66	**81.25**
Job/trade	18.08	17.13	36.86	17.98
Emergencies	0.68	0.53	0.48	0.62
Total	100	100	100	100

Source: ERESTEL 2013

Table 17: Mean of main variables of switcher, no switchers and total mobile phone user

Variables	Loyal	Switcher	Total mobile phone users
Female (=1)	0.50	0.43	0.50
Age (mean)	39.09	36.51	38.94
Evermate (=1)	0.65	0.63	0.64
Urban (=1)	0.83	0.90	0.83
Max. education level	6.56	7.17	6.60
Student (=1)	0.16	0.17	0.16
Working (=1)	0.65	0.74	0.66
Number of household's members	3.93	3.82	3.93
Ratio telecom/total hsh expenditure	0.08	0.09	0.08
Monthly income (PEN)	1250.93	1421.85	1261.53
Monthly expenditure per hsh member	600.62	750.47	609.26
Has fixed-line at house (=1)	0.31	0.41	0.31
User type (call receiver=1, maker=2)	1.41	1.56	1.42
Mobile phone plan (prepaid=1, postpaid/control=2)	1.31	1.51	1.33
Use internet from cellphone/tablet (=1)	0.42	0.53	0.43
Total individual expendture in mobile services (PEN)	32.92	50.95	33.97
Take promotions/sales (yes =1)	0.24	0.29	0.24
Changed mobile phone plan (=1)	0.02	0.05	0.02

Source: ERESTEL 2015

Smartphone Usage and Smartphone owner profile

For this section, I used the information from the Consumer survey on 'Habits, uses and attitudes towards mobile phone services' conducted by a private consulting firm, IPSOS. The survey is conducted yearly since 2012 and contains information of around 1100 individuals with ages between 12 and 70 years. The dataset contains socio-economic information and focuses in the habits and preferences of people when using smartphones. The following results are based on the survey conducted in 2014 to urban areas, and are restricted only to the surveyed population, which consist of 1328 individuals, from who 1180 (89% of surveyed individuals) aged between 12 and 70 years. All of the surveyed individuals own at least a mobile phone. 59.4% of them have Movistar as their network provider; 38.8%, Claro; and 1.78%, Nextel. Likewise, 63.4% of the mobile phone users are under the prepaid mobile service plan; rate that is kept even by network provider, with exception of Nextel, which has 61% of its users under a postpaid service plan. This last feature occurs due to the business scheme of Nextel, which as mobile network provider has targeted mainly the business population and give corporative services.

For the prepaid plan users, the monthly average expenditure on the service is about PEN 20 (which is equivalently to around USD 6.0), but the median monthly expenditure is only PEN 10. These figures are sustained even when are distinguished by provider.

In the case of postpaid users, 77% has data services included. The disaggregation by provider gives better insights, thus only 70% of Movistar's postpaid users has data plan, while 90% of Claro postpaid users has such service. Mobile data services are still small compared to the developed world, 60% of data plan users has data service up to 1GB, and 50% have less than 700MB data plan. Regarding their connection type, people connect to internet from WiFi networks and from mobile Data network at same rate, 20% each.

About the usage of the mobile phone, 35% use it to chat, 33% use SMS, 11% use it to make calls, and 11% use it to enter social network. In the case the individuals cannot contact the person by voice, 53% would use SMS, and 24% just decline to contact the person. Among individuals' priorities, 81% of the users uses their phone to contact family and friends, and only 15% use it for work related purposes.

From the surveyed population, 46.6% declares to have a smartphone, and 98% of them assert they use it as their main mobile phone. Across the network providers (companies), Claro stands as the most successful with smartphone penetration, 55% of its consumers has a smartphone; 43% of Nextel users have a smartphone, and this share declines to 41% in the case of Movistar's users.

Smartphone users usually own their phone set less than a year. Only 30.55% of this group has a smartphone for more than a year, and 22.4% has its smartphone for a period between 10 moths to a year. From all the smartphone users, Movistar has the highest rate (33%) of users with smartphone ownership older than a year. Regarding the operating system (OS) of the smartphone, 74% of smartphone users –that answered to the question– have Android OS, followed by 10% that have Windows mobile.[46]

When asked about the features of an ideal mobile phone, 43% of the 1180 mobile phone users respond the existence of fast processor as main feature, 15% mention a flash camera, and 12%

[46] 67% of the total smartphone users affirm to have Android OS, 10% do not answer the question.

mention long last battery as main feature. Likewise, among the decision variables to buy a mobile phone, the 32% of mobile phone users indicate price as the most important, 31.7% mention the network operator (company), and 16.6% indicated the phone model as decision variable.

Regarding the reason to change mobile phones, 25.5% of the mobile phone users declare because their phone broke, 22% because of mobile phone loss, and 21%, because it was stole. According to the survey, 49.8% of the mobile phone users expect to change their phone in more than 18 months (which is consistent with usual contract time for mobile phone acquisition at any mobile company), 12.8% expect to do it every 18 months, and 26.7%, every year.

Social networks are also present in Peruvians life; based on this surveyed population, 72.7% of the mobile phone users have a Facebook account, and 89% of them declare use it at least once a week. Tweeter have not got full Peruvian attention yet, and that explains why only 24.7% of the mobile users have a tweeter account.

Regarding the surveyed population, 42.5% of respondents declares to work, 17.4% are still in high school, and 15.9% do housework. Only 26.5% of the surveyed population are household head. The maximum level of education of the household head is incomplete non-university superior studies (for 35% of the respondents), complete university education (24.3%), and incomplete high school education (15.2%).

Table 18 shows the distribution of mobile phone users according to their Socioeconomic Level (which based on an index for covered basic needs) that rank population into SEL-A (high income level), SEL-B (mostly medium class level), SEL-C or lower (lower income level). It is shown that Mobile phone users belong mostly to SEL-C (29.7%) and lower SEL (35.5%), 20% belong to SEL-B and the remaining 14.4% belong to the high income level SEL-A. People form high and upper middle (B1) income level are in general postpaid users. In the case of mobile phone users with lower middle (B2) income level or lower, the structure change and users tend to be under a prepaid plan (the gap is accentuated with lower income level). It is important to note that among postpaid users, consumers of SEL-C account for the second largest group (after the SEL-A consumers) with 26%, this would be the case due to independent workers (that run their own micro economic activity, like taxi drivers, hairdressers, etc.) belong to this income level. Firms know this, and that explain why the largest portion of their users belong to SEL-C as well.

Table 18: Mobile phone user's distribution according to their socioeconomic Level, by mobile service plan and network provider

	Mobile phone service plan			**Mobile Network provider**			
	Prepaid (%)	**Postpaid (%)**	**Total (%)**	**Movistar (%)**	**Claro (%)**	**Entel/Nextel (%)**	**Total (%)**
A (High income)	47	123	170	91	76	3	170
	(27.65)	**(72.35)**	(100.0)	**(53.53)**	(44.71)	(1.76)	(100.0)
	(6.28)	(28.54)	(14.41)	(12.98)	(16.59)	(14.29)	(14.41)
B1	39	67	106	57	49	0	106
	(36.79)	(63.21)	(100.0)	(53.77)	(46.23)	(0.0)	(100.0)
	(5.21)	(15.55)	(8.98)	(8.13)	(10.70)	(0.0)	(8.98)
B2	78	56	134	86	44	4	134
	(58.21)	(41.79)	(100.0)	(64.18)	(32.84)	(2.99)	(100.0)
	(10.41)	(12.99)	(11.36)	(12.27)	(9.61)	(19.05)	(11.36)
C	238	112	350	199	144	7	350
	(68.0)	(32.0)	(100.0)	(56.86)	(41.14)	(2.0)	(100.0)
	(31.78)	(25.99)	(29.66)	(28.39)	(31.44)	(33.33)	(29.66)
D	172	46	218	137	77	4	218
	(78.90)	(21.10)	(100.0)	(62.84)	(35.32)	(1.83)	(100.0)
	(22.96)	(10.67)	(18.47)	(19.54)	(16.81)	(19.05)	(18.47)
E (Very low income)	175	27	202	131	68	3	202
	(86.63)	(13.37)	(100.0)	**(64.85)**	(33.66)	(1.49)	(100.0)
	(23.36)	(6.26)	(17.12)	(18.69)	(14.85)	(14.29)	(17.12)
Total	**749**	**431**	**1,180**	**701**	**458**	**21**	**1,180**
	(63.47)	(36.53)	(100.0)	(59.41)	(38.81)	(1.78)	(100.0)
	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Source: IPSOS survey 2014