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PRO-COMPETITIVE REGULATORY POLICIES FOR POST-PAID AND PRE-PAID MOBILE PHONE MARKETS

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ABSTRACT: *There are two types of switching costs when users change their mobile operator. The first stems from price discrimination when the network charges a lower price for on-net than for off-net calls. If the majority of the switching user's contacts are in their current network, this imposes an obstacle to changing the network, since in the new network they would have to pay a higher price for off-net calls. The other switching cost results from the switching user having to inform all their contacts about their new number in the other network. Mobile phone number portability (NP) reduces this switching cost.*

This paper's aim is to determine pro-competitive regulatory policies for the post-paid and pre-paid market segments. This distinction is important since the post-paid

market dominates in developed countries, while in less developed countries the pre-paid market dominates.

There are two operators in our model, the incumbent and a new entrant. In the post-paid market, NP reduces the level of market concentration. In the pre-paid market, NP has no impact on the convergence of market shares, and the reduction of access charges (the fee for terminating calls in the rival network) turns out to be a pro-competitive regulatory policy. There is no need for asymmetric access regulation where the incumbent pays higher access charges than the new entrant.

KEY WORDS: *Network competition, call externalities, switching costs, access pricing, price discrimination.*

JEL CLASSIFICATION: L14, L96

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1. INTRODUCTION

Mobile telephony is one important case of network externalities where the user's utility increases with the total number of users. The market can only exist and firms can only remain in the market when there are a sufficient number of users. Therefore, reaching the critical mass of users is a very important aspect of competition and firms use different strategies to reach the critical mass, such as providing service below cost. In many markets this behaviour is deemed to be anti-competitive, but in markets with network effects this has the potential to increase competition.

An access charge is the fee that operator A pays to operator B for calls that start from A's network and terminate in B's network. Regulators in some countries use asymmetric access regulation such that the incumbent pays a higher access charge to the entrant than the entrant pays to the incumbent. The objective of this policy is to help the entrant gain a market share. However, we will see that in post-paid and pre-paid markets, asymmetric access regulation is not necessary to achieve pro-competitive regulatory objectives.

In this paper we consider switching costs in the mobile telephony communications market. When switching costs exist, users are locked into their current operator, who can profitably exploit this situation by charging higher prices.¹ In other words, switching costs give market power to firms. In this particular market there are explicit and implicit switching costs. The most important explicit switching cost comes from the user who changes network having to inform all their contacts about their new number. This is particularly costly for business users, who may miss calls from potential business partners. In order to reduce this switching cost, regulators have enforced mobile phone number portability (NP). This policy was first adopted in Singapore in 1997. The first countries in Europe to use this policy were the Netherlands and the UK in 1999. In 2002 the European Commission issued a directive that all member states should implement NP. The last EU countries to adopt this policy were Bulgaria and Romania in 2008, while Serbia introduced NP in 2011. There are empirical as well as theoretical papers that analyse the effects of this policy. Some papers claim that it can turn out to be anti-competitive, which was the case in Hong Kong, which used two-part tariffs consisting of a fixed subscription fee and per minute prices that were higher for off-net calls. In cases like this, with the reduction of switching costs the users of a small network may

¹ See Klemperer (1995) for a survey on switching costs.

decide to join a large network to benefit from on-net discounts. However, nowadays operators' pricing strategies are quite different. Post-paid users pay a subscription fee for a package that contains a certain number of minutes that can be used for on-net and off-net calls, and these users rarely need to pay additional minutes because they can always subscribe to a sufficiently large package. This fact rules out the on-net discount benefit of the large network and makes NP portability pro-competitive.

Empirical evidence from the Serbian market after the enforcement of NP in 2011 reveals that the share of ported numbers is constantly increasing. 0.77% of all users used the NP option in 2012, 0.98% in 2014, and over 1% in 2015. The market share and profit of the largest operator declined, while for the smallest operator they increased, which suggests that NP was pro-competitive. At the same time, operators increased the number of on-net minutes available in their packages, which benefitted users.

Pre-paid users are more exposed to the implicit form of switching costs in the form of price discrimination. They do not pay a subscription fee but per-minute prices that are higher for off-net calls. It is costly for users to change network if most of their contacts are in their current network, since they will have to pay higher off-net prices. For this subset of users, on-net discounts still play an important role, and in this market segment the reduction of switching costs in the form of NP is less likely to have a pro-competitive effect. The regulator's best strategy to reduce switching costs in the pre-paid market is to reduce the degree of price discrimination.

Our modelling approach is similar to that of Shi, Chiang, and Rhee (2006), except that we analyse two market segments, post-paid and pre-paid, and use different pricing strategies. In the initial situation there are two operators in the market, one large (incumbent) and one small (entrant). Users have uniformly distributed switching costs: users with low switching costs change their operator while users with high switching costs stay with their current operator and updated market shares are calculated. Half of the users are in the pre-paid market and half in the post-paid market.

Our model aims to determine pro-competitive regulatory policies for post-paid and pre-paid markets. We have assumed that operators use pricing strategies that are observed in real markets: post-paid users pay a fixed subscription fee and pre-paid users pay per-minute prices. In contrast to the previous literature,

where the user's utility is represented by an indirect utility function, we use a direct utility function for post-paid users since their utility depends on the number of minutes available. We will see that in the post-paid market, reduction of switching costs in the form of NP benefits the small operator and there is no need for asymmetric access regulation where the incumbent pays a higher access charge than the entrant.

Pre-paid users maximise indirect utility because they care about per minute prices and benefit from call externalities by receiving free calls from other users. This effect is more important for pre-paid than post-paid users because of their lower purchasing power. Pre-paid users face price discrimination and pay higher prices for off-net calls. The operator's profit-maximising price for both on-net and off-net calls is higher than the marginal cost of providing the service. This result differs from the previous literature in that it is based on two-part tariffs where per-minute prices equal marginal costs and the operator's profit comes from the subscription fee. In the absence of a subscription fee the operator can only make profit by charging a per-minute price that is higher than the marginal cost. Reduction of switching costs by NP has no impact on these users and NP can never improve the market position of a small operator in the pre-paid market. The most important part of the switching cost for the pre-paid user stems from price discrimination; the regulator can achieve the objective of converging market shares by reducing access charges, and the necessary reduction of access charges is higher when the incumbent's initial market share is larger. Our result rules out the necessity of using asymmetric access regulation to reduce the level of concentration in both post-paid and pre-paid markets.

Our model has different policy implications for reducing switching costs in the post-paid and pre-paid market segments. The data on the shares of these users in different countries is interesting. At the end of 2013, 77% of users worldwide were pre-paid and 23% were post-paid.² In general, in more developed countries the share of post-paid users is much larger than in less developed countries. Between the end of 2013 and the end of 2016 the share of post-paid users increased marginally in Africa and Asia but significantly in Europe, North America, and Australia. Poor countries in Africa, Asia, and South America remain at the bottom of the list regarding the share of post-paid users.

² All data on the share of these two market segments is from Wireless Market Statistics (2015), https://www.globalrewardsolutions.com/wp-content/uploads/GRS-Mobile-Top-up_Wireless-Market-Statistics-2015.pdf.

North America has the largest share of post-paid users at 75%, followed by Europe with 50% (all data refers to the end of 2013). Within Europe the share of post-paid users reaches 75% in north-western countries and only 40% in south-eastern countries. In Latin America 20% are post-paid users, in northern Africa only 6%, and in Sub-Saharan Africa 4%. The share of post-paid users in the Middle East is 12%, in South Asia (India, Pakistan, and Afghanistan) 5%, and in China and Southeast Asia 15%. The highest share of post-paid users worldwide is 87% in Japan, South Korea, and Oceania.

The rest of the paper is organised as follows. The second section reviews the literature on switching costs in mobile phone markets. The third section gives a brief overview of switching costs in the Serbian market. The fourth section presents the results for the role of switching costs in post-paid and pre-paid markets. The fifth part presents the implications for regulatory policy based on the results of the theoretical model. The last section concludes the discussion.

2. LITERATURE REVIEW

The seminal paper by Laffont, Rey, and Tirole (1998a) uses Hotelling's model of spatial competition to formalise competition between two operators and considerably enriches the literature on network externalities in mobile phone telecommunications. Operators have marginal costs of on-net calls and off-net calls. For the latter type of call from network A to network B, operator A pays a per-minute access charge to operator B. If operators charge the same price for on-net and off-net calls the equilibrium price is characterised by a double mark-up over marginal cost. Because on-net and off-net call costs are different, operators price-discriminate and charge higher prices for off-net calls. Laffont, Rey, and Tirole (1998b) study the problem of price discrimination. According to Calzada and Valletti (2008) the access charge can also serve as a means to deter entry. When incumbents face a possible entrant they may increase their access charge and off-net price to deter entry. Hoering (2007) considers call externalities that exist when a user of one network benefits from receiving free calls from a user of another network. The entrant's users benefit from call externalities by receiving calls from the incumbent's network and the incumbent setting a higher off-net price than the entrant is an attempt to internalise call externalities, and might not reflect predatory behaviour.³

³ For more detailed discussion of these models, see Trifunović and Mitrović (2016a)

In the case of symmetric access charges the incumbent and the entrant charge the same access charge. The regulator may impose asymmetric access charges such that the incumbent's upper access charge bound is lower than the entrant's. Peitz (2005) analyses this policy and finds that this form of regulation increases the consumer's surplus and slightly reduces welfare. de Bijl and Peitz (2004) study the effects of this policy in a dynamic context.⁴

The second avenue of research is related to the switching costs that give market power to operators. Gabrielsen and Vagstad (2008) consider the implicit form of switching costs that stem from price discrimination. If users make most of their calls to friends and family that subscribe to the same network they will have considerable switching costs if they join another network, as they will have to make more expensive off-net calls. The other form of explicit switching cost stems from the fact that users need to change their number when they change network. Regulators introduced NP to reduce this cost and to enable users to keep their old number in the new network. Nevertheless, Shi, Chiang and Rhee (2006) find that this policy has some paradoxical effects if operators use two-part tariffs consisting of a fixed subscription fee and per-minute prices that are higher for off-net calls. In this context NP may turn out to be anti-competitive, since users may wish to join a large network and benefit from on-net discounts. This is exactly what happened in the Hong Kong market with NP where operators used two-part tariffs. The market share and profit of the largest operator increased and the same variables of the smallest operator were reduced.

Doganoglu and Grzybowski (2013) obtain a completely different result with a two-period model where the level of both network externalities and switching costs can be varied. There are two operators in the market, one large and one small. After a time, a group of users leaves the market and is replaced by new users that have to choose an operator. The second group of users changes its preferences after a time and switches operator, as it has low switching costs. The third group of users maintains its preferences and has high switching costs, meaning that it stays with its current operator. Doganoglu and Grzybowski (2013) show that increased switching costs benefit the firm with the larger market share in the first period, while an increased level of network externalities reduces the profits of the dominant firm.

⁴ Carter and Wright (2003) also analyse optimal access charges with asymmetric competitors.

Bühler and Haucap (2004) also claim that NP reduces switching costs and benefits consumers. However, if users port their number to a new network the users that call them are not sure which network they are calling. Because on-net calls are cheaper than off-net calls, operators may profit from asymmetric information by increasing access charges, making users worse off. Therefore, NP may increase as well as reduce total welfare, depending on which effect dominates. In order to diminish the latter effect the regulator should set the upper bound for access charges so that NP is welfare-improving.

The aim of Lee et al.'s (2006) empirical analysis is to determine the exact level and source of switching costs in the South Korean market. They find that the main source of switching costs is the need to change the phone number. However, other sources of switching costs remain even when NP is applied. The total cost of switching was estimated as US \$24–34 and the operator that aims to attract new users sells cheaper phones and subsidises user switching. When the Korean market was growing rapidly and operators wanted to attract new users this behaviour was particularly observed, with the objective of more than compensating for the subsidy in the future by exploiting locked-in users.

Based on UK data, Grzybowski (2008) finds that switching costs are heterogenous among networks and among user characteristics such as age, with older users having higher switching costs. Using data on the Spanish market, Maicas, Polo, and Sese (2009) get similar results: older people have higher switching costs and women have higher switching costs than men. Users that have subscribed longer to a particular network have higher switching costs. Furthermore, post-paid users have higher switching costs than pre-paid users. Switching costs increase a business's market power and NP reduces these costs, but even after this policy is enforced, switching costs persist.

Park (2011) studies the impact of NP in the US market. He finds that NP reduced the package price, but the price reduction was proportionally higher for more expensive packages. Also, dispersion of subscription fees for different operators' packages containing a similar number of minutes was especially reduced for more expensive packages, indicating fiercer competition. The second observation is that the average number of minutes in the package was increased and a larger number of minutes for the same fee can be considered a price reduction.

Sanchez and Asimakopoulos (2012) conduct a cross-country study related to NP for the EU. The share of ported numbers (churn rate) varies in different countries and in 2008 this share was the highest in Finland (68.7%). The effect of NP also depends on the porting period (number of days needed to port a number): the longer this period is the lower the effectiveness of NP. The second factor related to NP is the portability fee that users have to pay when they switch network, with similar effects on the effectiveness of NP. They also find that the churn rate is higher in markets where the number of users has a lower growth rate.

Per-minute prices fall constantly with technological innovation, and the aim of Cho, Ferreira, and Telang's (2013) empirical and theoretical study is to distinguish how much price reduction was a consequence of NP. They calculate the average price by dividing the average revenue per user by the number of minutes used and find that the average price fell by 8,7% due to NP, and that a longer porting time and a higher porting fee reduced this price reduction. Moreover, followers in the market reduced their NP prices more than incumbents, with the aim of attracting users from the incumbent. Additionally, NP reduced market concentration and price dispersion. The paper adds to previous research by measuring precisely the increase in the consumer's surplus. They find that the consumer's surplus increased by 2.86 euros per person after NP was enforced.

3. THE SERBIAN MARKET

In this section we will briefly describe the structure of the Serbian market and the impact of NP. This empirical survey motivated our theoretical considerations.⁵

In the Serbian market there are three mobile telephony operators: MTS, Telenor, and VIP. The first two operators were market incumbents, and VIP entered in 2006. The market growth rate was very high until 2008 and then much slower from 2009 until 2011; the market stabilised at 10.1 million users in 2011 and subsequent years. The state-owned company, MTS, was the largest operator in the market until between 2009 and 2014 it lost 1.4 million users (or 23.54%) while its competitors increased their number of users – Telenor by

⁵ A more detailed analysis of the Serbian market is presented in Trifunović and Mitrović (2016b).

18.75% and VIP by 95.79%. If we measure market share by total revenue, Telenor became the market leader in 2011 with MTS as the second largest operator, followed by VIP.

Due to the entry of VIP and the introduction of NP in 2011 the market concentration, measured by the Herfindahl-Hirschman Index (HHI), is constantly falling. Since the enforcement of NP the market share of MTS, the operator with the largest number of users, has reduced, while the market share of VIP, the operator with the smallest number of users, has increased. This might suggest that NP was pro-competitive in Serbia. In response to the reduced switching costs, operators aimed to increase the share of post-paid users.

After NP was introduced the financial performance (measured by EBITDA) of MTS, the largest operator by number of users, shows a downward trend, while the performance of VIP, the operator with the lowest number of users, shows an upward trend. This finding might also suggest that NP was a pro-competitive policy. NP also had a substantial impact on the number of minutes offered in post-paid packages.

4. THE MODEL

This section presents the model for studying the impact of switching costs on post-paid and pre-paid users, with the aim of providing pro-competitive regulatory policies. These two groups are considered separately because of the different ways they are charged for the service: post-paid users pay a fixed subscription fee while pre-paid users pay per-minute prices. We also consider these two markets separately because the proportions of these users depend on a country's level of economic and technological development.

4.1. Post-paid users

We assume that there are two operators in the market: large operator A (incumbent) and small operator B (entrant).⁶ There are a finite number of users in the unit interval and the size of the market is normalised at 1. The initial market shares are θ_A and θ_B . Post-paid users can subscribe to a sufficiently

⁶ Our modelling approach relies on Shi et al. (2006). The model in this section is similar to their model, but some assumptions and the implications are different due to the fact that we use direct utility instead of indirect utility. The results and assumptions for the pre-paid market are quite different.

large package so that they do not need to pay additional per-minute prices. Even if they use all the package minutes they can buy additional minutes for a fixed fee. Post-paid users that subscribe to network i pay a subscription fee F_i and for the fixed subscription fee these users obtain a certain number of on-net and off-net minutes that can be spent in a month. We will denote the available number of on-net minutes in a package offered by operator i by q_{ii} , and the number of off-net minutes by q_{ik} . The users' direct utility functions from on-net and off-net calls are $u(q_{ii}) = u_{ii}$ and $u(q_{ik}) = u_{ik}$. The users' total utility is influenced by network externalities and the subscription fee:

$$v_i = \alpha_i u_{ii} + (1 - \alpha_i) u_{ij} - F_i, \quad (1)$$

where α_i is the updated market share that will be defined below. Users have rational expectations and they anticipate future market shares in equilibrium. If users switch from network i to network k its switching cost is ψ_{ik} and this cost is uniformly distributed in the interval $[0, \Psi]$. We will assume that half of the users are post-paid users, and the other half are pre-paid users. Therefore, $\theta_A + \theta_B = 1/2$, and $\theta_A > \theta_B$ (A is the large operator). The threshold value that makes the user indifferent between staying with network i and switching to network k is ψ_{ik}^* , and this is the value of the switching cost for the marginal user. Users who have switching costs lower than ψ_{ik}^* will switch from network i to network k , while users with higher switching costs will stay with network i . We will suppose that marginal users initially subscribe to network i , which implies that some users of network i will switch to network k , while all users of network k remain in that network. Therefore, if users switch from network i to network k , their utility is $v_k - \psi_{ik}$. The switching cost of the marginal user is:

$$\psi_{ik}^* = v_k - v_i = \alpha_k (u_{kk} - u_{ik}) + (1 - \alpha_k) (u_{ki} - u_{ii}) + F_i - F_k. \quad (2)$$

Users have different switching costs and mobile phone number portability reduces the maximal amount of switching cost Ψ . The reduced switching cost is captured by the lower value of Ψ , which has two effects: it reduces the average value of switching costs for all users, and users become more homogenous with respect to their switching costs.

Because some users of network i switch to network k , while all users of network k remain in that network, and because the switching cost is uniformly distributed, updated market shares can be calculated as follows:

$$\alpha_k = \theta_k + \frac{\psi_{ik}^*}{\Psi} \theta_i, \quad \alpha_i = \theta_i - \frac{\psi_{ik}^*}{\Psi} \theta_i, \quad (3)$$

where network k 's updated market share is larger than its initial market share, and consequently i 's market share is lower. By substituting the switching cost of marginal users in (3) we obtain:

$$\alpha_k = \frac{\Psi \theta_k + \alpha_k (u_{kk} - u_{ik}) \theta_i + (1 - \alpha_k) (u_{ki} - u_{ii}) \theta_i + (F_i - F_k) \theta_i}{\Psi}. \quad (4)$$

Solving the last equation with respect to α_k we obtain:

$$\alpha_k = \frac{\Psi \theta_k + (u_{ki} - u_{ii}) \theta_i + (F_i - F_k) \theta_i}{\Psi - (u_{kk} + u_{ii} - u_{ik} - u_{ki}) \theta_i}, \quad (5)$$

In the same fashion we can obtain the equilibrium market share for operator i :

$$\alpha_i = \frac{\Psi \theta_i - (u_{kk} - u_{ik}) \theta_i - (F_i - F_k) \theta_i}{\Psi - (u_{kk} + u_{ii} - u_{ik} - u_{ki}) \theta_i}, \quad (6)$$

and suppose that $\Psi - (u_{kk} + u_{ii} - u_{ik} - u_{ki}) \theta_i > 0$ to obtain positive market shares.

Operators also have rational expectations and the total revenue of operator i is the product of the number of subscribers and the fixed subscription fee:

$$R_i = \alpha_i F_i, \quad (7)$$

and the first-order condition with respect to F_i yields:

$$\theta_i \Psi - (u_{kk} - u_{ik}) \theta_i + F_k \theta_i - 2F_i \theta_i = 0. \quad (8)$$

This equation defines the best response function, $F_i = f(F_k)$. The total revenue of operator k is $R_k = \alpha_k F_k$ and the first-order condition with respect to F_k gives:

$$\Psi \theta_k + (u_{ki} - u_{ii}) \theta_i - 2F_k \theta_i + F_i \theta_i = 0. \quad (9)$$

The solution to this system is:

$$F_k = \frac{1+\theta_k}{3\theta_i} \Psi + \frac{(2u_{ki}-2u_{ii}-u_{kk}+u_{ik})}{3}, \quad (10)$$

$$F_i = \frac{1+\theta_i}{3\theta_i} \Psi + \frac{(u_{ki}-u_{ii}-2u_{kk}+2u_{ik})}{3}, \quad (11)$$

$$F_i - F_k = \frac{\theta_i - \theta_k}{3\theta_i} \Psi + \frac{u_{ik} - u_{ki} + u_{ii} - u_{kk}}{3}. \quad (12)$$

Bu using (12) in (5) and (6), we obtain the updated equilibrium market shares:

$$\alpha_k = \frac{(1+\theta_k)\Psi + 2(u_{ki}-u_{ii})\theta_i + (u_{ik}-u_{kk})\theta_i}{3(\Psi - (u_{kk}+u_{ii}-u_{ik}-u_{ki})\theta_i)}, \quad (13)$$

$$\alpha_i = \frac{(1+\theta_i)\Psi - 2(u_{kk}-u_{ik})\theta_i - (u_{ii}-u_{ki})\theta_i}{3(\Psi - (u_{kk}+u_{ii}-u_{ik}-u_{ki})\theta_i)}. \quad (14)$$

Now suppose that $i = A$ and $k = B$, which implies that users switch from the large to the small network; and recall that according to the initial conditions $\frac{1}{2} > \theta_A > \theta_B > 0$. If the large operator is losing its market share, its updated market share is lower than its initial market share, $\alpha_A < \theta_A$:

$$\alpha_A = \frac{(1+\theta_A)\Psi - 2(u_{BB}-u_{AB})\theta_i - (u_{AA}-u_{BA})\theta_A}{3(\Psi - (u_{BB}+u_{AA}-u_{AB}-u_{BA})\theta_A)} < \theta_A, \quad (15)$$

$$\Psi(1-2\theta_A) < (u_{BB}-u_{AB})\theta_A(3\theta_A-2) + (u_{AA}-u_{BA})\theta_A(3\theta_A-1). \quad (16)$$

Because operators provide additional minutes in a package for on-net calls when all minutes for on-net and off-net calls are used, it is logical to assume that $u_{AA}-u_{BA} > 0$ and $u_{BB}-u_{AB} > 0$. Suppose, further, that both operators provide

the same number of minutes in a package, such that $u_{AA} - u_{BA} = u_{BB} - u_{AB} = \Delta u$. With these assumptions the last equality reduces to:⁷

$$\Psi < 3\Delta u\theta_A. \quad (17)$$

This clearly implies that the reduction of switching costs reduces the left-hand side of (17) and is pro-competitive in the post-paid market. There is no need for asymmetric access regulation to increase the entrant's market share.

4.2. Pre-paid users

In this section we consider how switching costs affect pre-paid users in a market where A is again the large operator and B the small operator. Half of the users are pre-paid users. Therefore, $\theta_A + \theta_B = 1/2$, and $\theta_A > \theta_B$.

In the pre-paid market, operators price discriminate and users pay a higher price for off-net than for on-net calls, $p_{ik} > p_{ii}$, and make more on-net calls such that $u(p_{ii}) > u(p_{ik})$, where $u(\cdot)$ is indirect utility. Users also benefit from call externalities⁸ by receiving free calls. The utility from receiving calls is smaller than the utility from making calls, and the parameter $0 < \beta < 1$ measures this lower level of utility. The total utilities of users that subscribe to networks i and k are:

$$v_i = \alpha_i u_{ii} + \alpha_k u_{ik} + \beta \alpha_i u_{ii} + \beta \alpha_k u_{ki}, \quad (18)$$

$$v_k = \alpha_k u_{kk} + \alpha_i u_{ki} + \beta \alpha_k u_{kk} + \beta \alpha_i u_{ik}, \quad (19)$$

where the first two terms measure the utility of making on-net and off-net calls and the last two elements capture the utility from receiving on-net and off-net calls.

The operators do not charge a subscription fee to the segment of pre-paid users, and users pay per-minute prices that are higher for off-net traffic. The marginal cost of on-net calls is denoted by c and the access charge by a . Thus, ac is the

⁷ Note that we have assumed that $\dots \Psi > 2\Delta u\theta_A \dots$ for market shares is positive, and the equilibrium where the large operator loses market share exists when $2\Delta u\theta_A < \Psi < 3\Delta u\theta_A$.

⁸ Post-paid users also benefit from call externalities, but these externalities are more important for pre-paid users, who have lower purchasing power.

marginal cost of off-net calls. Equilibrium prices can be obtained by maximising the profit of operator i :

$$\Pi_i = \alpha_i(p_{ii} - c)q_{ii}(p_{ii}) + (1 - \alpha_i)(p_{ik} - ac)q_{ik}(p_{ik}). \quad (20)$$

The first-order condition with respect to on-net price gives:

$$q_{ii}(p_{ii}) + (p_{ii} - c)q'_{ii}(p_{ii}) = 0, \quad (21)$$

$$p_{ii} = c - \frac{q_{ii}(p_{ii})}{q'_{ii}(p_{ii})} > c. \quad (22)$$

This result shows that the equilibrium on-net price is higher than the marginal cost of on-net calls, which differs from previous research on two-part tariffs (Shi et al. 2006) where the equilibrium price is equal to the marginal cost and the profit stems from the subscription fee. In our setup there is no subscription fee for pre-paid users and the operator profits by charging a higher price than the marginal cost.

In the same fashion, the first-order condition with respect to the off-net price gives:

$$p_{ik} = ac - \frac{q_{ik}(p_{ik})}{q'_{ik}(p_{ik})} > ac, \quad (23)$$

and the off-net price is higher than the marginal cost of the off-net call.

We will now determine when the small network can increase its market share in the pre-paid user segment. The switching cost of the marginal user who switches from network i to network k is:

$$\psi^*_{ik} = v_k - v_i = \alpha_k(u_{kk} + \beta u_{kk} - u_{ik} - \beta u_{ki}) + (1 - \alpha_k)(u_{ki} + \beta u_{ik} - u_{ii} - \beta u_{ii}). \quad (24)$$

The updated market share of operator k that increases its market share is:

$$\alpha_k = \theta_k + \frac{\psi^*_{ik}}{\Psi} \theta_i, \quad (25)$$

$$\alpha_k = \frac{\Psi\theta_k + \alpha_k(u_{kk} + \beta u_{kk} - u_{ik} - \beta u_{ki})\theta_i + (1 - \alpha_k)(u_{ki} + \beta u_{ik} - u_{ii} - \beta u_{ii})\theta_i}{\Psi}, \quad (26)$$

$$\alpha_k = \frac{\Psi\theta_k + (u_{ki} + \beta u_{ik} - u_{ii} - \beta u_{ii})\theta_i}{\Psi - (1 + \beta)(u_{kk} + u_{ii})\theta_i + (1 - \beta)(u_{ki} - u_{ik})\theta_i}. \quad (27)$$

The updated market share of operator i whose market share decreases is:

$$\alpha_i = \frac{\Psi\theta_i - [(1 + \beta)u_{kk} + \beta u_{ki} + u_{ik}]\theta_i}{\Psi - (1 + \beta)(u_{kk} + u_{ii})\theta_i + (1 - \beta)(u_{ki} - u_{ik})\theta_i}. \quad (28)$$

Now, if $i = A$ and $k = B$, large operator A 's market share decreases when its updated market share is lower than the initial market share:

$$\alpha_A = \frac{\Psi\theta_A - [(1 + \beta)u_{BB} + \beta u_{BA} + u_{AB}]\theta_A}{\Psi - (1 + \beta)(u_{BB} + u_{AA})\theta_A + (1 - \beta)(u_{BA} - u_{AB})\theta_A} < \theta_A. \quad (29)$$

$$\theta_A < \frac{(1 + \beta)u_{BB} + \beta u_{BA} + u_{AB}}{(1 + \beta)(u_{AA} + u_{BB}) - (1 - \beta)(u_{BA} - u_{AB})}. \quad (30)$$

If the regulator imposes symmetric access regulation, such that $u_{AB} = u_{BA}$, the above condition is reduced to:

$$\theta_A < \frac{u_{BB} + u_{AB}}{u_{BB} + u_{AA}} < 1. \quad (31)$$

Observe that Ψ does not appear in (31) and that the reduction of switching costs due to NP does not affect market shares in the pre-paid market. Note also that condition (31) is independent of the level of call externalities. Call externalities can have an impact on the intensity of competition only in the case of asymmetric access regulation. The right-hand side of (31) is increasing in $u_{AB} = u_{BA}$ (these utilities are a decreasing function of off-net prices), which means that reduction of access charges is the policy that acts pro-competitively in the pre-paid market. It can be inferred from (31) that the higher the incumbent's initial market share, the higher the necessary reduction of access charges. Therefore, in the pre-paid market, NP has no impact on the convergence of market shares, and this objective can be achieved by lowering

the level of access charges. This result rules out the necessity of using asymmetric access regulation in the pre-paid market. Although asymmetric access regulation is used in some countries to help entrants to reach a critical mass of users, this policy has not been proven effective in practice, which we discuss in the following section.

Condition (31) also implies that the incumbent can reduce its on-net price (increase u_{AA}) and make this condition less likely to hold. By finding the partial derivative of (31) with respect to u_{BB} we can determine that:

$$\frac{u_{AA} - u_{AB}}{(u_{BB} + u_{AA})^2} > 0, \quad (32)$$

which means that the entrant has an incentive to reduce its prices to increase its market share. This behaviour is observed in reality where the data shows a rapid reduction of on-net prices for pre-paid users.

5. IMPLICATIONS FOR REGULATORY POLICY

We have studied pro-competitive regulatory policies for two separate market segments, in contrast to previous literature that is based on the integral treatment of these markets, so possibly blurring their peculiarities and resulting in suboptimal policies.

Sidak, Vassallo, and Sabetti's (2015) interesting empirical research is related to our model. They study the impact of asymmetric access regulation on entrants to the market. According to the European Commission, the regulator can impose asymmetric access charges, limited to a 4-year period, until the entrant reaches a critical mass of users (estimated to be between 15% and 20% of the market).

Sidak, Vassallo, and Sabetti (2015) claim that asymmetric access regulation reduces the incentive for less efficient competitors to reduce their costs. The second concern relates to the so-called 'waterbed effect' identified by Schiff (2008) and Genakos and Valetti (2011). This effect exists when the incumbent increases the prices of its services to compensate for the lower access charge that it receives for calls terminating on its network. Genakos and Valetti (2011) determine that for the dominant operator a 10% reduction in the access charge triggers a 5% price increase for users of its network.

Based on these theoretical foundations, Sidak, Vassallo, and Sabetti (2015) analyse empirically the impact of symmetric and asymmetric access charges on the evolution of entrants' market shares. The countries in their sample that have adopted asymmetric access charges are Austria, Belgium, Denmark, Finland, Germany, Hungary, Ireland, Italy, Netherlands, Switzerland, and the UK. The control sample consists of countries that use symmetric access charges: Australia, Brazil, Chile, Columbia, Czech Republic, Hong-Kong, Israel, Philippines, Portugal, Singapore, South Africa, Spain, Sweden, and Turkey.

The main finding of the paper is that asymmetric access regulation does not give an advantage to entrants compared to symmetric access regulation. Moreover, entrants in the system of symmetric access regulation gain a slightly higher market shares than entrants in the system of asymmetric access charges. The results of this empirical research are aligned with the findings of our model.

We analyse post-paid and pre-paid markets separately. For the post-paid market we have determined that the main source of switching costs is number portability and this policy acts pro-competitively.

In the pre-paid market with symmetric access regulation we have identified that in a market with a dominant operator, lowering access charges can reduce switching costs, and the reduction of access charges is an increasing function of the incumbent's market share. Our results show that asymmetric access regulation is not necessary in post-paid and pre-paid markets and that a lower level of market concentration can be achieved by symmetric access regulation.

In the empirical research of Sidak, Vassallo and Sabetti (2015) the sample of countries that have adopted asymmetric access regulation consists of highly developed countries where the share of pre-paid users is very small. In our model we have proved that in the-post paid market, convergence of market shares can be achieved by adopting NP without having to adopt asymmetric access regulation. In less developed countries where the pre-paid market dominates, NP is not that effective and increased competition can be achieved by reducing access charges. It would be interesting for further empirical research to study the impact of reduced access charges on the evolution of entrants' market shares in countries with a high share of pre-paid users.

6. CONCLUSION

Reduction of switching costs through NP has a considerable impact on telecommunication markets. We have shown with actual pricing strategies that this policy is more likely to be pro-competitive in the post-paid market than in the pre-paid market. In the post-paid market this policy is unambiguously pro-competitive.

In the pre-paid market segment the reduction of switching costs in the form of NP has no impact on the market shares of either the small or the large operator: switching costs that stem from price discrimination are more important. The regulator could achieve the objective of convergence of market shares by reducing access charges and there is no need for asymmetric access regulation.

Our model is simple, but it provides the important conclusion that pro-competitive regulatory policies should be differentiated depending on the share of post-paid and pre-paid users. One possible extension of the model is to divide switching costs between one element that is common to all users and another that is different between users and uniformly distributed in some interval. The reduction of switching costs could be modelled by reducing only the common element of switching costs without altering the dispersion of switching costs for all users.

In our research we have focused on the traditional practice of operators. The new market trend is bundling of mobile and fixed phone services with cable internet and TV providers. This new environment creates many new research questions that open avenues for further research, particularly from the point of view of industrial organisation and competition policy.

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