

Access Charges Regulation under Asymmetric Mobile Networks

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ABSTRACT

In order to suggest an appropriate regulatory regime in a context of firm asymmetry, this study has developed a mathematical model that allows to elucidate comparisons of three different regulatory scenarios. In the unregulated market, the low-cost firm is more likely to become dominant in the market. Symmetric regulation has an immediate effect on off-net prices, which fall to the level of its marginal costs. Finally, asymmetric regulation is a highly effective way of promoting market entry. Asymmetric regulation can generate higher social welfare.

Keywords: Access charge regulation, asymmetry, reputation, interconnection

JEL Codes: L12, L51, L96

INTRODUCTION

In the mobile market, incumbents and entrants have different cost structures, among other reasons because incumbents have remained longer in the market than entrants, also because they have a greater scope in the services they provide, have greater spectrum and/or have deployed more infrastructure. Likewise, it is likely for the entrant to be dominated by the incumbent due to late entry. This is one of the major aspects of firm asymmetry, which has become a topic of debate on anti-competitive and predatory practices that may be developed by dominant firms. Therefore, there has been an intense debate about whether asymmetric operators should be treated differently in order to remove inequalities caused by exogenous factors (Goral and Karacaer, 2011). The entrant may incur in higher costs and may require the intervention of the regulator in order to achieve certain market share and be financially viable. To promote market entry and competition especially in the short term, regulators may impose an asymmetric access charge regulation¹. This problem is less complicated

when asymmetry has decreased after a transition period. In that sense, the US and many European countries have used a path towards symmetric access charge regulation (Goral and Karacaer, 2011; Lee, Lee and Jung, 2010). Asymmetric regulation has been replaced by symmetric regulation in countries such as Sweden, Denmark, Poland and Portugal (Lee, Lee and Jung, 2010). However, in some countries, especially in developing countries, there is substantial evidence about network asymmetry, which still plays an important role in market concentration.

However, much of the existing literature focuses exclusively on symmetric operators or asymmetric operators from a conventional firm asymmetry point of view. This study compares the effects of asymmetric regulation on social welfare under a competition framework of two asymmetric mobile network operators, both in their cost structure and in their reputation. In addition to the greater reputation of the incumbent as assumed in Carter and Wright (2003), from the perspective of the consumer, the incumbent can be as good as or worse than the entrant in terms of reputation, especially

¹Asymmetric access charge regulation has been considered as an acceptable measure in different markets such as some European countries, and several countries in Latin America. Under this regulation, an incumbent with significant market power is regulated to set cost-based access charges

while an entrant with a small market share should set reasonable access charges. This regulation can promote the entry of small networks and subsequently intensify competition.

when the technology has changed rapidly, and legacy networks have given way to new competitors. In this model, both firms offer their services under network-based price discrimination and two-part tariffs. Social welfare, consumer surplus and producer surplus are analyzed under three different regulatory policies: (1) no regulation, (2) symmetric regulation of cost-based access charges, and (3) asymmetric regulation of cost-based access charges. Asymmetry in costs leads to asymmetric market results. In contrast to on-net prices, off-net prices diverge from the marginal cost given that firms charge access mark ups. The access charge regulation is necessary to eliminate distortion and allow under this asymmetry framework for having increases in the consumer surplus. However, the regulator should consider these regulations carefully when asymmetric networks are significantly different from the efficiency point of view. It may be reasonable to implement asymmetric regulation instead of symmetric regulation when the cost differential, differences in reputation and/or degree of substitutability between networks is not very high. Otherwise, asymmetric regulation decreases consumer surplus by making symmetric regulation more appropriate under these circumstances.

LITERATURE REVIEW

In many countries, the telecommunications regulator is in charge of monitoring the behavior of telecommunications network providers and regulates access charges in order to discourage the predatory behavior of larger providers, thus expecting to stimulate competition in the mobile market. Much of the related literature supports the access charge regulation between firms with own infrastructure. In the symmetric context, mobile networks can take undue advantage of reciprocal asymmetric charges by using them as a tacit collusion instrument in order to reduce competition (Armstrong, 1998, Laffont, Rey and Tirole, 1998a). When networks agree to set a common access charge, retail prices should be high in order to cover the access charge and prevent a price war. With respect to a linear pricing scheme, it is proven that retail prices are high because there is a profit margin that is charged additionally to access charges (Laffont, Rey and Tirole, 1998a). Likewise, under two-part tariffs, networks obtain profits from the fixed charges they collect and set retail prices taking as a reference the average cost obtained from weighting the on-net marginal cost and the off-net perceived cost (Carter and Wright, 2003,

Laffont, Rey and Tirole, 1998a, Lopez and Rey, 2009). Moreover, the off-net price is higher than the current cost, even under a network-based price discrimination scheme and a linear pricing scheme, because networks can charge profit margins additionally to access charges (Laffont, Rey and Tirole, 1998b). These results indicate that double marginalization is a real phenomenon that causes reductions in consumer welfare. However, regardless of the existence of a call externality, networks obtain profits as a result of the fixed charges they collect in telephony plans and set on-net and off-net prices equal to their perceived costs under two-part tariffs and network-based price discrimination. Under certain circumstances, networks could set access charges equal to cost in order to maximize benefits (Laffont, Rey and Tirole, 1998b). Additionally, Calzada and Valletti (2008) and Gans and King (2001) argue that networks could agree to set access charges below their costs in order to reduce competition, which in turn would reduce consumer welfare.

Much of the relevant literature also mentions that networks can set access charges above their costs as a mechanism to reduce competition or affect their rivals in a regulatory non-intervention scenario. This behavior reduces social welfare. Although some studies agree with the imposition of access charges below cost or a Bill and Keep system (Cambini and Valletti, 2003) as a mechanism to increase social welfare, many regulators prefer the cost-based access charge regulation. However, in the presence of firm asymmetry, the asymmetric access charge regulation, especially in less mature markets, is important to regulators. This is because there is a concern that a large network with market power could put its rivals at a disadvantage or enclose the market through high access charge setting strategies, increasing the differential between on-net and off-net prices (Hoerning, 2007; Lopez and Rey, 2009).

Carter and Wright (2003) introduce a competition model between asymmetric networks where brand loyalty is taken into account and in which networks maintain the same cost structure under a uniform pricing scheme. The benefits received by the consumers of the incumbent operator are product of brand loyalty only. As a result, the incumbent and entrants are symmetric from the consumer's perspective. The aforementioned authors emphasize that the larger network prefers to set reciprocal cost-based access charges. Similar to Carter and Wright (2003), Peitz (2005)

researched asymmetric networks under network-based price discrimination with two-part tariffs. This author concludes that asymmetric access charge regulation is more appropriate than symmetric regulation given that it generates increases in consumer surplus and benefits entrant firms. Stuhmeier (2013) also reinforces the standard result that the asymmetric regulation favoring the entrant can increase its benefits in a cost asymmetry scenario. However, we found that there is no effect on equilibrium market shares as a result of network-based price discrimination. Baranes and Vuong (2012) highlight that the asymmetric regulation can intensify market competition and increase social welfare in certain situations. However, Lee, Lee and Jung (2010) argue that a reduction in access charge asymmetry can contribute to an increase of consumer surplus when the costs of the entrant are low and the degree of substitutability between services is high.

Recent empirical literature has proven that retail prices show significant reductions as a result of the reduction in access charges, when applying a cost-based access charge regulation. However, there is no evidence supporting the adverse effect that the regulation has on the benefits of a mobile network operator (Genakos and Valletti, 2015). Moreover, Dewenter and Haucap (2005) use data from different mobile network operators to confirm that small networks have an incentive to increase their access charges under asymmetric regulation. This empirical evidence confirms the results of this study together with the relevant theoretical literature. However, the conclusions about asymmetric regulation can vary according to the different problems and perspectives analyzed.

In the next section, we present a model of asymmetric networks under two-part tariffs and network-based price discrimination. Likewise, the different cost structures are presented, as well as the asymmetry parameters in the regulation. In section 4, the results generated on the market and effects of three regulatory policies are discussed. The implications for public policy are also mentioned. Finally, section 5 concludes with the main findings and some suggestions for regulators.

Model

There are only two mobile network operators offering in the market one type of service² with

²This study can be applied to voice, text and any type of services in mobile networks.

the same quality. Network 1 has lower costs than network 2. From a static point of view, both networks have already made their investments in infrastructure and compete on prices. A consumer can subscribe only to one network. According to mobile number portability, we assume that subscribers can change network operators without facing switching costs. Therefore, there is no consumer "entrapment". Networks compete for subscribers that are uniformly differentiated according to the standard Hotelling model. Consumers are located in interval $[0, 1]$. Both networks have full coverage, and are located at the ends of the Hotelling lines. Network 1 is at point 0 and network 2 is at point 1. Consumers have different preferences. The preference of a consumer for a particular network can be construed as the distance between the consumer location and the network location. The closer the consumer is to the network, the stronger the consumer's preference for that network. This is because the consumer experiences a disutility as a transportation cost in the Hotelling model. The disutility corresponds to the discrepancy between the ideal consumer network and the network available. In this model of two mobile networks, t represents the disutility per unit of the distance in interval $[0, 1]$. Disutility is assumed as a linear function of distance.

According to the assumption of total coverage, i.e. Laffont, Rey and Tirole (1998a), the fixed surplus for connecting to the network i (μ_i) is presumably greater than the disutility caused for not connecting to the ideal network³. As a result, nobody refuses to connect to a network. μ_i is constant and derived from the reputation of the network i related to its popularity, service quality or brand image. The network with a better reputation provides a higher level of fixed surplus to consumers. β is the reputation asymmetry parameter, which represents the difference between the fixed surplus levels of both networks. $\beta = \mu_1 - \mu_2$. In addition to the Carter and Wright model (2003), which only assumes that $\beta > 0$, this study assumes that β can be positive, negative or zero. $\beta > 0$ if network 1 (the low cost firm) offers a higher fixed surplus than network 2 (the high-cost firm), e.g. consumers may know more about firm 1 or it may be more reliable than firm 2,

³Laffont, Rey and Tirole (1998a) assume that, in a context of symmetric networks, both networks offer consumers the same fixed surplus for being connected to the same network. However, in this study, asymmetric networks offer different fixed surplus levels.

while $\beta < 0$ if network 1 offers a lower fixed surplus than network 2 (network 2 has a higher reputation than firm 1). Finally, $\beta = 0$ if both networks offer the same amount of fixed surplus to consumers. Therefore, consumers perceive that both networks are symmetric in reputation⁴.

Under the assumption of switching costs equal to zero, consumers can alternate between both networks without any problem. A consumer will choose the network offering highest net profit. A subscriber choosing network i will obtain a net utility of (w_i). Both networks compete on two-part tariffs. Network i offers an on-net price of (p_i), off-net price of (\hat{p}_i) and fixed charge of (F_i). After having achieved an interconnection agreement, each network completes all incoming off-net calls and consequently collects access charges from its rival. Network i sets the access charge (a_i) unilaterally.

Due to the balanced call pattern assumption, each consumer has the same probability of receiving a call. Thus, market shares reflect the number of users in a network and in the opposite network. α_1 is the market share of network 1; and $\alpha_2 = 1 - \alpha_1$ is the market share of network 2. In order to simplify the model, the profit for receiving calls is not taken into account. The consumer's net utility w_i is detailed below.

$$w_i(p_i, \hat{p}_i, F_i) = \text{net surplus of making onnet calls} + \text{net surplus of making offnet calls} - \text{fixed charge}$$

$$w_1(p_1, \hat{p}_1, F_1) = \alpha_1 v(p_1) + \alpha_2 (\hat{p}_1) - F_1 \quad (1.1)$$

$$w_2(p_2, \hat{p}_2, F_2) = \alpha_2 v(p_2) + \alpha_1 (\hat{p}_2) - F_2 \quad (1.2)$$

$v(p)$ is the consumer's net surplus for making a call.

$$v(p) = \max_q \{U(q) - pq\} = \frac{1}{2} - p + \frac{p^2}{2} \quad (1.3)$$

p is the usage price; $p \in \{p_1, p_2, \hat{p}_1, \hat{p}_2\}$. Consumers have identical demand functions. However, each subscriber can generate different call traffic flows, given that it faces different retail prices depending on the network to which it is subscribed. In this model, without the

⁴In this study, we assume that the reputation of networks is exogenous and constant. However, from a dynamic perspective, reputation may depend on endogenous variables such as market shares, service quality and network strategies. For this reason, networks can be allowed to vary their reputation levels in a model.

assumption of call externality, the caller is the payer (Calling Party Pays) and the person receiving the call does not assume any cost for answering. The gross surplus of a consumer for making a call is given by $U(q) = q - \frac{1}{2}q^2$, where q represents the duration of the call in terms of minutes, corresponding to the associated usage price (p); $q \in \{q_1, q_2, \hat{q}_1, \hat{q}_2\}$.⁵

In equilibrium, a marginal consumer indifferent between both networks obtains the same utility from choosing between network 1 and network 2. This profit consists in the net utility (w_i), reputation fixed surplus μ_i and disutility for not connecting to the ideal network. The marginal consumer is located at point α_1 in interval $[0,1]$. The location of the marginal consumer indicates the market share of network 1. Thus, from the point of view of the marginal consumer, the utility from network 1 is equal to that from network 2 as shown below.

$$w_1 + \mu_1 - t\alpha_1 = w_2 + \mu_2 - t(1 - \alpha_1) \quad (1.3a)$$

$$w_1 + \beta - t\alpha_1 = w_2 - t(1 - \alpha_1) \quad (1.3b)$$

$\sigma = \frac{1}{2t}$ is the degree of substitution between both networks⁶.

By substituting $t = \frac{1}{2\sigma}$ in the equation above and rearranging, we obtain the market share of network

$$\alpha_1(p_1, \hat{p}_1, p_2, \hat{p}_2, F_1, F_2) = \frac{1}{2} + \sigma\beta + \sigma[w_1(p_1, \hat{p}_1, F_1) - w_2(p_2, \hat{p}_2, F_2)] \quad (1.4)$$

Both networks have different cost structures. This asymmetry can be product of the sequential

⁵For simplicity, we assume that each subscriber has an identical utility function for making calls. As a result, the demand function for making calls is shown below.

$$U'(q) = 1 - q = p$$

As a result, the demand function is linear; $q(p) = 1 - p$ where $p \in \{p_1, p_2, \hat{p}_1, \hat{p}_2\}$ and $q \in \{q_1, q_2, \hat{q}_1, \hat{q}_2\}$ respectively. However, some studies assume other forms of utility function and demand function. For example, Hoerning (2007) and Laffont, Rey and Tirole (1998a, 1998b) use a constant-elasticity demand function.

⁶According to Laffont, Rey and Tirole (1998a), the degree of substitutability (σ) is positive. If σ is close to zero, both networks are extremely differentiated. Conversely, if σ is high, both networks are highly substitutable.

market entry, asymmetric allocation of spectrum resources, differences in bands and/or discrepancies in the deployment of technology, which directly affects marginal costs. We assume networks incur in different marginal costs for origination and termination of calls, but they face the same costs for connecting a subscriber. f_i is the cost for connecting a subscriber such as connection costs, administrative and billing costs, among others. For simplicity, we assume $f_1 = f_2$.⁷ To complete a call, the respective networks provide call origination, transit and termination services. Call transit occurs when the signal is transferred from the facilities where the call is generated to the facilities where it is terminated. Firm i has a marginal cost for originating a call c_{oi} and marginal cost for terminating a call c_{ti} in terms of expenditure per minute; $i \in \{1, 2\}$. We assume the transit cost is zero for simplicity. Therefore, the total marginal costs for an on-net call are $c_{oi} + c_{ti}$. We also assume that the marginal cost for origination and termination of a network are identical because they involve the same facilities to originate an outgoing call and terminate an incoming call. Moreover, we assume that fixed costs, such as common costs, are equal to zero.

This study assumes that both networks shall not enter the market at the same time. The new firm enters the market when the established firm has already been operating in the market for some time. The established firm may have experienced economies of scale in the monopoly period, and therefore its marginal cost is lower than that of the new firm. It is also possible for the established firm to have higher costs. The new firm may invest in different technologies to reduce its costs or experience the advantages of assigning better spectrum frequencies, while the established firm still faces sunk costs in its facilities, since it cannot modernize them immediately. As a result, the new firm may

⁷The purpose of this study is to research the on-net and off-net prices offered by both networks with different cost structures. This model assumes that networks have asymmetric origination and termination costs since these costs play an important role in pricing. The cost of connecting a subscriber may vary among competing firms according to the administration, which is not the focus of this study. For simplicity, we assume that the fixed costs of both networks for connecting a subscriber (f_i) are identical.

incur in lower costs than the established firm⁸. In this model, we assume that the origination and termination costs of network 1 are lower than those of network 2. The origination and termination costs can be compared as follows.

$$c_{oi} = c_{ti} = c_i; i \in \{1, 2\} \tag{1.4a}$$

$$c_1 < c_2 \text{ y } f_1 = f_2 \tag{1.4b}$$

In order to evaluate the asymmetric access charge regulation, which tends to be implemented to promote market entry in the situation where the new firm is at a disadvantage due to its higher costs, this study focuses mainly on the case where the established firm incurs in lower costs.

The Two-Part Tariff Structure (Postpaid Scheme)

Both networks set two-part tariffs under network-based price discrimination. First, a subscriber incurs in a fixed charge (F_i) to connect to a network and then pays for usage (p_i, \hat{p}_i) when calls are made⁹. The profit of network i consist of the revenue generated from providing the service to its subscribers and the revenue charged to the other network to guarantee access. The revenue generated from subscriptions consists in providing on-net calls, originating off-net calls, and fixed charges paid by users. In addition, network i collects access charges per minute (a_i) from network j when an incoming call originated by network j ; $i, j \in \{1, 2\}$ and $i \neq j$ is terminated. The profit function of firm i can be written as

$$\pi_i = \alpha_i [\alpha_i (p_i q_i - 2c_i q_i) + \alpha_j (\hat{p}_i \hat{q}_i - (c_i + a_j q_i + F_i - f_i + a_j a_i - c_i q_j)] \tag{1.5}$$

Temporality of Game

⁸An example of different technologies is the 3G technology, which is more advanced and has a lower marginal cost than 2G technology.

⁹In different countries such as Colombia, mobile operators offer a variety of contracts other than the typical two-part tariff contract (monthly subscription and pay-per-use). However, this model follows the conventional two-part tariff model. In this context, the cost of connecting a consumer (f_i) can include the costs of free minutes of the plan. If a consumer uses up his free minutes, he must pay for additional calls.

To find equilibrium, a two-stage game is designed, which is solved with backward induction¹⁰.

Stage 1

Both networks carry out an interconnection agreement and set their access charges simultaneously

Stage 2

Networks compete on prices by simultaneously setting the fixed charge, and on-net and off-net prices

Scenarios

Market results are analyzed in the following three scenarios. The first two scenarios are observed as comparative scenarios. The market results, aggregate consumer surplus and aggregate producer surplus in the last scenario are compared to scenarios used as comparative scenarios

Comparison 1

The deregulated market

The first comparison refers to the market equilibrium without any type of regulatory intervention. Both networks can set their own access charges unilaterally.

Comparison 2

Symmetric regulation of cost-based access charges

The second comparison introduces symmetric regulation in access charges. Each regulated network sets its access charges equal to the termination cost. The profit function of the network *i* is

$$\pi_i = \alpha_i [\alpha_i (p_i q_i - 2c_i q_i) + \alpha_j (\hat{p}_i \hat{q}_i - (c_i + c_j) \hat{q}_i) + F_i - f_i] \quad (1.6)$$

Where $i, j \in \{1, 2\}$ and $i \neq j$

Asymmetric Regulation of Cost-Based Access Charges

In order to evaluate the effects of asymmetric regulation, which is usually adopted for purposes of promoting the entry of new competitors, this scenario focuses only on the situation in which the new firm has a higher cost and lower market share. The established firm

(low-cost network 1) is regulated so that cost-based access charges are set, $a_1 = c_1$. On the other hand, the new firm (high-cost network 2) can set a_2 . Thus, the profit functions of networks 1 and 2 are as presented below.

$$\pi_1 = \alpha_1 [\alpha_1 (p_1 q_1 - 2c_1 q_1) + \alpha_2 (\hat{p}_1 \hat{q}_1 - c_1 + a_2 q_1 + F_1 - f_1)] \quad (1.7)$$

$$\pi_2 = \alpha_2 [\alpha_2 (p_2 q_2 - 2c_2 q_2) + \alpha_1 (\hat{p}_2 \hat{q}_2 - c_2 + c_1 q_2 + F_1 - f_1 + a_1 a_2 a_2 - c_2 q_1)] \quad (1.8)$$

Social Welfare

The aggregate consumer surplus (CS) is the sum of all consumer's utility. Each consumer's utility consists of the net utility from making calls, the differential in the fixed surplus levels of networks for reputation (if it chooses network 1) and the disutility from choosing a network that is not the ideal network.

$$CS = \left[\alpha_1 (w_1 + \beta) - \int_0^{\alpha_1} \alpha t d\alpha \right] + \left[\alpha_2 w_2 - \int_{\alpha_1}^1 (1 - \alpha) t d\alpha \right]$$

$$CS = \alpha_1 (w_1 + \beta) + (1 - \alpha_1) w_2 - \left[\frac{\alpha_1^2 + (1 - \alpha_1)^2}{4\sigma} \right] \quad (1.9)$$

$\alpha_1 (w_1 + \beta)$ is the sum of the net utility of consumers subscribing to network 1 (the low-cost firm), including the differential in fixed surplus levels

$(1 - \alpha_1) w_2$ is the sum of the net utility of the consumer subscribing to network 2 (the high-cost firm)

$\left[\frac{\alpha_1^2 + (1 - \alpha_1)^2}{4\sigma} \right]$ is the total disutility of all consumers for connecting to network 1 or network 2 other than the ideal network.

The aggregate producer surplus (PS) is the sum of profits of both firms

$$PS = \pi_1 + \pi_2 \quad (1.10)$$

The social benefit is the total consumer surplus and producer surplus.

Results

The market results of the three scenarios are compared in the sections presented below. The equilibrium result of the unregulated market and the symmetric regulation of cost-based access charges are the comparisons 1 and 2, respectively.

Comparison 1

The Unregulated Market

¹⁰. In this model, the entrant has already entered the market and therefore a dynamic point of view for entry and exit is beyond this framework.

In this scenario, firms are allowed to set their own access charges unilaterally.

The Behavior of Mobile Network Operators in the Unregulated Market

Firms have three instruments (on-net price (p_i), off net price (\hat{p}_i) and fixed charge (F_i)) to compete for subscribers in the second stage of the game. For simplicity, we assume that the fixed charge (F_i) is a function of market share α_i . If a network modifies its prices and intends to maintain a constant market share, it will need to change its fixed charge in order to balance its net profit. In the second stage of the game, after differentiating its profit function with respect to the on-net price, off-net price, and market share, the results of profit maximization are

$$p_i^* = 2c_i \quad y \quad \hat{p}_i^* = c_i + a_j; i, j \in \{1, 2\} \text{ e } i \neq j \quad (1.11)$$

Proposition 1

When asymmetric networks compete under the network-based price discrimination and two-part tariffs scheme, both the high-cost firm and the low-cost firm set their prices equal to their perceived costs¹¹ (pricing at marginal costs). The high-cost firm sets higher on-net prices than the low-cost firm, i.e. $p_2^* > p_1^*$.

Both equilibrium prices (both on-net and off-net) are equal to their respective marginal costs. This result is not different from that found in the relevant literature on two-part tariffs in the context of identical costs between firms (Laffont, Rey and Tirole, 1998b, Lopez and Rey, 2016). When firms charge two-part tariffs, they set their prices at the level of perceived costs and do not obtain profit from the origination of calls. Therefore, the profit function depends solely on the revenue obtained from the collection of fixed charges and collection for terminating incoming off-net calls (access income). Additionally, when a firm increases its fixed charge, two effects on profits occur. On the one hand, the direct effects of an increase in a fixed charge leads to an increase in subscription profits. On the other hand, the indirect effect can reduce its market share given

¹¹The perceived costs vary according to the termination of calls. The perceived cost of an on-net call is the sum of the current marginal cost of origination and termination of calls in the same network. The perceived cost of an off-net call is the total current marginal cost for origination and the access charge imposed by the network where the call ends.

that its net profit is reduced and the marginal consumer can switch to the other network. When the firm loses market share, there is a reduction in the total revenue received for fixed charges and the revenue resulting from access charges may also decrease. As a result, the fixed charge maximizing profits should balance these two effects so network's profits reach a peak.

Remark 1

In the deregulated market, the critical value of the asymmetry parameter ($\hat{\beta}$), which indicates the dominant network is

$$\hat{\beta} = -\frac{1}{2} [v(c_1 + a_2^*) - v(2c_2) - v(c_2 + a_1^*) + v2c1 < 0 \quad (1.11a)$$

The low-cost firm (network 1) has a higher market share than the high-cost firm if $\beta > \hat{\beta}$

The critical value of the asymmetry parameter ($\hat{\beta}$) is determined by the costs of both networks. $\hat{\beta}$ is negative. Although the low-cost firm has a lower reputation than the high-cost firm (but the asymmetry parameter is greater than the critical level $\hat{\beta}$), the low cost-firm serves most consumers. This is because the low-cost firm is more cost-efficient and offers lower prices to attract consumers. From a static point of view, the marginal cost is exogenous, in such a way that firms cannot adjust their cost structure in the short term. To assume a dominance position, the high-cost firm must make its reputation better than that of the low-cost firm until the asymmetry parameter is lower than the critical level. In addition, when the cost differential is reduced, the critical value of the asymmetry parameter increases and the difference between the market shares of both networks decreases. The market share of a network is determined by the asymmetry parameter and the cost structures of both networks.

Proposition 2

The network with the highest market share sets higher fixed charges and generates higher profits than the network with the lowest market share.

According to the pricing scheme where the price is equal to the marginal cost, networks receive profit only from fixed charges and the access charge. Assuming that both firms have the same connection costs per subscriber ($f_1 = f_2$), when both networks have different market shares in the asymmetric equilibrium, the large firm (the firm with the highest market share) will collect a higher fixed charge than that of the small firm.

However, the large firm maintains a higher market share despite its higher fixed charge given that it offers a more attractive utility due to its lower on-net price and/or higher fixed reputation surplus. Therefore, most consumers still perceive that the utility of the large firm are greater despite the higher fixed charge.

Proposition 3

Both networks unilaterally set access charges above cost, i.e. $a_1^ > c_1$ and $a_2^* > c_2$. The network with the highest market share sets a higher profit margin than the network with lowest market share.*

In the absence of access charge regulation, both firms unilaterally charge access mark ups in the first stage of the game. As a result, off-net prices, which are equal to their perceived costs, are higher than their current marginal costs since the prices are set to cover the associated profit margins. Similar to the findings on uniform pricing reported by Armstrong (1998) and Laffont, Rey and Tirole (1998a), this result is a strong indication of the appearance of tacit collusion in this cost asymmetry environment. Networks will not initiate a price war through off-net call pricing. In contrast to some findings supporting that firms with identical costs would set an access charge based on reciprocal costs (Laffont, Rey and Tirole, 1998b) or even an access charge below reciprocal costs (Calzada and Valletti, 2008), this study shows that when networks have different costs, the dominant firm will take advantage of the difference in costs and the fact that access charges are set above cost. Off-net prices above cost are not close to socially optimal prices, which should equal the current marginal costs. Regardless of the access margins, on-net prices remain unchanged. Both networks set their on-net prices at the current marginal costs.

We also found that the larger network establishes not only a higher fixed charge, but a higher access charge than the small network. When a network increases its access charge, both positive and negative effects are generated on its own profits. First, when its access charges increase, the rival's off-net price increases. As a result, its own market share can increase also increasing its profits. Second, when its access charge increases, its rival makes adjustments by reducing its fixed charge. In order to face the reaction of its rival, the network must reduce its fixed charge, which has a negative impact on its own profits. For the larger network, the first effect weighs more than the second effect,

compared to the small network. Therefore, the larger network can set higher access charges and receive higher profits than the smaller network.

In the absence of reputation asymmetry ($\beta = 0$), the low-cost firm certainly has a higher market share due to its cost efficiency. Additionally, when both networks are different in reputation, the larger firm is more likely to be the low-cost firm. If its reputation is not very bad, compared to the high-cost firm, the low-cost firm shall have a higher market share and receive higher profits than the high-cost firm. However, the difference in market shares and benefits is minimal as the difference in reputation decreases. When the reputation of the low-cost firm is reduced (β is reduced), the low-cost firm loses market power and can no longer set relatively high fixed charges and access charges (so that its rival increases its off-net price by force)¹². As a result, the firm loses profits. Moreover, when its reputation is extremely bad when compared, the low-cost firm may not preserve its dominance position in the market. The low-cost firm becomes the small network earning lower profits than the high-cost firm, which becomes the large network.

Comparative Statics Analysis

In the unregulated market, the effects of the asymmetry parameter (β), the degree of substitutability (σ) and network costs on the equilibrium results are as presented below.

Observation 1

- When the asymmetry parameter increases, the low-cost firm can increase its market share, i.e. $\frac{\partial \alpha_1^*}{\partial \beta} > 0$
- When the degree of substitutability between networks is high, the market share of the large firm increases. As a result, the differential between market shares is higher, i.e. when $\alpha_i^* > \alpha_j^*$, $\frac{\partial \alpha_i^*}{\partial \sigma} > 0$ and $\frac{\partial (\alpha_i^* - \alpha_j^*)}{\partial \sigma} > 0$; $i \in \{1, 2\}, i \neq j$.
- When the costs of a network increase, its market share decreases, but its rival's market share increases, i.e. $\frac{\partial \alpha_i^*}{\partial c_i} < 0, \frac{\partial F_j^*}{\partial a_i} < 0$ where $i \in \{1, 2\}, i \neq j$

¹² $\frac{dm_1}{d\beta}$ where m_1 is the access mark ups of network 1; $m_1 = a_1 - c_1$.

- When a network decides to increase its access charge, the fixed charge of both networks is reduced, i.e. $\frac{\partial F_i^*}{\partial \alpha_i} < 0$, $\frac{\partial F_j^*}{\partial \alpha_i} < 0$ where $i \in \{1, 2\}$, $i \neq j$

Market shares are affected by different exogenous factors. First, when a network's reputation increases, such network can increase the number of subscribers, as well as its market share.

Second, if both networks are moderately substitutable, some consumers decide not to switch to the large network because they still receive certain utility from the small network, which is closer to their ideal network. On the other hand, if both networks have a higher degree of substitutability, some of those consumers may decide to join the large network. Therefore, if networks are close competitors in terms of substitutability, the large network can increase its market share more easily. Subsequently, the small network is more likely to exit the market. As a result, differentiating the service can be one of the strategies of the small network to expand its market in this context. In other words, when the degree of substitutability is higher or the horizontal differentiation (represented by t) is close to zero, the competition gets closer to a Bertrand price competition model. However, this study focuses on a shared market equilibrium. Thus, the degree of substitutability should not be very high when compared to the cost differential.

Third, the difference in costs is a key factor for asymmetric results. When the cost of a network increases, its on-net price increases as well. From the consumer's perspective, the network service is less attractive. Some of its subscribers switch to the rival, and therefore its market share is reduced. Subsequently, the rival's market share increases.

In addition to the three exogenous factors, in equilibrium, the decision of a network about access charges affects the setting of the fixed charge in the last stage. When a network increases its access charge, it is likely to earn more profits from the revenue it receives from access. However, its rival will react by reducing the fixed charge. The network must reduce its own fixed charge to prevent some consumers from switching to its rival. Therefore, if a network decides to increase its access charge, the profit-maximizing fixed charges of both firms are reduced.

Scenario 2

Symmetric Regulation of Cost-Based Access Charges

High-cost and low-cost firms are regulated to set their access charges at the value of termination costs.

The behavior of mobile network operators under the symmetric access charge regulation

When $a_1 = c_1$ and $a_2 = c_2$ in the first stage of the game, according to (1.11), the on-net and off-net prices are:

$$p_i^* = 2c_i \quad y \quad \hat{p}_i^* = c_i + c_j; \quad i, j \in \{1, 2\} \quad e \quad i \neq j \quad (1.11b)$$

According to the assumption that the marginal costs of network 1 are lower than those of network 2, the on-net price of the high-cost firm is higher than the off-net prices of both firms. $p_2^* > \hat{p}_2^* = \hat{p}_1^* > p_1^*$

Proposition 4

Under symmetric regulation of cost-based access charges, both firms set their on-net prices equal to the current marginal costs. The high-cost firm offers on-net prices greater than those of the low-cost firm. However, both firms offer the same level of off-net prices, which are equivalent to the current marginal costs.

Both networks set their profit-maximizing access charges according to their marginal costs. From (1.11),

$$p_1^* = 2c_1, p_2^* = 2c_2, \hat{p}_1^* = \hat{p}_2^* = c_1 + c_2 \quad (1.11c)$$

Under symmetric regulation, the on-net and off-net prices of both networks are set at cost since no profit margin is allowed. The high-cost firm can set its on-net price at a lower level than the high-cost firm due to its cost efficiency.

Remark 2

Under the symmetric regulation of cost-based access charges, the critical value of the asymmetry parameter $\hat{\beta}$ is

$$\hat{\beta} = -\frac{1}{2}[v(2c_1) - v(2c_2)] < 0 \quad (1.11d)$$

The low-cost firm has a higher market share if $\beta > \hat{\beta}$. Additionally, the critical value under symmetric regulation ($\hat{\beta}$) is greater than that of the unregulated market (β), i.e. $\hat{\beta} > \beta$

Symmetric regulation eliminates the effect of the access margin that is strategically imposed by the low-cost firm. As a result, the critical

value of the asymmetry parameter is higher than that of the unregulated market because it depends solely on the cost differential. The high-cost firm has a greater tendency to take over the dominant position under symmetric regulation than in the unregulated market¹³, especially when the high-cost firm has a better reputation.

Proposition 5

Under symmetric regulation of cost-based access charges, the network with the highest market share sets higher fixed charges and obtains a greater profit than the network with lowest market share.

Under symmetric regulation, both on-net prices and off-net prices are equal to their marginal costs. Firms generate profit only from fixed charges due to marginal-cost-based pricing and the absence of access mark ups. Similar to the results in the unregulated market, the larger network can collect a higher fixed charge and still serve most consumers due to its comparatively more attractive utility in terms of cost efficiency and/or reputation.

Asymmetric Regulation of Cost-Based Access Charges

The new firm may be a potential competitor that can increase the degree of competition in the market if it is cost-efficient and/or its reputation is good enough. For example, its costs may be lower than those of the established firm. As a close rival, the new firm is able to compete aggressively, which will improve social welfare. In this case, asymmetric regulation is unnecessary. However, in the initial stage of entry, the new firm is more likely to be inefficient in terms of cost and reputation, and therefore it is at a disadvantage and at risk of leaving the market. Despite the inefficiency of the entrant, the regulator may impose this regulation for purposes of intensifying competition rather than letting the established firm take control of the entire market as a monopolist.

This section focuses on the situation where the new firm has higher costs and obtains lower

market share in order to assess the asymmetric regulation as a policy to facilitate entry. Under this regulation, the established firm (the low-cost firm) is regulated so that it sets its access charge for the value of its costs. In contrast, in this context the new firm (the high-cost firm) can determine its own access charge.

The Behavior of Mobile Network Operators Under Cost-Based Access Charge Regulation

Network 1 (the low-cost established firm) sets its access charge equal to its marginal cost, and network 2 (the new firm with high cost) can set its own access charge. According to (1.11), on-net and off-net prices in equilibrium are:

$$p_i^* = 2c_i; i, j \in \{1, 2\} \text{ e } i \neq j \tag{1.11e}$$

$$\hat{p}_1^* = c_1 + a_2 \tag{1.11f}$$

$$\hat{p}_2^* = c_2 + c_1 \tag{1.11g}$$

$p_2^* > \hat{p}_2^* > p_1^*$ y $p_1^* > \hat{p}_1^* > p_1^*$ since network 2 sets access mark ups.

Proposition 6

Under asymmetric regulation of cost-based access charges, the new firm with high costs sets access mark ups. When asymmetric regulation is imposed instead of symmetric regulation, its effects on the equilibrium results are as follows.

- The market share of the low-cost established firm is reduced, but that of the new firm increases
- Fixed equilibrium charges of both firms are reduced
- In general, the benefit of the new firm increases, but that of the established firm is reduced

While the access charge of the established low-cost firm is set at cost due to regulation, the new firm with high cost chooses access charges above costs to maximize its benefit. Asymmetric regulation has significant effects on the market result. First, the access mark ups of the new firm can increase the market share of the firm and reduce that of the established firm. This is because the new firm can increase the off-net price of the established firm through its access mark ups.

Second, the access mark ups also cause the established firm to react by reducing its fixed charge. Therefore, the fixed equilibrium charge of the new firm is affected in two different ways. When the off-net price of the established firm increases according to the access mark ups

¹³For example, assuming that the asymmetry parameter is b where $\hat{\beta} < b < \beta$, the high-cost firm obtains a smaller market share than the low-cost firm in the unregulated market but becomes dominant with greater market share under symmetric regulation.

of the new firm, the service of the established firm seems less attractive. Thus, the market share of the new firm may increase. The new firm will receive more profits if it decides to increase its fixed charge. However, when it charges access mark ups, the established firm decides to reduce its fixed equilibrium charge $\left(\frac{\partial F_1^*}{\partial a_2}\right) |_{a_2=c_2} < 0$ as a response. If the new firm does not reduce its fixed charge, it will lose market share and will not be able to take advantage of its access mark ups. Therefore, the new firm finally maximizes its profit by decreasing its fixed charge. In summary, when the new firm sets access mark ups, both equilibriums are reduced. This finding is similar to the result of Peitz (2005), studying asymmetric networks with different fixed profits, but with identical costs.

Third, the fixed charge of the established firm changes more drastically than that of the new firm, and its off-net price is higher. This leads to a reduction in the market share of the established firm. Therefore, the benefits of the established firm are reduced, and the benefits of the new firm increase compared to the symmetric regulation scenario.

Remark 3

Under asymmetric regulation of cost-based access charges, the critical value of the asymmetry parameter $\left(\hat{\hat{\beta}}\right)$ is

$$\hat{\hat{\beta}} = -\frac{1}{2} [v(c_1 + a_2^*) - v(2c_2) - v(c_1 + c_2)] + v2c1 \tag{1.11h}$$

The low-cost firm has a higher market share if $\beta > \hat{\hat{\beta}}$. The critical value under asymmetric regulation is the largest, followed by those of symmetric regulation $\left(\hat{\beta}\right)$ and that of the unregulated market $\left(\hat{\beta}\right)$ respectively, i.e. $\hat{\hat{\beta}} > \hat{\beta} > \hat{\beta}$.

Under asymmetric regulation, the critical value of the asymmetry parameter is larger than the symmetric regulation and the unregulated market respectively. Regarding scenarios 1 and 2, the high-cost firm must offer a fixed surplus significantly higher than the low-cost firm in order to have a greater market share. The great discrepancy in reputation is necessary for the high-cost firm to achieve dominance in the market. However, in order to become the large network under asymmetric regulation, the low-cost firm requires only a small difference in

reputation than what it would need under other regulatory regimes.

Proposition 7a

When the established firm has lower costs and greater market share than the new firm, the comparison of market shares in the unregulated market (nereg), under the symmetric regulation of cost-based access charges (sim) and under the asymmetric regulation of cost-based access charges (asim) is as shown below.

- The comparison of the market share of the established firm is

$$\alpha_{1\text{sinreg}}^* > \alpha_{1\text{sim}}^* > \alpha_{1\text{asim}}^* \tag{1.11i}$$

- The comparison of the market share of the new firm is

$$\alpha_{2\text{sinreg}}^* < \alpha_{2\text{sim}}^* < \alpha_{2\text{asim}}^* \tag{1.11j}$$

Asymmetric regulation is more effective to facilitate the entry of new firms with high costs. Conversely, the established low-cost firm may prefer that there be no regulatory intervention. This is because its market share is reduced after the regulator adopts either symmetric regulation or asymmetric regulation.

Proposition 7b

When the established firm has lower costs and greater market share than the new firm, the comparison of benefits of the new firm in the unregulated market (sinreg), under the symmetric regulation of cost-based access charges (sim) and under the asymmetric regulation of cost-based access charges (asim) is as presented below

$$\pi_{2\text{sinreg}}^* < \pi_{2\text{sim}}^* < \pi_{2\text{asim}}^* \tag{1.11k}$$

Asymmetric regulation is beneficial only for the new firm (the high-cost firm in this scenario). Compared to the other regulatory regimes, the new firm can enter the market and obtain the greatest profit under asymmetric regulation. Conversely, the established low-cost firm inevitably loses profit as a result of asymmetric regulation.

Social Welfare

The effects of the three regulatory regimes on social welfare are discussed below.

The Unregulated Market

As established in proposition 1.3, both networks set profit margins over access charges, and consequently, off-net prices increase. Price distortion has adverse effects on consumers. In

addition, the larger network takes full advantage of its dominance in order to put the market position of the small network at risk by aggressively setting access charges. Therefore, deregulation is not an appropriate policy in this context.

Symmetric Regulation of Cost-Based Access Charges

Compared to the result in the unregulated market, off-net prices are drastically reduced since profit margins over access are not allowed under this regulation.

Additionally, the large network can no longer use its profit margins over access as a predatory tool to harm its small rival. As a result, distortions of usage charges are avoidable. Due to cost-based access charges, consumers and the small firm benefit highly from this regulation, as established in proposition 1.7b.

Asymmetric Regulation of Cost-Based Access Costs

In the unregulated market (scenario 1), both networks unilaterally set their access charges above cost and generate some profit from the profit margins over access charges. The on-net prices are set for the value of the current marginal costs, but off-net prices are distorted by profit margins over access. This can reduce the aggregate consumer surplus. Symmetric regulation and asymmetric regulation can be pragmatic approaches to minimize distortion in this situation. When both networks are efficient in terms of costs and reputation, it is appropriate to impose an asymmetric regulation to curb the increase in profit margins over access and in retail prices.

However, when issues such as facilitating entry and promoting competition in the long term are taken into account, asymmetric regulation should be considered compared to symmetric regulation.

The next section focuses on the case in which network 1 is the low-cost established firm with greater market share than network 2, which is the new high-cost firm. The effects of asymmetric regulation on the aggregate consumer surplus and the aggregate producer surplus are compared to the effects of the symmetric regulation (scenario 2).

Aggregate Consumer Surplus

According to (1.9), the asymmetric regulation, which allows the new firm to set access mark

ups $a_2 > c_2$, has an ambiguous effect on the consumer surplus. Asymmetric regulation may not guarantee an increase in the total net utility of each group of consumers. However, asymmetric regulation certainly reduces total disutility. The difference between the market shares of both firms is minimal when the new firm is allowed to set access charges above costs. Compared to the result of the symmetric regulation, the new firm can capture certain market share of the established low-cost firm. Thus, asymmetric regulation reduces the differential between the market shares of both networks. Therefore, it is ambiguous to conclude that asymmetric regulation can increase the aggregate consumer surplus as a whole. The derivative of the aggregate consumer surplus with respect to the access charge of the new firm is:

$$\begin{aligned} \frac{\partial CS}{\partial a_2} = & 2\alpha_1 v(p_1) \frac{\partial \alpha_1}{\partial a_2} + (\alpha_1 - \alpha_1^2) v'(\hat{p}_1) + \\ & (1 - 2\alpha_1) v(\hat{p}_1) \frac{\partial \alpha_1}{\partial a_2} - \alpha_1 \frac{\partial F_1}{\partial a_2} - F_1 \frac{\partial \alpha_1}{\partial a_2} + \beta \frac{\partial \alpha_1}{\partial a_2} - \\ & 2(1 - \alpha_1) v(p_2) \frac{\partial \alpha_1}{\partial a_2} + (1 - 2\alpha_1) v(\hat{p}_2) \frac{\partial \alpha_1}{\partial a_2} - \\ & (1 - \alpha_1) \frac{\partial F_2}{\partial a_2} + \frac{\partial \alpha_1}{\partial a_2} F_2 + \frac{1}{\sigma} (1 - 2\alpha_1) \frac{\partial \alpha_1}{\partial a_2} \end{aligned} \tag{1.11}$$

Asymmetric regulation can increase the aggregate consumer surplus in the event that the asymmetry parameter in reputation (β) is not very high, and the cost differential is not very large when compared to the degree of substitutability (σ). When asymmetric regulation is imposed, the market share of the new firm and profit increase. On the other hand, the low-cost established firm loses market share and benefits. Thus, the difference in market shares is minimal under asymmetric regulation.

Asymmetric regulation has two different effects on the aggregate consumer surplus. First, a negative effect on consumer surplus occurs when the market share of the established firm is reduced. A different example is the case in which the established firm has a much higher fixed reputation surplus ($\beta > 0$) but some consumers decide to switch to the new network. These consumers must waive the extra surplus (β) for joining the established firm. As a result, asymmetric regulation can cause a reduction in the consumer utility from fixed surplus. Second, if the cost differential is not very large compared to the degree of substitutability (σ), there is a positive effect of the asymmetric regulation on consumer surplus. When certain consumers switch to the new network, the total disutility for not connecting to the ideal

consumer network is reduced (disutility is the lowest when both networks have equal market shares). Meanwhile, consumers in the new network must incur in higher average prices as a result of cost inefficiency. In summary, the benefits of asymmetric regulation may exceed disadvantages if the following conditions are satisfied: (1) the asymmetry parameter (β) is not very high, (2) the degree of substitutability is sufficiently low, and (3) the costs of both networks are not very different.

Aggregate Producer Surplus

Compared to the result obtained under asymmetric regulation (scenario 2), the low-cost established firm reduces its profits while the new high-cost firm receives more profits under asymmetric regulation. Regarding cost-based access charges, when the new firm decides to charge access mark ups, the magnitude of the profits that the established firm loses exceeds that of the profits that the new firm earns. In the aggregate, the producer surplus is reduced.

Optimal Regulations

If the entrant is efficient enough to compete with the established firm, the regulator can choose symmetric regulation to eliminate the distortions of access charges and off-net prices, which inevitably occur in the unregulated market. However, it can be questioned whether asymmetric regulation should be implemented to encourage entry and promote competition in the market in the situation where the new firm has higher costs and low market share. Like the standard result of Baranes and Vuong (2012) and Peitz (2005), this study provides clear evidence that asymmetric regulation is an efficient measure to stimulate the generation of profits by the new firm, as well as market entry. While the result of Peitz (2005) suggests that asymmetric regulation may increase consumer surplus, this study finds that the effect of asymmetric regulation on consumer surplus and social welfare is not entirely clear, as established in the preceding section. This can increase social welfare in the situation where the cost differential and the discrepancy in reputation is not significant and the services of both networks are well differentiated.

The main objective of this discussion is the efficiency of the entrant and its differentiated service. This study concludes that the asymmetry generated by the inherent inefficiency of the entrant should not be the justification for imposing asymmetric

regulation. Additionally, asymmetric regulation is socially acceptable when the entrant is an alternative to traditional telecommunications services such as fifth generation mobile services. In the product introduction period, the entrant may incur in higher costs and the asymmetric regulation of its access charges may preserve its viability to remain in the market. From a social perspective, asymmetric regulation is necessary to intensify market competition through a sufficiently differentiated service in this situation. In addition, asymmetric regulation should be implemented as a temporary measure in the first phases of the new service. When the asymmetry of firms is reduced in a more mature phase, it does not make sense to implement asymmetric regulation.

On the other hand, asymmetric regulation can reduce social welfare when the new firm has considerably higher costs, lower reputation, and high substitutability with the established firm. This is because the new firm is inefficient in terms of cost and reputation. Additionally, from the consumer's point of view, its product is not sufficiently differentiated regarding the existing product and may not fill any gap in the market to satisfy consumers. Thus, any regulatory support to the new firm can distort the market and reduce social welfare. Meanwhile, on the supply side, asymmetric regulation can cause a reduction in the profits of the established firm and the aggregate producer surplus. This may generate conflict on the established firm when the issue of asymmetric regulation is publicly discussed.

CONCLUSION

This study researches competition between two asymmetric networks under a two-part tariff and network-based price discrimination scheme. Networks are different in cost and reputation. To maximize their own benefits, both networks apply cost-based pricing. As a result, networks receive profits only from fixed charges and access revenue. When the market is deregulated, networks unilaterally set access charges above costs. The low-cost firm has a greater tendency to have a greater market share if its reputation is not lower than that of the high-cost firm. When the difference in reputation is lower, the difference between the market shares of both networks is small. Additionally, the network with the highest market share can collect a higher value for access charges, fixed charge

and, therefore, generate a greater profit than the network with lower market share.

Off-net prices increase since, in the unregulated scenario, both networks choose access charges above cost. This is harmful to consumers. If the regulator imposes the symmetric cost-based access charge regulation, this can reduce the off-net prices of both networks to their current marginal costs. A network can no longer make its rival's off-net price less attractive by setting access mark ups. Thus, the result in the asymmetric market directly reflects the cost differential and/or the discrepancy in reputation and is not distorted by the strategic profit margins. Compared to the result of the unregulated scenario, the symmetric regulation can reduce the differential between the market shares of both networks. However, there is some concern about the viability of the new firm in the situation where it has a high cost and a low market share. The regulator can choose the asymmetric cost-based access charge regulation in order to encourage the market entry of the new firm and oblige the established firm to abandon its monopoly power. Consumer welfare may increase if the cost differential and the discrepancy in reputation are not substantial and the service of both networks is sufficiently different. On the other hand, the benefit and market share of the established firm is reduced. Consequently, the regulator should implement asymmetric regulation instead of symmetric regulation when the high-cost competitor with differentiated service is not very inefficient in terms of cost and reputation. Otherwise, asymmetric regulation is likely to cause such distortions in the market that end up affecting total welfare.

Compared to other regulatory approaches, cost-based access charge regulations are more practical because regulators require only the declaration of the cost structure by the mobile network operator to set access charges. Additionally, in a static framework, asymmetric regulation may increase the profits of the new high-cost firm and may increase consumer welfare in certain situations. It is acceptable for the regulator to allow new firms to set profit margins over access in order to facilitate market entry and the launch of new services into the market. However, in the long term, both firms should compete strongly and increase efficiency in activities such as cost reduction and quality improvements. Asymmetric regulation should

act as an incentive for the new firm to enter the market, but this regulation should have a period of validity. Moreover, the regulator should promote competition in the market. Additional research is required to evaluate optimal regulations in the long term. In addition, this study assumes that networks offer only one service, so it would be interesting to research competition in multi-service markets.

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