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Abstract

We examine the effects of mobile termination rate regulation in asymmetric oligopolies. We do this by extending existing models of asymmetric duopoly and symmetric oligopoly where consumer expectations about market shares are passive. We first calibrate product differentiation parameters using detailed data from the Spanish market from 2010. Next, we predict equilibrium outcomes and welfare effects under alternative scenarios of future termination rates. Lowering termination rates typically lowers profits of all networks and improves consumer and total surplus.

JEL: D43, K23, L51, L96

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1 Introduction

An important technological aspect of mobile telecommunications is that subscribers of different network operators can call each other, which means that different networks are compatible. The possibility (and even obligation) to interconnect networks has been key to promote entry and competition. Since most people will only subscribe to one of the networks, each network holds a monopoly position over the so called market for termination of calls directed to its subscribers.

Regulators around the world, and especially in the European Union, have been and still are concerned about too high mobile termination rates (MTR) and intervene in the markets of termination. The reason is that high termination rates are thought to lead to inefficiently high retail prices. At present, the European Commission recommends national regulatory authorities (NRAs) to push termination rates further down to the cost of terminating a call by the end of 2012 (EC 2009). Network operators, on the other hand, have been and keep opposing cuts in termination rates. They often argue that lowering MTRs will lead to the reduction of handset subsidies and that in the end, consumers are hurt by this. This is sometimes referred to as a waterbed effect. Although the existence of a waterbed effect is usually acknowledged by regulators, the strength of this effect is heavily disputed.

The burden of MTR regulation is quite high and time consuming. Each NRA needs to start a round of public consultations with stakeholders every time it wants to propose a reduction in MTR. This involves several rounds of discussions and debates, backed up by consultants and studies. One may ask oneself whether all this effort is worth spending. Namely, the mainstream theoretical models (Laffont, Rey and Tirole [1998b], and Gans and King [2001]) predict that lowering MTR towards cost indeed improves total welfare but does so by increasing industry profit at the expense of consumer surplus. This is somewhat puzzling given the opposition by the industry and the intentions of NRAs (who are supposed to protect consumers) to reduce MTRs. Hurkens and López (2010) recently established a new theoretical result, that in fact predicts the opposite: consumers benefit and industry loses from reductions in MTR. This new theory emphasizes the role of network externalities, and in particular, the role of consumer expectations. The puzzle is resolved when consumers' expectations are assumed passive but required to be fulfilled in equilibrium (as defined by Katz and Shapiro [1985]), instead of being rationally responsive to non-equilibrium prices, as assumed in earlier works. It is worth mentioning that a few recent papers also attempt to reconcile the mentioned puzzle (Armstrong and Wright [2009], Hoernig, Inderst and Valletti [2009], and Jullien Rey and Sand-Zantman [2010])[1].

[1] These three papers have in common that they introduce additional realistic features of the telecommuni-

In this article we intend to quantify the consumer gains and industry losses of MTR regulation by calibrating our new model. In order to do so we dispose of a rich data set of the Spanish market, made publicly available by CMT, the Spanish NRA. This data set contains not only data about number of subscribers, minutes of traffic, and revenues, but also distinguishes between pre-pay and post-pay clients, and on-net and off-net traffic. Moreover, it contains data about revenues obtained from termination and those obtained from fixed monthly subscription fees. This is important since theoretical predictions depend crucially on the type of competition (linear or non-linear tariffs) and on whether termination-based price discrimination is allowed for or not. The data reveal that only post-pay clients pay monthly fixed fees and that there exist (on average) significant on-net/off-net price differentials. Since post-pay clients make much more calls and generate much more revenues than pre-pay clients, we focus in this article on this segment of the market. Moreover, we will allow firms to charge different prices for on- and off-net calls.

Before we can start with the calibration it is necessary to extend our theoretical model in order to allow for (i) more than two firms, (ii) asymmetries (in market shares and in termination rates), and (iii) call externality. In fact, our theoretical model has been extended and shown to be robust to all three extensions in isolation. However, in order to calibrate the Spanish market we need to extend our model in all three directions simultaneously. Since it is very hard to obtain analytical results for this triple extension, we resort to numerical methods. The first two are necessary since in Spain there are four major firms with very asymmetric market shares. Moreover, not all networks have been subject to the same MTR. We believe the extension to call externalities to be important as it has been argued (e.g. Harbord and Pagnozzi [2010], Harbord and Hoernig [2010]) that if the call externality is very strong, so that people enjoy receiving calls as much as placing calls (or even more, since receiving calls is usually free of charge in Europe) reducing MTRs may be beneficial both to firms and to consumers, despite the reduction in handset subsidies, simply because consumers will receive much more calls when MTRs and, as a consequence, retail prices are reduced.

Our simulation results show that lowering termination rates toward cost is always good for consumer surplus and total welfare but hurts all firms. While the increase in total welfare is mild ($0.5 - 1\%$ per quarter), total profit is seriously affected (from -5.4% to -23%); the improve on consumer surplus is moderate ($1.6\% - 5.4\%$). These figures are, however,

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cation industry into the Laffont, Rey and Tirole (1998a,b) framework and then show that for some parameter range joint profits are maximized at termination charges above cost. Moreover, these papers conclude that the need to regulate termination charges is reduced since the socially optimal termination charge would also be above cost. In contrast, Hurkens and López (2010) find that total welfare is maximized with termination charges at or below cost.

higher for larger values of the call externality parameter. We also obtain that the two larger operators increase their market share as we reduce the level of MTRs. The bill and keep regime yields the better outcome in terms of total welfare.

Our simulations confirm that there exists a partial waterbed effect on the fixed component of the three-part tariff. While the fixed fee decreases as the termination charge increases, firms keep part of termination rents instead of passing them on to their customers; this explains why profit is decreasing in termination charge. As it is shown in Hurkens and López (2010), the partial waterbed effect result is due to the assumption of passive consumer expectations. Nonetheless, we also observe in our asymmetric oligopoly model that lowering MTR does not always lead to increases in the fixed fee. This is the case for the largest firm, which may reduce its fixed fee for a strong call externality. On the other hand, above cost termination charges may induce the smallest operator to offer negative fixed fees (i.e., subsidies); still it makes positive profit because of termination revenues. Finally, we explore the impact of asymmetric termination rates on competition and welfare. We first consider asymmetric access price regulation of the form that the smallest firm (i.e. Yoigo) is allowed to charge an access markup, whereas the rest of firms are subject to cost-based regulation. The result is that Yoigo gains and other firms loose. Although granting an access markup to the smallest operator slightly raises consumer surplus, it does reduce total welfare. This result is analogous to that of Peitz (2005) for two firms and no call externality. Finally, when also Orange (which is the third operator in the market) is granted an access markup, both Yoigo and Orange benefit. In addition, Orange increases its market share at the expense of the two larger operators (i.e. Movistar and Vodafone).

The plan of the paper is as follows. Section II introduces the model. Section III calibrates the model with Spanish market data reported by CMT. Section IV reports our simulation results and Section V concludes. All figures are gathered in the Appendix.

2 The Model

To estimate the impact on total welfare, consumer surplus and producer surplus of regulation in the Spanish market we need to consider a model of competition between multiple networks with asymmetric market shares. In addition, the model must allow for price discrimination between on-net and off-net calls and consider call externalities.

As commented above, in Hurkens and López (2010) we analyzed competition between (i) an arbitrary number of networks, (ii) asymmetries, and (iii) call externality. However, we examined each case in isolation. For our purposes we need to extend our theoretical model in all three directions simultaneously. The general model will be constructed as follows: (i) to consider an arbitrary number of networks and imperfect competition we will use the Logit model, (ii) to introduce asymmetries in market shares we will allow for a brand loyalty parameter (as in Carter and Wright [1999, 2003]), (iii) finally, we will introduce call externality by assuming that receivers obtain utility from receiving a call, as in Jeon et al. (2004), Berger (2004, 2005), and López (2011).

We will relax the assumption of rationally responsive expectations and replace it by one of fulfilled equilibrium expectations (as in Hurkens and López [2010]): First consumers form expectations about network sizes, then firms set prices, and finally consumers make optimal subscription or purchasing decisions, given the expectations and the prices.[2] In equilibrium, realized and expected network sizes coincide. We know that under rationally responsive expectations, while reducing mobile termination rates to cost raises total surplus, it may decrease consumer surplus. In particular, consumer surplus increases when termination rates are lowered only if the call externality is very strong. However, under (passive) self-fulfilling expectations, decreasing termination rates raises consumer surplus even if the call externality is low.

The model we consider is a generalization of the network competition model with (passive) self-fulfilling expectations. We consider competition between $n \geq 2$ full-coverage networks. Each has the same cost structure. The marginal cost of a call equals $c = c_O + c_T$, where c_O and c_T denote the costs borne by the originating and terminating network, respectively. To terminate an off-net call, the originating network $j \neq i$ must pay a non-negative access charge a_i to the terminating network i. The termination mark-up from terminating a call in network i is equal to

$$m_i \equiv a_i - c_T.$$

Networks (i.e., firms) offer differentiated but substitutable services. Firms compete for a continuum of consumers of mass M. Each firm i $(i = 1, ..., n)$ charges a fixed fee F_i and may discriminate between on-net and off-net calls. Firm i's marginal on-net price is written p_{ii} and off-net price for a call from network i to network j is written p_{ij}. Consumer's utility from making calls of length q is given by a concave, increasing and bounded utility function $u(q)$, whereas consumer's utility from receiving a call of that length is $\overline{u}(q)$. We assume that $\overline{u} = \beta u$. Call demand $q(p)$ is defined by $u'(q(p)) = p$. The indirect utility derived from making calls at price p is $v(p) = u(q(p)) - pq(p)$. For given prices p_{ii} and p_{ij}, the profit

[2] Instead, under rationally responsive expectations the literature assumes that first firms offer prices, then consumers form expectations about network sizes and make optimal subscription decisions, given the prices and their expectations. This means that for all prices (even for those out of the equilibrium) expectations are required to be self-fulfilling.

earned on the on-net calls is

$$R(p_{ii}) = (p_{ii} - c)q(p_i),$$

whereas the profit earned on the off-net calls to network j is

$$\hat{R}_j(p_{ij}) = (p_{ij} - c - m_j)q(p_{ij}).$$

In order to calibrate the model we shall assume that call demand is linear. Thus, $R(p)$ has a unique maximum at $p = p^M$, is increasing when $p < p^M$, and decreasing when $p > p^M$, where p^M denotes the monopoly price.

We make the standard assumption of a balanced calling pattern, which means that the percentage of calls originating on a given network and completed on another given (including the same) network is equal to the fraction of consumers subscribing to the terminating network. Let α_i denote the market share of network i. The profit of network i is therefore equal to:

$$\pi_i \equiv \alpha_i M \left(\alpha_i R(p_{ii}) + \sum\nolimits_{j \neq i} \alpha_j \hat{R}_j(p_{ij}) + \sum\nolimits_{j \neq i} \alpha_j m_i q(p_{ji}) + F_i - f \right). \tag{1}$$

Market share. The n firms have complete coverage and compete for a continuum of consumers of mass M. Market shares are derived using a Logit model. Given some expectations β_i and prices, a customer subscribed to firm i obtains the following utility

$$w_i = \gamma_i + \beta_i[v(p_{ii}) + \overline{u}(q(p_{ii}))] + \sum\nolimits_{j \neq i} \beta_j \left[v(p_{ij}) + \overline{u}(q(p_{ji}))\right] - F_i,$$

where $\gamma_i \geq 0$ is the brand loyalty parameter for network i.

We now add a random noise term and define $U_i = w_i + \mu\varepsilon_i$, for $i = 1...n$. The parameter $\mu > 0$ reflects the degree of product differentiation in a Logit model. A high value of μ implies that most of the value is determined by a random draw so that competition between the firms is rather weak. The noise terms ε_i are random variables of zero mean and unit variance, identically and independently double exponentially distributed. They reflect consumers' preference for one good over another. A consumer will subscribe to network i if and only if $U_i > U_j$ for $j \neq i = 1...n$. The probability of subscribing to network i is denoted by α_i where

$$\alpha_i = \frac{\exp[w_i/\mu]}{\sum_{k=1}^{n} \exp[w_k/\mu]}. \tag{2}$$

Note that

$$\frac{\partial \alpha_i}{\partial F_i} = -\frac{\alpha_i(1 - \alpha_i)}{\mu}, \tag{3}$$

while for $j \neq i$

$$\frac{\partial \alpha_j}{\partial F_i} = \frac{\alpha_i \alpha_j}{\mu}. \tag{4}$$

Consumer surplus. Consumer surplus in the Logit model has been derived by Small and Rosen (1981) and for a mass $M = 1$ is given by (up to a constant)

$$CS = \mu \ln \left(\sum_{k=1}^{n} \exp[w_k/\mu] \right). \tag{5}$$

Timing. The terms of interconnection are regulated. Given access charges $\{a_1, ..., a_n\}$ (or equivalently, given termination mark-ups $\{m_1, ..., m_n\}$) the timing of the game is as follows:

1. Consumers form expectations β_i about the number of subscribers of each network i with $\beta_i \geq 0$, and $\sum_i \beta_i = 1$ (i.e. we assume full participation).

2. Firms take these expectations as given and choose simultaneously retail tariffs $T_i = (F_i, \{p_{ij}\}_{j=1}^n)$.

3. Consumers make rational subscription and consumption decisions, given their expectations and given the networks' tariffs.

Therefore, market share α_i is a function of prices and consumer expectations. Self-fulfilling expectations imply that at equilibrium $\beta_i = \alpha_i$.

Call prices. It is straightforward to show that the optimal on-net price equals

$$p_{ii} = \frac{c}{1+\beta}. \tag{6}$$

This price maximizes the total surplus from on-net calls. Note that this price is equal to cost when there is no call externality (that is, when $\beta = 0$) but is strictly below cost when call externalities exist. In this way the network perfectly internalizes the externality.

In order to obtain the formula for off-net prices, we need to resort to the usual perceived marginal cost principle: a firm can offer its subscribers the same surplus more efficiently by setting p_{ij} closer to cost while adjusting the fixed fee F_i accordingly. When there is no call externality this yields $p_{ij} = c + m_j$. However, when there exist call externalities one needs to be careful in an oligopoly with at least three firms. For example, lowering p_{ij} will improve the welfare of consumers on networks i and j, but not on other networks k. Raising F_i so as to maintain the number of subscribers of network i constant is possible. However, the relative market shares of networks j and k would change. In this example, α_j/α_k would increase. It would thus not be correct to assume that *all* market shares remain constant. To circumvent this problem we will assume that each network i charges a uniform off-net price $\hat{p}_i$ for calls to all networks $j \neq i$. In this case, a change in $\hat{p}_i$ affects all subscribers from networks $j \neq i$ equally and thus keeps their relative market shares constant. Adjusting F_i to keep α_i constant now implies that in fact all market shares are kept constant. It is straightforward to show that the optimal off-net price equals

$$\hat{p}_i = \frac{\sum_{j \neq i} \alpha_j (c + m_j)}{1 - (1 + \beta)\alpha_i}. \tag{7}$$

Note that this off-net price increases in the call externality parameter. The higher the benefit of receiving calls, the higher will be the optimal off-net price in order to reduce the relative attractiveness of rival networks.

Fixed fees. The fixed fees are obtained by keeping call prices constant in the profit function and computing the first-order conditions using equations (3) and (4). After substituting the call prices found in equations (6) and (7) this yields

$$F_i = f + \frac{\mu}{1 - \alpha_i} - 2\alpha_i R(p_{ii}) + \frac{2\alpha_i}{1 - \alpha_i} \sum_{j \neq i} \alpha_j \hat{R}_j(\hat{p}_i) + \frac{2\alpha_i}{1 - \alpha_i} \sum_{j \neq i} \alpha_j m_i q(\hat{p}_j). \tag{8}$$

Equilibrium. The equilibrium prices are given in terms of market shares, which are endogenous. In order to solve for the equilibrium market shares one needs to combine equations (6), (7), (8) and (2). Analytically this is hard, if not impossible, to do but numerically there is no problem, as long as one knows the termination charges, call demand, the strength of the call externality and the cost, product differentiation and brand loyalty parameters. We will calibrate most of these parameters using publicly available data from CMT, the Spanish national regulatory authority. We use data from the last quarter of 2010 reported in CMT (2010).

3 Calibration of parameters

The Spanish market has four major networks, plus several small virtual network operators. We restrict attention to the four major networks, Movistar, Vodafone, Orange and Yoigo.[3] Since our model assumes firms compete in non-linear tariffs, we use only the data pertaining to post-pay customers. Table I reports the number of lines and relative market shares.

[3] The rest are MVNOs, which accounted for about 2.3% of post-pay mobile subscriptions in the last quarter of 2010 (Table 67, CMT, 2010).

Network	Post-Pay Lines	Market Share (%)
(1) Movistar	13723681	44.7
(2) Vodafone	9418402	31.7
(3) Orange	6454558	21.0
(4) Yoigo	1119354	3.6
Total	30715995	100.0

Table 1: Subscribers and Market shares in 2010Q4

The costs of origination and termination of a call is estimated at €0.0245/minute.[4] We have no evidence on the fixed cost per subscriber. We assume $f = 0$. It does not influence directly the loss in industry profit or the gain in consumer surplus as a result of lowering termination rates. However, it does indirectly influence the results since we will calibrate product differentiation parameter μ from the observed and predicted average fixed fees. However, our results appear to be very robust to changes in μ so that we do not expect this assumption to affect the results significantly.

We calibrate the call demand function by imposing linearity, assuming that price elasticity equals -0.5[5] and by observing from the CMT data that average call price for post-pay clients is equal to $\bar{p} = 0.108462$ (found by dividing total revenue from call minutes by the number of minutes).[6] We find $q(p) = \bar{a} - \bar{b}p$ where

$$\bar{a} = 654.9 \text{ and } \bar{b} = 2012.7.$$

Note that this call demand function should be interpreted as the total number of minutes called by a single subscriber, assuming that each subscriber calls a mass 1 of other subscribers, each with equal probability. Of course, in reality people make more calls of shorter duration, but that does not influence the analysis. Our approach in this respect follows closely de Bijl and Peitz (2000, 2004).

We assume that in the last quarter of 2010 networks played the equilibrium, given the existing termination rates. These termination rates were equal to €0.049505/minute for the three largest firms and €0.067361/minute for the smallest operator Yoigo (CMT, 2009). Let

[4] This estimate is provided by the Spanish regulator (CMT, 2009) in the Resolution approving the establishment of a glide-path from October 2009 until April 2012. Also, the French regulator estimates that the long-run incremental cost on mobile networks lies between 1 and 2 euro-cents (ARCEP, 2008). Harbord and Hoernig (2010) assume a long-run marginal or incremental cost of originating and terminating calls on mobile networks of 1ppm.

[5] Harbord and Hoernig (2010) argue that an elasticity of demand for mobile-originated calls of -0.5 is consistent with the recent literature (Dewenter and Haucap [2008]), the UK Competition Commission (2003) and Ofcom.

[6] See tables 48 and 56 in CMT (2010).

us denote this combination of termination charges by a^{2010}. This means that the observed market shares for 2010Q4 are the equilibrium market shares. We can obtain the on-net and off-net call prices (as a function of the unknown call externality parameter β). Similarly, we can find the equilibrium fixed fees, which will depend on β and μ. In order to calibrate μ we use the observation from the data about average fixed fees among post-pay subscribers. This average fixed fee in 2010Q4 was 11.61 euros (per quarter).[7] We can calibrate μ from solving

$$\sum_k \alpha_k F_k = 11.64.$$

This yields μ as a function of β.[8]

Finally, substituting the calibrated μ and using the prices obtained, the formulas for market shares in the Logit model will yield us the brand loyalty parameters (all as functions of β). To be precise, it will yield us the difference in brand loyalty parameters $\gamma_1 - \gamma_2$, $\gamma_2 - \gamma_3$, and $\gamma_3 - \gamma_4$. Since only the differences matter, we assume without loss of generality that $\gamma_4 = 0$.

We could try to calibrate the call externality parameter β by observing that the difference between average off-net price and on-net price equals 0.0322.[9] The theoretical difference between average off-net and on-net prices is increasing in β. For $\beta = 0$ this difference equals approximately 0.026. This is obtained from the formulas for on- and off-net prices (6) and (7) and from the observation that average off-net price equals

$$\frac{\sum_k \alpha_k (1-\alpha_k) q(\hat{p}_k) \hat{p}_k}{\sum_k \alpha_k (1-\alpha_k) q(\hat{p}_k)}.$$

We can calibrate β by solving for the value that matches theoretical and observed difference between average off-net and on-net prices. This yields $\beta^* = 0.0727$. It suggests the call externality is very mild. On the other hand, we know that in reality not all post-pay contracts involve termination-based price discrimination. Some contracts will specify uniform call prices. This obviously reduces the observed on-net/off-net price differential. The true call externality may thus be stronger than β^*. Since we have no data on the proportion of contracts with termination-based price discrimination, we are not able to get a more precise calibration result. Still, if the call externality were very strong, firms would have incentives to create a large difference between prices for off-net and on-net calls and would not be very tempted to offer contracts with uniform prices. One may expect that firms only offer uniform calls prices if the gain from optimal termination-based price discrimination is small compared

[7] See Table 58 in CMT (2010).

[8] In our simulations μ decreases with β: from 10.27 for $\beta = 0$ to 6.67 for $\beta = 0.8$.

[9] This can be deduced from the numbers for on- and off-net calls in Tables 48 and 56 of CMT (2010).

to the attractiveness of offering a simple uniform tariffs. This then would again suggest that call externalities are not extremely strong. Also note that for $\beta > 0.95$ the largest firm would, in theory, set the off-net price so high as to choke-off off-net calls altogether.[10] In most of the simulation results we report we let $\beta \in [0, 0.8]$ but values between 0.1 and 0.3 seem more plausible to us.

4 Simulation results

In this section, we first explore the implications of various schemes for termination rates. Secondly, we address the issue of asymmetric termination rates. We use the calibrated model to simulate how prices, consumer surplus, profits and welfare change under different MTR regimes. The first regime we consider is the one that will be in place at 2012Q1 according to the glide-path announced by CMT. These termination rates are

$$a^{2012} = (0.04, 0.04, 0.04, 0.049764).$$

That is, €0.04/minute for Movistar, Vodafone and Orange, and €0.049764/minute for Yoigo. The next regime we simulate is where all termination rates are set equal to the cost of termination, that is, $a_i = a^{c-b} \equiv 0.0245$. Finally, we also consider the outcomes under a hypothetical regime of bill and keep with $a_i = a^{b\&k} \equiv 0$. The bill and keep regime is special since below cost termination charges may lead some firms to set off-net price *below* on-net price, especially when the call externality is relatively weak. We believe that such pricing strategies are hard to implement. Therefore we impose that off-net prices cannot be below on-net price. This implies that when firms would want to do this, they in fact must charge a uniform price for on- and off-net calls. This price would be equal to perceived marginal cost, so that firm i would then charge $p_{ii} = \hat{p}_i = \alpha_i c + (1 - \alpha_i) c_O$.

4.1 Alternative scenarios of future termination rates

We first report simulation results for prices, market shares and individual profits. Then, we discuss the implications of these results on total consumer surplus, total profit and total welfare.

Prices. Figures 1 and 2 illustrate the outcomes in fixed fees and usage prices of various interconnection arrangements $(a^{2010}, a^{2012}, a^{c-b}, a^{b\&k})$ for $\beta \in [0, 0.8]$. Not surprisingly, the off-net price increases with the level of the access charge and β. Earlier we noted that firms

[10] Because $q(p) = 0$ for $p > 0.325$.

have incentives to raise off-net prices when the benefit of receiving calls is higher because this reduces the relative attractiveness of rival networks. However, Figure 1 shows that Yoigo has little incentive to do this. The reason is that the amount of calls originated in that network is small. Hence Yoigo harms the customers of rival networks very little when it increases the off-net price.

Since off-net price is increasing in the access charge, for a sufficiently low access charge it may happen that off-net price lies below on-net price. In particular, we observe that this is the case when the bill and keep regime is adopted. Here there is a critical level of β below which on-net price will be higher than off-net price, in which case we assume that firms set a uniform price. In our simulations, we identify four clear regions: (1) $\beta < 0.29$, (2) $0.29 \leq \beta < 0.51$, (3) $0.51 \leq \beta < 0.68$, and (4) $\beta \geq 0.68$. As Figure 1 shows, under the bill and keep regime, when $\beta > 0.68$ on-net price lies below off-net price for all firms. When $\beta < 0.68$ Orange's off-net price is lower than its on-net price, thereby in this region Orange sets the same price for on-net and off-net prices. Similarly, Vodafone and Movistar charge a uniform price for $\beta < 0.51$ and $\beta < 0.29$, respectively.

Regarding the fixed fees the following points should be noted. There exists a waterbed effect on the fixed component of the three-part tariff. This result is perfectly consistent with what the theoretical result established in Hurkens and López (2010) led us to expect. The number of off-net calls terminated on network i equals $n_i = \alpha_i(1-\alpha_i)$ which is increasing in α_i when $\alpha_i < 1/2$. Therefore, as the termination rate increases, the profit from terminating calls increases and each firm will compete more fiercely for market share. Yet, as will be clear below, the waterbed effect is not full. This means that firms keep part of termination rents instead of passing them on to their customers, and thus their profit is lower when the termination rate decreases. As it is shown in Hurkens and López (2010), the partial waterbed effect result is due to the assumption of passive consumer expectations. We say that they are passive in the sense that they do not respond to out of equilibrium deviations by firms. Under rationally responsive expectations, however, the waterbed effect would be higher than one hundred per cent. Consumers having rationally responsive expectations means that any change of a price by one firm is assumed to lead to an instantaneous rational change in expectations of all consumers, such that, given these changed expectations, optimal subscription decisions will lead realized and expected network sizes to coincide. (For a detailed discussion of consumer expectations and termination rates see Hurkens and López [2010].) Remarkably, lowering MTR does not always lead to increases in the fixed fee. As Figure 2 illustrates, Movistar's fixed fee is lower with a^{2012} and a^{c-b} than with a^{2010} when the call externality is strong (i.e. for $\beta > 0.7$). It is this last result which is not intuitively immediate. A glance at equation (7) tells us that for large market share and strong call externality, off-net price is also high. Then, the amount of off-net calls originated on the large network is low when β is high. Reducing the termination charge, brings down the off-net price of the large network, which boosts the amount of off-net calls originated in that network and thereby raises significantly the relative attractiveness of rival networks (since β is high). This leads the large network to reduce its fixed fee so as to maintain its market share.

Simulations show that Yoigo's fixed fee is negative with a^{2010} and a^{2012}. The rest of firms has a substantial advantage in demand because of incumbency. Therefore, Yoigo has to compete more aggressively than its rivals to get some market share. As commented above, the greater is the termination charge the more intense is competition. As Yoigo has to undercut the price of its rivals so as to get some market share, high termination charges lead Yoigo to offer subsidies. Still Yoigo makes positive profit because of termination revenues.

Market shares. Market shares are affected by termination rates through their impact on prices. Figure 3 illustrates the effect of termination charges on market shares for different values of β. Let us first turn our attention to the cases: a^{2010}, a^{2012}, and a^{c-b}. We observe that the market share of the two largest operators (Movistar and Vodafone) is higher when the access charge decreases. Conversely, the Orange's market share is lower with a^{2012} (respectively a^{c-b}) than with a^{2010} for $\beta < 0.4$ ($\beta < 0.6$). Similarly, the Yoigo's market share is increasing with the access charge, its market share is thus lower with a^{2012} and a^{c-b} than with a^{2010}. The appropriate conclusion seems to be that decreasing the access charge favours (in terms of market shares) the larger operators. The reason is that reducing the termination charge reduces the incentives for firms to compete for market share, this in turn makes it easier for the two larger operators to increase their market share at the expense of the smaller operators. Turning now to the bill and keep regime, it is interesting to note that for moderate values of the call externality parameter, Movistar increases significantly its market share at the expense of rivals' customer bases.

Profit. Firms' profit is typically increasing in the access charge. It has already been noted that the waterbed effect is not full. Therefore, as firms keep part of the termination rents instead of passing them to their customers, they suffer from cuts in termination rates. The worst scenario from the viewpoint of firms is adopting the bill and keep regime. In this case, Vodafone yields the lowest profit for $\beta = 0.3$ (i.e., when Movistar starts to charge different prices for on- and off-net calls), whereas Orange reaches its lowest profit for $\beta = 0.5$ (i.e., when Vodafone starts to charge different prices for on- and off-net calls). We also note that for access charges at or above cost, the profit of the two larger operators is increasing in β (as long as it is not too high). Conversely, for low/moderate values of β, Orange and Yoigo's profit decrease with β.

	$\Delta\%\ TCS$				$\Delta\%\ TP$				$\Delta\%\ TW$			
β	0.1	0.3	0.5	0.7	0.1	0.3	0.5	0.7	0.1	0.3	0.5	0.7
a^{2012}	1.6	1.7	2.1	3.4	-5.4	-5.0	-4.6	-4.8	0.5	0.8	1.1	2.2
a^{c-b}	4.2	4.6	5.4	7.9	-16.9	-15.9	-14.7	-14.3	1.0	1.6	2.5	4.6
$a^{b\&k}$	5.4	8.2	10.1	13.9	-23.4	-32.8	-34.9	-35.2	1.0	2.3	3.7	6.8

Table 2: % Change in Total Consumer Surplus, Total Profits and Total Welfare Over a^{2010}

Aggregate surpluses and total welfare. We now proceed to analyse the impact of termination charges on aggregate surpluses and total welfare. We compute total consumer surplus ($TCS \equiv M * CS$), total profits ($TP \equiv \sum_{i=1}^{4} \pi_i$) and total welfare ($TW$) which equals the sum of the two previous terms. In Hurkens and López (2010) we already showed that for $\beta = 0$ total welfare is maximized with termination charges at cost (a^{c-b}), whereas consumer surplus is maximized with a below-cost termination charge. According to our simulations, for $\beta = 0$ total consumer surplus is 3.9% higher with $a^{b\&k}$ than with a^{2010}, total welfare is 0.72% higher with a^{c-b} than with a^{2010}, and total profits is 17.1% lower with a^{c-b} than with a^{2010}, and 17.3% lower with $a^{b\&k}$ than with a^{2010}. Table II details the change in aggregate surpluses of various interconnection arrangements over a^{2010} for different positive values of the call externality parameter β (results are reported in percentage).

Not surprisingly, total consumer surplus and total welfare are decreasing in termination charge, whereas total profit is increasing in termination charge. What is striking about Table II however, is the small change on total welfare and the large change on total profit when the industry adopts the bill and keep regime, as compared to the base scenario a^{2010}. In particular, for $\beta = 0.1$ total consumer surplus and total welfare increase by 5 and 1% respectively, whereas total profit decreases by 23%.

4.2 Asymmetric termination rates

The focus of this paper has been to examine the implication of alternative scenarios of future termination rates. The case of asymmetric termination rates is of particular interest. For this reason, we compare the case where all firms' MTRs are regulated at cost with the one where only the smallest and most recent entrant Yoigo is allowed to charge $a_4 = 0.04$ (denoted by a^*); and the one where both Yoigo and Orange are allowed to charge an MTR equal to 0.04 (denoted by a'). Table III details the outcomes. Clearly Yoigo gains and the other firms loose from getting the exclusive preferential treatment a^*. Yoigo's profit increases above 100% because its starting profit is small. Notice that consumers are also better off, whereas total welfare is reduced. This result is in line with Peitz (2005). He considers an asymmetric market and termination-based price discrimination, and shows that by granting

β		α_1	α_2	α_3	α_4	$\Delta\pi_3$	$\Delta\pi_4$	ΔCS	ΔTW
	a^{c-b}	0.47	0.31	0.19	0.01				
0.1	a^*	0.47	0.30	0.19	0.02	-2.89%	138%	0.05%	-0.12%
	a'	0.44	0.27	0.26	0.02	70.27%	92%	-0.24%	-0.48%
	a^{c-b}	0.47	0.31	0.19	0.01				
0.3	a^*	0.47	0.30	0.19	0.02	-3.61%	159%	0.07%	-0.13%
	a'	0.44	0.27	0.25	0.02	69.75%	101%	-0.21%	-0.56%
	a^{c-b}	0.46	0.31	0.20	0.01				
0.5	a^*	0.46	0.31	0.19	0.02	-4.55%	168%	0.11%	-0.14%
	a'	0.44	0.27	0.25	0.02	63.32%	101%	-0.17%	-0.62%
	a^{c-b}	0.44	0.32	0.21	0.01				
0.8	a^*	0.44	0.31	0.20	0.03	-5.9%	163%	0.21%	-0.12%
	a'	0.42	0.28	0.25	0.02	53.22%	94.84%	-0.16%	-0.65%

Table 3: Change in Orange and Yoigo's Profit, Consumer Surplus and Total Welfare Over Cost-Based Access Charges (a^{c-b})

an access markup to the smaller operator, its profit and consumer surplus increase, whereas total surplus decreases. Our simulations show that this result holds in asymmetric oligopolies with passive expectations and positive call externality. However, since Yoigo is very small, the aggregate effects are really minor. When also Orange is allowed to charge 0.04 for terminating calls, it benefits a lot and Movistar and Vodafone are hurt. In particular, Orange increases its market share at the expense of Movistar and Vodafone's customer bases. The effect on Yoigo's profit is also positive because of termination revenues. Nonetheless, consumer surplus and total welfare decrease for all values of the call externality parameter.

5 Conclusion

We have shown that the effects of MTR regulation can be predicted by first calibrating the model of Hurkens and López (2010) (extended to account for asymmetries and call externalities) and then calculating equilibrium outcome under different MTR regimes. We did this for the Spanish market and found that lowering termination rates toward cost is always good for consumer surplus and total welfare but hurts all firms. As we reduce the level of MTRs, firms' profit significantly decrease, whereas the impact of reducing termination charges on consumer surplus and welfare is moderate and mild respectively. Remarkably, lowering MTR does not always lead to increases in the fixed fee. We saw that the largest firm may actually reduce fixed fee when call externality is strong. In addition, market shares of the two larger firms typically increase as the termination charge decreases. Our simulations also show that above-cost termination charges may induce the smallest operator to offer subsidies so as to capture some market share. Asymmetric termination rates of the form that the smaller firms are allowed to charge an access markup, whereas the larger firms are subject to cost-based regulation results in higher profits for the smaller firms but also in lower total welfare.

References

[1] ARCEP (2008). *Les Référentiels de Coûts de Opérateurs Mobiles en 2008,* Paris.

[2] Armstrong, M. & Wright, J. (2009). Mobile Call Termination. *Economic Journal,* 119: F270-F307.

[3] Berger, U. (2004). Access Charges in the Presence of Call Externalities. *Contributions to Economic Analysis & Policy* 3: Iss. 1, Article 21.

[4] Berger, U. (2005). Bill-and-Keep vs. Cost-Based Access Pricing. *Economics Letters,* 86: 107-112.

[5] Carter, M. & J. Wright. (1999). Interconnection in Network Industries. *Review of Industrial Organization*, 14: 1-25.

[6] Carter, M. & J. Wright. (2003). Asymmetric Network Interconnection. *Review of Industrial Organization*, 22: 27-46.

[7] Competition Commission (2003). *Vodafone, O2, Orange and T-Mobile: Reports on References Under Section 13 of Telecommunications Act 1984 on Charges Made by Vodafone, Orange, O2 and T-Mobile for Terminating Calls Made by Fixed and Mobile Networks, HMSO, London.*

[8] CMT (2009). *Resolution Approving the Establishment of a Glide-Path to Set Prices for Voice Termination Connection Services on Mobile Networks Belonging to Operators Determined to Have Significant Market Power.* (July 29, 2009).

[9] CMT (2010). *Estadísticas del sector: IV Trimestre - 2010.* Available at: http://www.cmt.es/es/publicaciones/anexos/20110401_IVT_2010_.pdf

[10] De Bijl, P.W.J., & Peitz, M. (2000). *Competition and regulation in telecommunications markets.* CPB Netherlands Bureau for Economic Policy Analysis. Hague, Netherlands.

[11] De Bijl, P.W.J., & Peitz, M. (2004). Dynamic regulation and entry in telecommunications markets: a policy framework. *Information Economics and Policy* 16: 411-437.

[12] Dewenter, R. & Haucap, J. (2008). Demand elasticities for mobile telecommunications in Austria. *Journal of Economics and Statistics,* 228: 49-63.

[13] EC 2009. *Commission Recommendation on the Regulatory Treatment of Fixed and Mobile Termination rates in the EU.* (2009/396/EC). *Official Journal of the European Union* (May 20, 2009), L124/67-L124/74.

[14] Gans, J.S., & King, S.P. (2001). Using '*Bill and Keep*' Interconnect Arrangements to Soften Network Competition. *Economics Letters*, 71: 413-420.

[15] Harbord, D. & Hoernig, S. (2010). Welfare Analysis of Regulating Mobile Termination Rates in the UK (with an Application to the Orange/T-Mobile Merger). CEPR Discussion Paper 7730.

[16] Harbord, D. & Pagnozzi, M. (2010). Network-based price discrimination and 'bill and keep' vs. 'cost-based' regulation of mobile termination rates. *Review of Network Economics* 9(1), Article 1.

[17] Hoernig, S., Inderst, R., & Valletti, T. (2009). Calling Clubs: Network Competition with Non-Uniform Calling Patterns. Mimeo.

[18] Hurkens, S. & Jeon, D.S. (2009). Mobile Termination and Mobile Penetration. UFAE and IAE Working Papers, 774.09.

[19] Hurkens, S. & López. A.L. (2010). Mobile Termination, Network Externalities, and Consumer Expectations. IESE Working Paper D/850-E.

[20] Jeon, D.S., Laffont, J.J., & Tirole, J. (2004). On the "Receiver-Pays" Principle. *Rand Journal of Economics,*35: 85-110.

[21] Jullien, B., Rey, P. & Sand-Zantman, W. (2009). Mobile Call Termination revisited. *IDEI Working Paper*, n^o 551.

[22] Katz, M.L. & Shapiro, C.S. (1985). Network Externalities, Competition, and Compatibility. *American Economic Review,* 75: 424-440.

[23] Laffont, J.J., Rey, P. & Tirole, J. (1998a). Network Competition I: Overview and Nondiscriminatory Pricing. *Rand Journal of Economics*, 29: 1-37.

[24] Laffont, J.J., Rey, P. & Tirole, J. (1998b). Network Competition II: Price Discrimination. *Rand Journal of Economics,* 29: 38-56.

[25] López, A.L. (2011). Mobile termination rates and the receiver-pays regime. *Information Economics and Policy,* 23: 171-181.

[26] Peitz, M. (2005). Asymmetric regulation of access and price discrimination in telecommunications. *Journal of Regulatory Economics* 28: 327-343.

Appendix

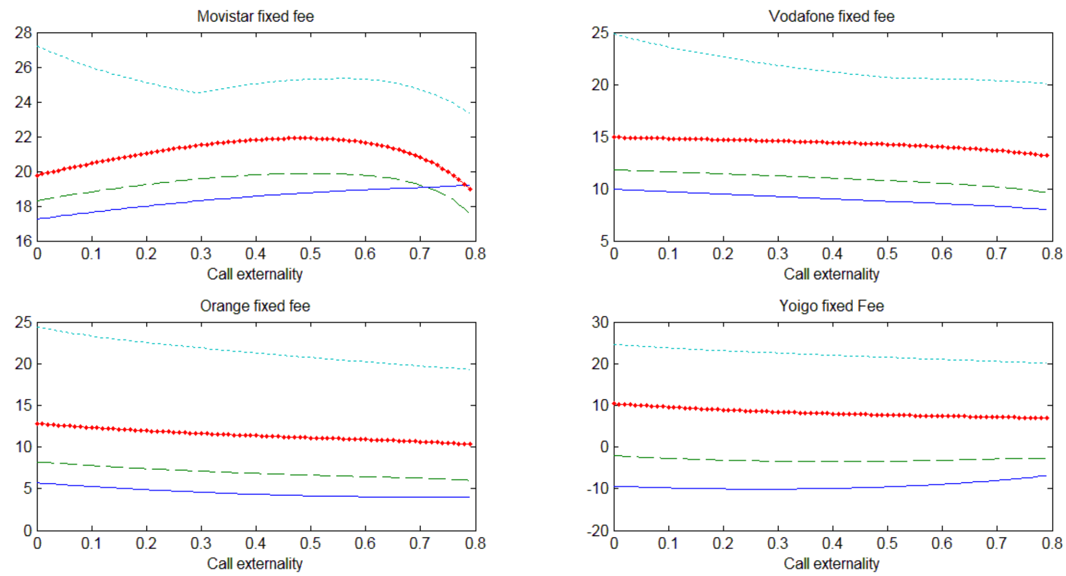

Figure 1: Equilibrium Fixed Fees [a^{2010} (-), a^{2012} (- -), a^{c-b} (.-), $a^{b\&k}$ (..)]

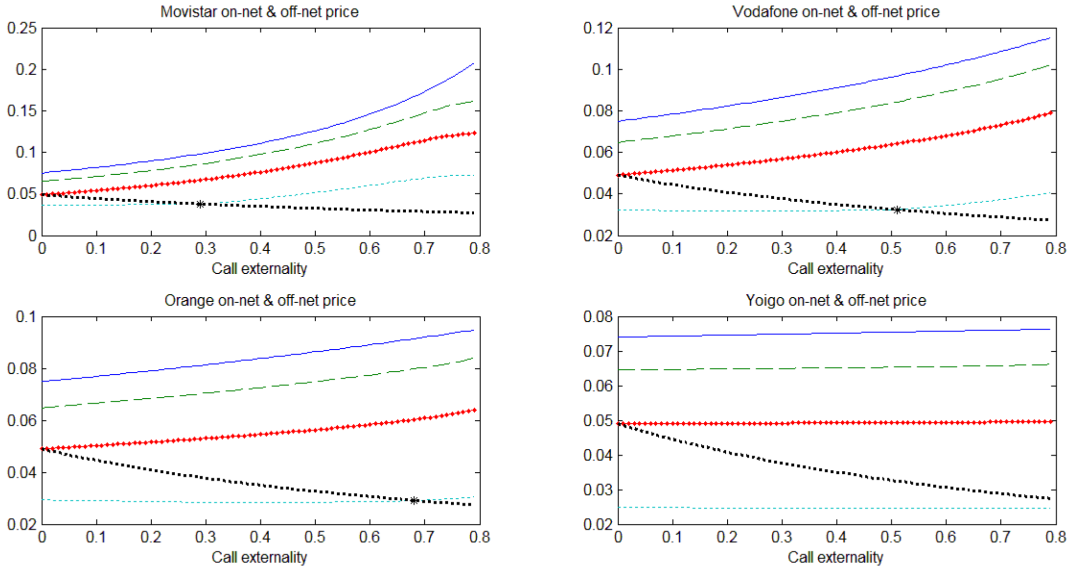

Figure 2: Equilibrium Off-Net Prices [a^{2010} (-), a^{2012} (- -), a^{c-b} (.-), $a^{b\&k}$ (..)] and On-Net Price (bold dashed line)

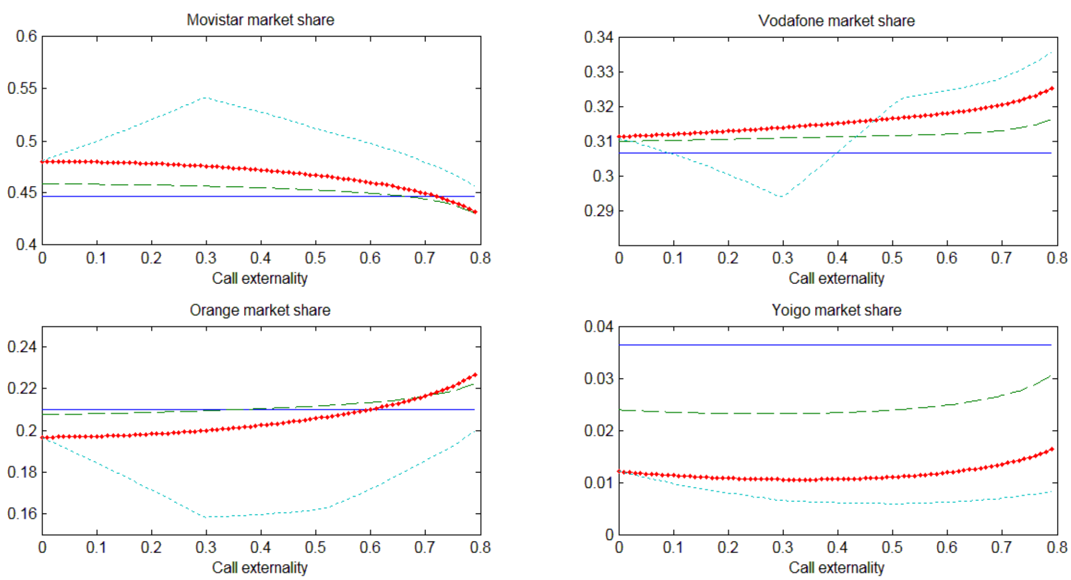

Figure 3: Equilibrium Market Shares [a^{2010} (-), a^{2012} (- -), a^{c-b} (.-), $a^{b\&k}$ (..)]

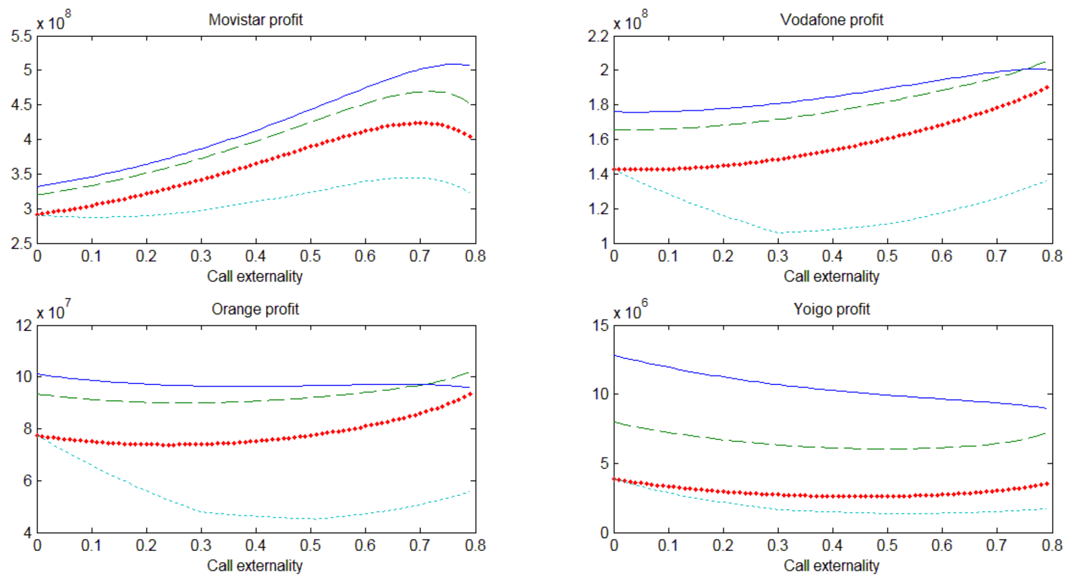

Figure 4: Equilibrium Profits [a^{2010} (-), a^{2012} (- -), a^{c-b} (.-), $a^{b\&k}$ (..)]