

# The welfare effects of mobile termination rate regulation in asymmetric oligopolies: The case of Spain<sup>1</sup>

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## **Abstract**

This paper examines the effects of mobile termination rate regulation in asymmetric oligopolies. It extends existing models of asymmetric duopoly and symmetric oligopoly where consumer expectations about market shares are passive. First, demand and product differentiation parameters are calibrated using detailed data from the Spanish market from 2010. Next, equilibrium outcomes and welfare effects under alternative scenarios of future termination rates are predicted. 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

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. The intervention of European and national regulators has led to a reduction of the average MTR in the EU from €0.1265 to €0.0855 between October 2005 and October 2008.<sup>1</sup> At present, the European Commission recommends national regulatory authorities (NRAs) to push termination rates further down to the cost of terminating a call (estimated to be between 1 and 2 euro cents) 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, & Tirole, 1998b; Gans & 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. It is also inconsistent with the empirical findings of Growitsch, Marcus, and Wernick (2010) who analyzed the effect of a reduction in MTR between 2005 and 2008 on retail price and demand. 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 & Wright, 2009; Hoernig, Inderst, & Valletti, 2011; Jullien, Rey, & Sand-Zantman, 2010)<sup>2</sup>.

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<sup>1</sup>See Growitsch et al. (2010).

<sup>2</sup>These three papers have in common that they introduce additional realistic features of the telecommunication industry into the Laffont et al. (1998a,b) framework and then show that for some parameter range

This article intends to quantify and predict the consumer gains and industry losses of future MTR regulation in Spain by calibrating the Hurkens and López (2010) model. In order to do so this paper employs a rich data set of the Spanish market, made publicly available by CMT, the Spanish NRA. This data set contains not only information 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, the focus in this article will be on this segment of the market. The model will therefore allow for firms to compete in non-linear tariffs with possibly distinct prices for on- and off-net calls.

Before starting with the calibration it is necessary to extend the 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, the theoretical model has been extended and shown to be robust to all three extensions in isolation. However, in order to calibrate the Spanish market it is necessary to extend the model in all three directions simultaneously. Since it is very hard to obtain analytical results for this triple extension, one has to resort to numerical methods. The first two extensions 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. The extension to call externalities is important as it has been argued by Harbord and Pagnozzi (2010) and 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 are reduced, and, as a consequence, retail prices are reduced. In particular, Harbord and Hoernig (2010) calibrate an extension of the Laffont et al. (1998b) model, so as to allow for asymmetric oligopoly and call externality. They find that as MTR is reduced to cost, firms' profits increase for any level of the call externality parameter, whereas total welfare and consumer surplus are decreased for low values of the call externality. In particular, they predict that consumer surplus increases only if the call

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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.

externality parameter exceeds 0.5.

The present paper calibrates the call externality parameter, employing data from the Spanish market, to be very mild, about 0.07. Nevertheless, the simulation results show that lowering termination rates toward cost (from about 5 to 2.45 euro cents) is good for consumer surplus and total welfare but hurts all firms. While the percentage increase in total welfare is mild (+0.9%), total profit is seriously affected (−17%); the improvement in consumer surplus is moderate (+4.1%). In absolute terms, however, consumer surplus increases by about 580 million euros per year. The bill and keep regime yields an even better outcome in terms of consumer surplus.

The simulations confirm that there exists a partial waterbed effect on the fixed component of the three-part tariff.<sup>3</sup> While the (average) fixed fee increases as the termination charge decreases, firms cannot increase it too much so that customers do benefit from lower MTR. The partial waterbed effect also explains why profit is reduced when termination charge is lowered. According to Hurkens and López (2010), the partial waterbed effect result is due to the assumption of passive consumer expectations. Nonetheless, one can observe in the simulated asymmetric oligopoly model that lowering MTR does not always lead to increases in the fixed fee of every firm. In particular, the largest firm may reduce its fixed fee when the call externality is strong. 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, the paper explores the impact of asymmetric termination rates on competition and welfare. Two forms of asymmetric MTR regulation are considered. First, only 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 lose. 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. Second, when both Orange (which is the third operator in the market) and Yoigo are granted an access markup, both firms benefit. In addition, Orange increases its market share at the expense of the two larger operators (i.e. Movistar and Vodafone). In this case consumer surplus is reduced in comparison with the situation where all firms are subject to cost-based regulation.

The plan of the paper is as follows. Section 2 introduces the model. Section 3 calibrates the model with Spanish market data reported by CMT. Section 4 reports the simulation results and Section 5 concludes. The Appendix contains some robustness checks.

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<sup>3</sup>This is consistent with Genakos and Valetti (2011) who empirically find that the waterbed effect is not full.

## 2 The model

To estimate the impact on total welfare, consumer surplus and producer surplus of regulation in the Spanish market one needs 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, Hurkens and López (2010) analyzed competition between (i) an arbitrary number of networks, (ii) asymmetries, and (iii) call externality. However, each case was examined in isolation. In order to calibrate the model for the Spanish market, one needs to extend the 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 the Logit model will be used, (ii) to introduce asymmetries in market shares this paper follows Carter and Wright (1999, 2003) by allowing for a brand loyalty parameter, (iii) finally, call externalities will be introduced by assuming that receivers obtain utility from receiving a call, as in Jeon, Laffont, and Tirole (2004), Berger (2004, 2005), Cambini and Valletti (2008), and López (2011).

The standard assumption of rationally responsive expectations will be relaxed and replaced by one of fulfilled equilibrium expectations (as in Hurkens & 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.<sup>4</sup> In equilibrium, realized and expected network sizes coincide. It is known that under rationally responsive expectations, reducing mobile termination rates to cost raises total surplus, but 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 or even absent.

The model in this paper is a generalization of the network competition model with (passive) self-fulfilling expectations. It considers 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

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<sup>4</sup>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.

$$m_i \equiv a_i - c_T.$$

Networks (i.e., firms) offer differentiated but substitutable services. Firms compete for a continuum of consumers of mass  $M$ . Each firm  $i$  ( $i = 1, \dots, n$ ) 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  $\bar{u}(q)$ . It is assumed that  $\bar{u} = \beta u$ . 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 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 the call demand function is assumed to be 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.

As is standard in the literature, the calling pattern is assumed to be balanced, 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  $\alpha_i$  denote the market share of network  $i$ . The profit of network  $i$  is therefore equal to:

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

*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  $\beta_i$  and prices, a customer subscribed to firm  $i$  obtains the following utility

$$w_i = \gamma_i + \beta_i [v(p_{ii}) + \bar{u}(q(p_{ii}))] + \sum_{j \neq i} \beta_j [v(p_{ij}) + \bar{u}(q(p_{ji}))] - F_i,$$

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

Define  $U_i = w_i + \mu \varepsilon_i$ , for  $i = 1, \dots, n$ . The noise terms  $\varepsilon_i$  are random variables of zero mean and unit variance, identically and independently double exponentially distributed.

They reflect consumers' preference for one good over another. The parameter  $\mu > 0$  reflects the degree of product differentiation in a Logit model. A high value of  $\mu$  implies that most of the value is determined by the random draw so that competition between the firms is rather weak. A consumer will subscribe to network  $i$  if and only if  $U_i > U_j$  for  $j \neq i = 1, \dots, n$ . The probability of subscribing to network  $i$  is denoted by  $\alpha_i$  where

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

Note that

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

while for  $j \neq i$

$$\frac{\partial \alpha_j}{\partial F_i} = \frac{\alpha_i \alpha_j}{\mu}. \quad (4)$$

*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)

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

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

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

$$p_{ii} = \frac{c}{1 + \beta}. \quad (6)$$

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, one needs 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,  $\alpha_j/\alpha_k$  would increase. It would thus not be correct to assume that *all* market shares remain constant. To circumvent this problem, 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  $\alpha_i$  constant now implies that in fact all market shares are kept constant. It is straightforward to show that the optimal off-net price equals

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

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

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

*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. Most of these parameters will be calibrated using publicly available data from CMT, the Spanish national regulatory authority. For these calibrations the data from the last quarter of 2010

reported in CMT (2010) will be used.

### 3 Calibration of parameters

The Spanish market has four major networks, plus several small virtual network operators. Attention is restricted to the four major networks, Movistar, Vodafone, Orange and Yoigo.<sup>5</sup> Since the model assumes firms compete in non-linear tariffs, only the data pertaining to post-pay customers is used. Table 1 reports the number of lines and relative market shares.

Table1. Subscribers and market shares in 2010Q4

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

The costs of origination and termination of a call is estimated at €0.0245/minute.<sup>6</sup> Since no data is available on the fixed cost per subscriber it is simply assumed that  $f = 0$ . This 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 the product differentiation parameter  $\mu$  will be calibrated from the observed and predicted average fixed fees. However, the results appear to be very robust to changes in  $\mu$  so that this assumption is not expected to affect the results significantly.

The call demand function is calibrated by imposing linearity, assuming that price elasticity equals  $-0.5$ <sup>7</sup> and by observing from the CMT data that average call price for post-pay

<sup>5</sup>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).

<sup>6</sup>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. Table A.1 in the Appendix reports some robustness checks for termination cost parameters equal to 1 and 3 euro cents.

<sup>7</sup>This value is also assumed by Harbord and Hoernig (2010). They argue that an elasticity of demand for mobile-originated calls of  $-0.5$  is consistent with the recent literature. Dewenter and Haucap (2008) reported short-run demand elasticities of between  $-0.26$  and  $-0.40$ . The UK Competition Commission (2003) received estimates varying between  $-0.48$  and  $-0.80$ . Finally, Ofcom (2007) states that a reasonable range for the elasticity is between  $-0.2$  and  $-0.4$ . Table A.2 in the Appendix reports some robustness checks for the cases of an elasticity equal to  $-0.3$  and  $-0.7$ .

clients is equal to  $\bar{p} = 0.108462$  (found by dividing total revenue from call minutes by the number of minutes) while the average number of minutes per subscriber equals  $\bar{q} = 436.6$ .<sup>8</sup> Solving  $q(\bar{p}) = \bar{q}$  and  $-0.5 = -\bar{b}\bar{p}/q(\bar{p})$  yields the call demand function  $q(p) = \bar{a} - \bar{b}p$  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. The approach in this respect follows closely de Bijl and Peitz (2000, 2004).

It is assumed 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). Denote this combination of termination charges by  $a^{2010}$ . This means that the observed market shares for 2010Q4 in Table 1 are in fact the equilibrium market shares. One can now obtain the on-net and off-net call prices (as a function of the unknown call externality parameter  $\beta$ ) from equations (6) and (7). Similarly, one can find the equilibrium fixed fees from equation (8). These will depend on  $\beta$  and  $\mu$ . In order to calibrate  $\mu$  one can 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).<sup>9</sup> One can thus calibrate  $\mu$  from solving

$$\sum_k \alpha_k F_k = 11.61.$$

This yields  $\mu$  as a function of  $\beta$ .<sup>10</sup>

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

The call externality parameter  $\beta$  can be calibrated by observing that the difference between average off-net price and on-net price equals 0.0322.<sup>11</sup> The theoretical difference between average off-net and on-net prices is increasing in  $\beta$ . For  $\beta = 0$  this difference equals

<sup>8</sup>See Tables 48 and 56 in CMT (2010).

<sup>9</sup>See Table 58 in CMT (2010).

<sup>10</sup>In the simulations  $\mu$  decreases with  $\beta$ : from 10.27 for  $\beta = 0$  to 6.67 for  $\beta = 0.8$ .

<sup>11</sup>This can be deduced from the numbers for on- and off-net calls in Tables 48 and 56 of CMT (2010).

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

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

One can calibrate  $\beta$  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, 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  $\beta^*$ . Since no data is available on the proportion of contracts with termination-based price discrimination, it is not possible 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 call prices if the gain from optimal termination-based price discrimination is small compared to the attractiveness of offering a simple uniform tariff. 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.<sup>12</sup> In most of the reported simulation results,  $\beta \in [0, 0.8]$  but values between 0.1 and 0.3 seem more plausible.

## 4 Simulation results

In this section, first the implications of various future schemes for termination rates are explored. Second, the issue of asymmetric termination rates is addressed. The calibrated model is used to simulate how prices, consumer surplus, profits and welfare change under different MTR regimes. The first regime considered 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 second regime considered is where all termination rates are set equal to the cost of termination, that is,  $a_i = a^{c-b} \equiv 0.0245$ . Finally, the hypothetical regime of bill and keep with  $a_i = a^{b\&k} \equiv 0$  is considered. The bill and keep regime is special since below cost termination

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<sup>12</sup>Because  $q(p) = 0$  for  $p > 0.325$ .

charges may lead some firms to set off-net price *below* on-net price, especially when the call externality is relatively weak. Since such pricing strategies are hard to implement, it is imposed 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 then be equal to perceived marginal cost, so that firm  $i$  would charge  $p_{ii} = \hat{p}_i = \alpha_i c + (1 - \alpha_i) c_O$ .

#### 4.1 Alternative scenarios of future termination rates

First, the simulation results for prices, market shares and individual profits are reported. Next, the implications of these results on total consumer surplus, total profit and total welfare are discussed.

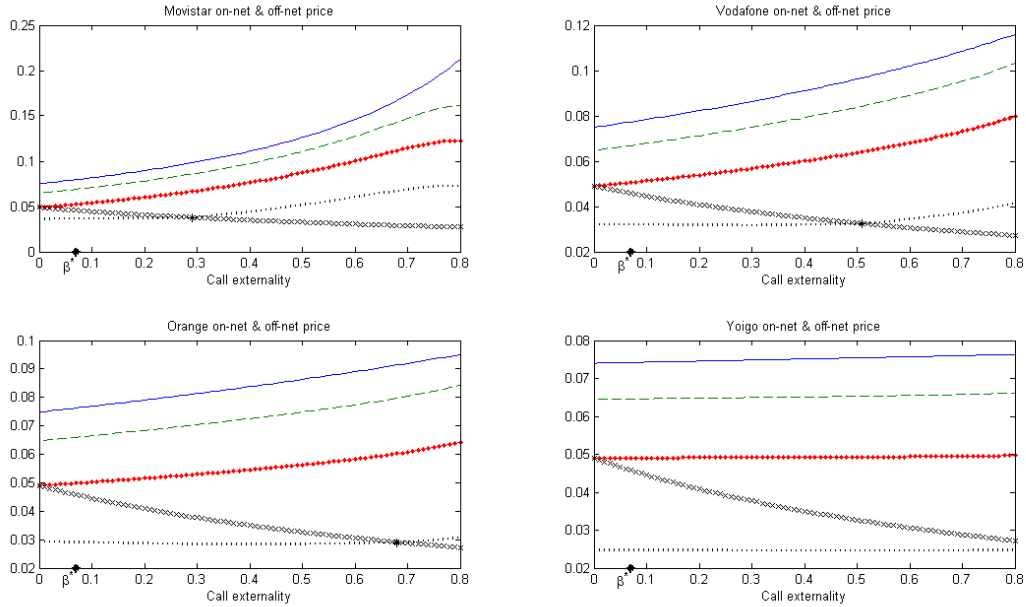


Figure 1: Equilibrium off-net prices under different MTR regimes [ $a^{2010}$  (-),  $a^{2012}$  (- -),  $a^{c-b}$  (-.),  $a^{b\&k}$  (.)] and on-net price (x).

*Prices.* Figs. 1 and 2 illustrate the outcomes in usage prices and fixed fees of various interconnection arrangements ( $a^{2010}$ ,  $a^{2012}$ ,  $a^{c-b}$ ,  $a^{b\&k}$ ) for  $\beta \in [0, 0.8]$ . Unsurprisingly, the off-net price increases with the level of the access charge and  $\beta$ . This follows of course from equation (7). Fig. 1 shows that Yoigo, having a very small market share, has little incentive to raise off-net price for larger values of  $\beta$  since the amount of calls originated in that network is small. Hence Yoigo harms the customers of rival networks very little by increasing the

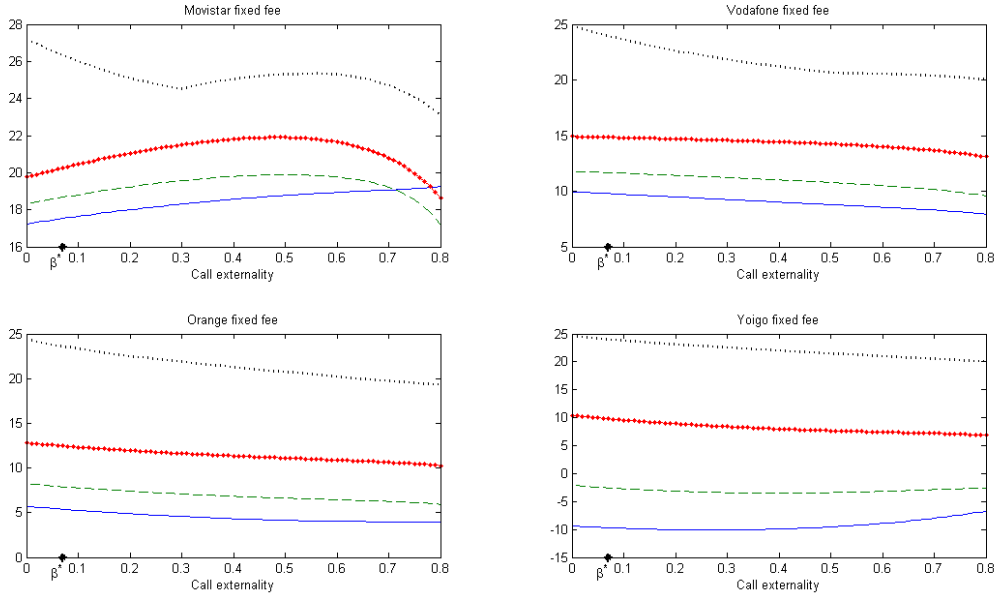


Figure 2: Equilibrium fixed fees under different MTR regimes [ $a^{2010}$  (-),  $a^{2012}$  (- -),  $a^{c-b}$  (-.),  $a^{b\&k}$  (.)].

off-net price. In other words, the strength of the call externality is not important for very small firms (say, recent entrants) in terms of setting (off-net) retail 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, this is the case when the bill and keep regime is adopted. Here there is a critical level of  $\beta$  below which on-net price (as defined in (6)) will be higher than off-net price (as defined in (7)), in which case it is assumed that firms set a uniform price. In the simulations, four clear regions are identified: (i)  $\beta < 0.29$ , (ii)  $0.29 \leq \beta < 0.51$ , (iii)  $0.51 \leq \beta < 0.68$ , and (iv)  $\beta \geq 0.68$ . In region (i), all four firms must charge a uniform price; in region (ii) only Movistar price discriminates between on- and off-net calls; in region (iii) Movistar and Vodafone price discriminate; in region (iv) only Yoigo keeps charging a uniform price.

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 the theoretical result established in Hurkens and López (2010). The number of off-net calls terminated on network  $i$  equals  $n_i = \alpha_i(1 - \alpha_i)$  which is increasing in  $\alpha_i$  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 shown in Hurkens and López (2010), the partial waterbed effect result is due to the assumption of passive consumer expectations. Consumer expectations are passive in the sense that they do not respond to out of equilibrium deviations by firms. Under rationally responsive expectations, 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, in an asymmetric oligopoly lowering MTR does not always lead to an increase in the fixed fee. As Fig. 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  $\beta > 0.7$ ). To understand this result, observe from equation (7) that a firm’s off-net price is increasing in its market share and in the call externality parameter  $\beta$ . Thus, the amount of off-net calls originated on the largest network is quite low. 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  $\beta$  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 other firms have a substantial advantage in demand because of incumbency (that is, their brand loyalty parameter is high). 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. Nevertheless, Yoigo makes positive profit because of termination revenues.

*Market shares.* Market shares are affected by termination rates through their impact on prices. Fig. 3 illustrates the effect of termination charges on market shares for different values of  $\beta$ . First consider the cases:  $a^{2010}$ ,  $a^{2012}$ , and  $a^{c-b}$ . The market shares of the two largest operators (Movistar and Vodafone) increase as the access charge decreases. Conversely, the market share of Orange is lower with  $a^{2012}$  (respectively  $a^{c-b}$ ) than with  $a^{2010}$  for  $\beta < 0.4$  (respectively, for  $\beta < 0.6$ ). Similarly, Yoigo’s market share is reduced when access charge is decreased. 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, which in turn makes it easier for the two larger operators to increase their market share at the expense of the

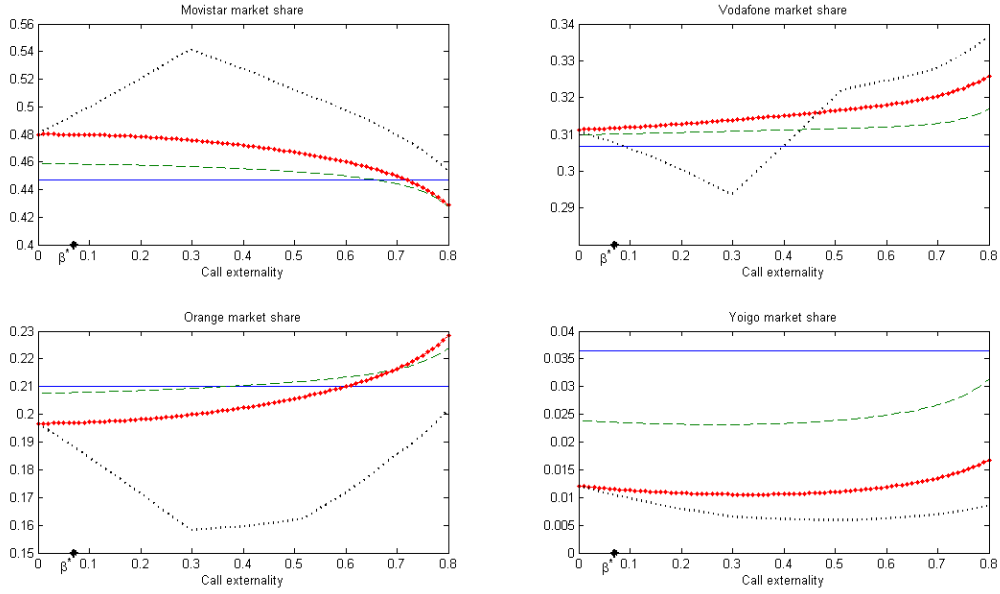


Figure 3: Equilibrium market shares under different MTR regimes [ $a^{2010}$  (-),  $a^{2012}$  (- -),  $a^{c-b}$  (.),  $a^{b&k}$  (.)].

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.* Fig. 4 shows that 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). Also note that for access charges at or above cost, the profit of the two larger operators is increasing in  $\beta$  (as long as it is not too high). Conversely, for low/moderate values of  $\beta$ , Orange and Yoigo's profit decrease with  $\beta$ .

*Aggregate surpluses and total welfare.* The impact of termination rates on total consumer surplus ( $TCS \equiv M * CS$ ), total profits ( $TP \equiv \sum_{i=1}^4 \pi_i$ ) and total welfare ( $TW = TCS + TP$ ) is analyzed next. Hurkens and López (2010) show theoretically in the absence of call externalities (i.e.,  $\beta = 0$ ) that total welfare is maximized with termination charges at cost ( $a^{c-b}$ ), whereas consumer surplus is maximized with a below-cost termination charge. The

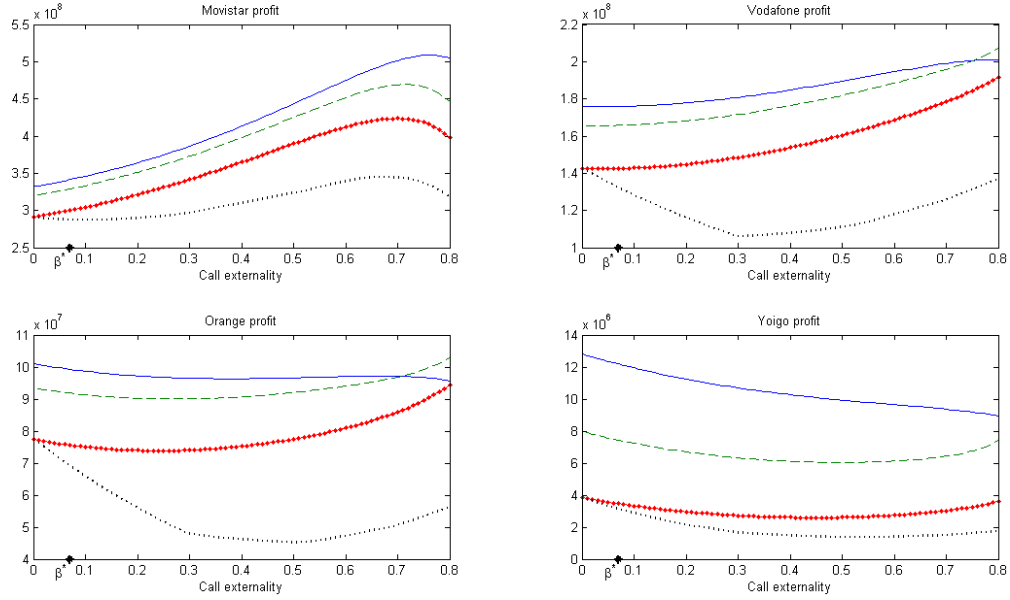


Figure 4: Equilibrium profits under different MTR regimes [ $a^{2010}$  (-),  $a^{2012}$  (- -),  $a^{c-b}$  (.-),  $a^{b\&k}$  (.)].

simulations show similar results hold in the case of an asymmetric oligopoly. In particular, for  $\beta = 0$ , a reduction in termination charge from  $a^{2010}$  to  $a^{c-b}$  increases total consumer surplus by 4.1%, reduces industry profit by 17.1%, and increases total welfare by 0.7%. Note that the bill and keep regime yields in this case less consumer surplus than cost-based termination rates. However, even for mild values of the call externality parameter bill and keep yields higher consumer surplus than cost-based regulation. Table 2 details the change in aggregate surpluses of various interconnection arrangements over  $a^{2010}$  for different positive values of the call externality parameter  $\beta$  (results are reported in percentage). Clearly, the higher is the call externality parameter, the higher is the gain in consumer or total welfare.

Table2. % Change in total consumer surplus, total profits and total welfare over  $a^{2010}$

$\beta$	$\Delta\% TCS$					$\nabla\% TP$					$\Delta\% TW$				
	0	<b>.07</b>	0.1	0.3	0.5	0	<b>.07</b>	0.1	0.3	0.5	0	<b>.07</b>	0.1	0.3	0.5
$a^{2012}$	1.5	<b>1.5</b>	1.6	1.7	2.1	5.6	<b>5.5</b>	5.4	5.0	4.6	0.4	<b>0.4</b>	0.5	0.8	1.1
$a^{c-b}$	4.1	<b>4.1</b>	4.2	4.6	5.4	17.1	<b>17.0</b>	16.9	15.9	14.7	0.7	<b>0.9</b>	1.0	1.6	2.5
$a^{b\&k}$	3.9	<b>4.9</b>	5.4	8.2	10.1	17.3	<b>21.7</b>	23.4	32.8	34.9	0.5	<b>0.8</b>	1.0	2.3	3.7

Although the percentage gains in consumer surplus and total welfare are mild compared

to the industry losses, in absolute terms the improvement in consumer surplus is substantial. Table 3 reports in detail how consumers are affected by different termination rate regimes in the case where the call externality parameter is fixed at the calibrated level  $\beta^* = 0.07$ . Lower termination rates result in substantially lower average price per minute, noticeably higher monthly fixed fees and a larger amount of minutes consumed. The total monthly bill stays approximately constant at €15. Total consumer surplus is increased by about 580 (690) million euros per year when termination rates are regulated at cost (set at zero, respectively).

Table 3. Average price per minute (euro cents), average monthly fixed fee (euros), average number of minutes per month, average monthly bill (euros), consumer surplus gain (with respect to  $a^{2010}$ ) per year (million euros)

$\beta = 0.07$	<i>Av. Price per minute</i>	<i>Av. Monthly Fixed Fee</i>	<i>Av. Number of minutes</i>	<i>Av. Monthly bill</i>	<i>CS gain wrt <math>a^{2010}</math></i>
$a^{2010}$	0.066	3.87	173.39	15.32	
$a^{2012}$	0.059	4.58	178.15	15.17	220
$a^{c-b}$	0.049	5.63	185.32	14.74	580
$a^{b\&k}$	0.033	8.35	195.71	14.93	690

## 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 since the Spanish regulator has initially allowed the most recent entrant, Yoigo, to charge a much higher termination rate than its established rivals. Similar asymmetries between established firms and entrants have been observed in other countries, such as the UK. Regulators presumably applied asymmetric MTRs in order to help the entrants grow and thereby increase competition in the market. The calibrated model in this paper can shed some light on the consequences of applying asymmetric MTRs and test whether such asymmetries do favour small firms and how this affects consumers. For this reason, in this subsection the case where all firms' MTRs are regulated at cost is compared with the one where (i) only the smallest and most recent entrant Yoigo is allowed to charge  $a_4 = 0.04$  (denoted by  $a^*$ ); and (ii) the one where both Yoigo and Orange are allowed to charge an MTR equal to 0.04 (denoted by  $a'$ ).

Table 4 details the outcomes. Clearly Yoigo gains and the other firms lose from getting the exclusive preferential treatment  $a^*$ . Yoigo's profit increases by more than 100%, mainly because its baseline profit is really low. 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 an access markup to the smaller operator, both its profit and consumer surplus increase, whereas total surplus decreases. The simulations show that his 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.

Table 4. Asymmetric termination rates: Change in Orange and Yoigo's profit, consumer surplus and total welfare over cost-based access charges ( $a^{c-b}$ )

$\beta$		$\alpha_1$	$\alpha_2$	$\alpha_3$	$\alpha_4$	$\Delta\pi_3$	$\Delta\pi_4$	$\Delta CS$	$\Delta TW$
0	$a^{c-b}$	0.48	0.31	0.19	0.01				
	$a^*$	0.47	0.30	0.19	0.02	-2.59	124.4%	0.05%	-0.11%
	$a'$	0.44	0.27	0.26	0.02	68.12%	84.67%	-0.25%	-0.43%
.07	$a^{c-b}$	<b>0.47</b>	<b>0.31</b>	<b>0.19</b>	<b>0.01</b>				
	$a^*$	<b>0.47</b>	<b>0.30</b>	<b>0.19</b>	<b>0.02</b>	<b>-2.79%</b>	<b>134.1%</b>	<b>0.05%</b>	<b>-0.11%</b>
	$a'$	<b>0.44</b>	<b>0.27</b>	<b>0.26</b>	<b>0.02</b>	<b>69.79%</b>	<b>89.99%</b>	<b>-0.24%</b>	<b>-0.47%</b>
0.1	$a^{c-b}$	0.47	0.31	0.19	0.01				
	$a^*$	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%
0.3	$a^{c-b}$	0.47	0.31	0.19	0.01				
	$a^*$	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%
0.5	$a^{c-b}$	0.46	0.31	0.20	0.01				
	$a^*$	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%

## 5 Conclusion

This paper has shown that the effects of MTR regulation can be predicted by first calibrating the model of Hurkens and López (2010) (extended to account for more than two firms, asymmetries and call externalities) and then calculating the equilibrium outcome under different MTR regimes. Employing a rich data set about the Spanish market it was found

that lowering termination rates towards cost is always (that is, for all values of the call externality) good for consumer surplus and total welfare but hurts all firms. Even though the calibrated call externality parameter is as low as 0.07, Spanish consumers gain about 580 million euros on a yearly basis from the reduction in MTR from €0.05 to cost. The reported gains in consumer surplus are most likely underestimated, as only post-pay clients are included in the analysis. Since pre-pay clients do not pay fixed fees, one would expect that these clients will hardly notice any waterbed effect so that a reduction in MTR will be passed on to consumers by means of lower retail prices.

The simulation results are consistent with the findings of Growitsch et al. (2010) in their case study of the Spanish market between 2006 and 2009. In that period the MTR was reduced from €0.11 to €0.057. In the same period average retail price was reduced, the number of minutes was increased, and also the monthly fixed fee increased. A further indicator of the reliability of the simulation results and the underlying model is that profits are predicted to decline steeply. This is consistent with the opposition that mobile network operators have exhibited over the last decade, not only in Spain but also in other European countries. In this respect the results are in stark contrast with the ones obtained by Harbord and Hoernig (2010) in their calibration of the UK market. They predict firms' profits to strongly increase as MTRs are reduced. The reason for this stark contrast must lie in the assumption about consumer expectations, since otherwise the underlying models<sup>13</sup>, calibration methods and assumptions are very similar.

## References

- [1] ARCEP (2008). *Les référentiels de coûts de opérateurs mobiles en 2008*. Paris. Retrieved from [http://www.arcep.fr/uploads/tx\\_gspublication/consult-tamobile2008-040908.pdf](http://www.arcep.fr/uploads/tx_gspublication/consult-tamobile2008-040908.pdf)
- [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(1), Article 21.
- [4] Berger, U. (2005). Bill-and-keep vs. cost-based access pricing. *Economics Letters*, 86, 107-112.

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<sup>13</sup>Harbord and Hoernig (2010) use the spokes model, an extension of the Hotelling model to markets with any number of firms, rather than the Logit model that is employed in the present paper. However, these models do not give qualitatively different results.

- [5] Cambini, C., & Valletti, T. (2008). Information exchange and competition in communications networks. *The Journal of Industrial Economics*, 56, 707-728.
- [6] Carter, M., & Wright, J. (1999). Interconnection in network industries. *Review of Industrial Organization*, 14, 1-25.
- [7] Carter, M., & Wright, J. (2003). Asymmetric network interconnection. *Review of Industrial Organization*, 22, 27-46.
- [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). Retrieved from <http://www.cmt.es/es/resoluciones/28-2009/4802228 - 4913840/RE-2009-7-29-2-2.pdf>
- [9] CMT. (2010). *Estadísticas del sector: IV trimestre - 2010*. Retrieved from [http://www.cmt.es/es/publicaciones/anexos/20110401\\_IVT\\_2010\\_.pdf](http://www.cmt.es/es/publicaciones/anexos/20110401_IVT_2010_.pdf)
- [10] 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*. Retrieved from [http://www.competition-commission.org.uk/rep\\_pub/reports/2003/475mobilephones.htm](http://www.competition-commission.org.uk/rep_pub/reports/2003/475mobilephones.htm)
- [11] De Bijl, P.W.J., & Peitz, M. (2000). Competition and regulation in telecommunications markets. *CPB Netherlands Bureau for Economic Policy Analysis*. The Hague, Netherlands.
- [12] 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.
- [13] Dewenter, R., & Haucap, J. (2008). Demand elasticities for mobile telecommunications in Austria. *Journal of Economics and Statistics*, 228, 49-63.
- [14] 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. Retrieved from <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:124:0067:0074:EN:PDF>
- [15] Gans, J.S., & King, S.P. (2001). Using ‘bill and keep’ interconnect arrangements to soften network competition. *Economics Letters*, 71, 413-420.

- [16] Genakos, C., & Valletti, T. (2011). Testing the ‘waterbed’ effect in mobile telecommunications. *Journal of the European Economic Association*. Forthcoming.
- [17] Growitsch, C., Marcus, J.S., & Wernick, C. (2010). The effects of lower termination rates (MTRs) on retail price and demand. *Communications & Strategies*, 80(4thQ), 119-140.
- [18] 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. Retrieved from <http://www.cepr.org/pubs/new-dps/dplist.asp?dpno=7730.asp>
- [19] 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.
- [20] Hoernig, S., Inderst, R., & Valletti, T. (2011). Calling circles: network competition with non-uniform calling patterns. *CEIS Tor Vergata Research Paper Series*, No. 206.
- [21] Hurkens, S., & López, A.L. (2010). Mobile termination, network externalities, and consumer expectations. IESE Working Paper D/850-E. Retrieved from <http://www.iese.edu/research/pdfs/DI-0850-E.pdf>
- [22] Jeon, D.S., Laffont, J.J., & Tirole, J. (2004). On the “receiver-pays” principle. *Rand Journal of Economics*, 35, 85-110.
- [23] Jullien, B., Rey, P., & Sand-Zantman, W. (2010). Mobile call termination revisited. *IDEI Working Paper*, n° 551. Retrieved from [http://www.idei.fr/doc/wp/2010/wp\\_idei\\_551.pdf](http://www.idei.fr/doc/wp/2010/wp_idei_551.pdf)
- [24] Katz, M.L., & Shapiro, C.S. (1985). Network externalities, competition, and compatibility. *American Economic Review*, 75, 424-440.
- [25] Laffont, J.J., Rey, P., & Tirole, J. (1998a). Network competition I: Overview and nondiscriminatory pricing. *Rand Journal of Economics*, 29, 1-37.
- [26] Laffont, J.J., Rey, P., & Tirole, J. (1998b). Network competition II: Price discrimination. *Rand Journal of Economics*, 29, 38-56.
- [27] López, A.L. (2011). Mobile termination rates and the receiver-pays regime. *Information Economics and Policy*, 23, 171-181.

- [28] Ofcom. (2007). *Mobile call termination statement*, 27 March, London. Retrieved from [http://stakeholders.ofcom.org.uk/binaries/consultations/mobile\\_call\\_term/statement/statement.pdf](http://stakeholders.ofcom.org.uk/binaries/consultations/mobile_call_term/statement/statement.pdf)
- [29] Peitz, M. (2005). Asymmetric regulation of access and price discrimination in telecommunications. *Journal of Regulatory Economics*, 28, 327-343.
- [30] Small, K.A., & Rosen, H.S. (1981). Applied welfare economics with discrete choice models. *Econometrica*, 49, 105-130.

## Appendix

Table A.1. Robustness (termination cost): Average prices, average consumption, and consumer surplus gain with respect to  $a^{2010}$

$c_T$	$\beta = 0.07$	<i>Av. Price per minute</i>	<i>Av. Monthly Fixed Fee</i>	<i>Av. Number of minutes</i>	<i>Av. Monthly bill</i>	<i>CS gain wrt <math>a^{2010}</math></i>
0.01	$a^{2010}$	0.046	3.87	186.23	12.47	
	$a^{2012}$	0.039	4.61	191.04	12.20	240
	$a^{c-b}$	0.020	6.70	204.83	10.81	1010
	$a^{b&k}$	0.013	7.88	209.07	10.75	1065
<b>0.0245</b>	$a^{2010}$	<b>0.066</b>	<b>3.87</b>	<b>173.39</b>	<b>15.32</b>	
	$a^{2012}$	<b>0.059</b>	<b>4.58</b>	<b>178.15</b>	<b>15.17</b>	<b>220</b>
	$a^{c-b}$	<b>0.049</b>	<b>5.63</b>	<b>185.32</b>	<b>14.74</b>	<b>580</b>
	$a^{b&k}$	<b>0.033</b>	<b>8.35</b>	<b>195.71</b>	<b>14.93</b>	<b>690</b>
0.03	$a^{2010}$	0.073	3.87	168.52	16.25	
	$a^{2012}$	0.066	4.57	173.25	16.16	213
	$a^{c-b}$	0.060	5.26	177.92	15.96	434
	$a^{b&k}$	0.041	8.50	190.66	16.35	558

Table A.2. Robustness (elasticity): Average prices, average consumption, and consumer surplus gain with respect to  $a^{2010}$

$\varepsilon$	$\beta = 0.07$	<i>Av. Price per minute</i>	<i>Av. Monthly Fixed Fee</i>	<i>Av. Number of minutes</i>	<i>Av. Monthly bill</i>	<i>CS gain wrt <math>a^{2010}</math></i>
-0.3	$a^{2010}$	0.066	3.87	162.25	14.63	
	$a^{2012}$	0.059	4.57	165.10	14.40	196
	$a^{c-b}$	0.049	5.56	169.40	13.88	520
	$a^{b\&k}$	0.033	7.99	175.65	13.90	625
-0.5	$a^{2010}$	<b>0.066</b>	<b>3.87</b>	<b>173.39</b>	<b>15.32</b>	
	$a^{2012}$	<b>0.059</b>	<b>4.58</b>	<b>178.15</b>	<b>15.17</b>	<b>220</b>
	$a^{c-b}$	<b>0.049</b>	<b>5.63</b>	<b>185.32</b>	<b>14.74</b>	<b>580</b>
	$a^{b\&k}$	<b>0.033</b>	<b>8.35</b>	<b>195.71</b>	<b>14.93</b>	<b>690</b>
-0.7	$a^{2010}$	0.065	3.87	184.54	16.00	
	$a^{2012}$	0.059	4.60	191.19	15.94	244
	$a^{c-b}$	0.049	5.71	201.24	15.59	639
	$a^{b\&k}$	0.033	8.70	215.76	15.96	756