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Seesaw in the Air: Interconnection Regulation and the Structure of Mobile Tariffs

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Abstract
Interconnection rates are a key variable in telecommunications markets. Every call that is placed must be terminated by the network of the receiving party, thus the termination end has the characteristic of an economic bottleneck and is subject to regulation in many countries. This paper examines the impact of regulatory intervention to cut termination rates of calls to mobile phones. We argue that regulatory cuts should have a differential impact according to the type of tariff the mobile customer subscribes to. While all mobile customers may pay higher prices because of a "waterbed" effect, termination rates also affect competition among mobile operators. We show that the waterbed effect is diluted, but not eliminated, for customers with pre-paid cards, where regulation also acts as impediment to "raise-each-other's-cost" collusive strategies that mobile networks can adopt. The waterbed effect is instead strongest for consumers with monthly (post-paid) subscription contracts.

Keywords: Interconnection, network competition, regulation, mobile phones
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1. Introduction

The prices mobile operators charge other (fixed or mobile) network operators for connecting calls to their subscribers have become a hotly debated issue among regulators and academics worldwide. These are called termination charges, and correspond to wholesale price agreements among network operators. Hence, these fees are not paid by retail customers directly, but feed indirectly into their bills. The level of termination charges is perceived to be high both in absolute terms, but also in relation to similar prices charged by fixed operators. Industry analysts stress that such charges play a critical role and may inhibit the growth of telecommunications services in general. Moreover, especially regarding the fixed-to-mobile (F2M) termination rates, a large theoretical literature has demonstrated that, independently of the intensity of competition for mobile customers, mobile operators have an incentive to set charges that will extract the largest possible surplus from fixed users.[3] This fear provided justification for regulatory intervention to cut these rates. However, reducing the level of F2M termination charges can potentially increase the level of prices for mobile subscribers, causing what is known as the "waterbed" or "seesaw" effect.

Genakos and Valletti (2010) (henceforth, GV) document empirically the existence and magnitude of the waterbed phenomenon using a uniquely constructed panel of mobile operators' prices across more than twenty countries over six years. Their results suggest that, although regulation reduced termination rates by about 10% to the benefit of callers to mobile phones from fixed lines, this also led to a 5% increase (varying between 2%-15% depending on the estimate) in mobile retail prices. While GV provide evidence of this phenomenon, their analysis falls short of showing the precise channels that may have lead to an increase in mobile retail bills following regulatory cuts of termination rates. In fact, mobile termination regulation affects F2M calls, but will also have an effect on mobile-to-mobile (M2M) termination rates. The level of M2M termination rates impacts on the cost of both making and receiving calls and, overall, on the intensity of competition for the market of mobile customers. Hence, the "pure" waterbed effect from F2M calls will coexist with, and possibly be confounded by, the effects from M2M calls.

This particular feature has been analyzed in a burgeoning literature on "two-way" access charges, which is where M2M termination belongs. This literature, initiated by the seminal works of Armstrong (1998) and Laffont et al. (1998), has shown how the impact of termination rates on retail prices is subtle, as it depends on the type of contracts that operators

[3] See, for example, Armstrong (2002), Wright (2002), Vogelsang (2003), and Valletti and Houpis (2005).

can offer to their customers. Typically, high (reciprocal) termination deals can have a "collusive" effect of sustaining high retail prices and profits when operators compete in linear prices. This result collapses, and can actually be reversed, when competition is in two-part tariffs, and operators set differential charges according to whether the call is destined to consumers of the same operator ("on-net" calls), or belonging to rivals ("off-net" calls).

In this paper we first synthesize the literature on two-way access charges. We then discuss the impact that regulation of mobile termination rates should have on mobile customers' bills, distinguishing between the pure (or direct) waterbed effect from F2M calls and the strategic (indirect) effect of regulation through its impact on the price of M2M calls. We derive two hypotheses that we then test empirically. In particular, we discuss how the waterbed effect is expected to be strong for mobile customers subscribing to non-linear monthly contracts (post-paid) and be particularly strong on the fixed component of the contract, while it should be diluted for customers with pre-paid cards (pay-as-you-go). We find strong support for both hypotheses, highlighting the importance of these direct and indirect channels, and of taking into consideration the structure of tariffs when examining the waterbed phenomenon in mobile telephony.

It is important to emphasize that most of the literature at this early stage is, in fact, theoretical in nature. Very few works have endeavoured empirical investigations, despite the very practical problem underlying the entire interconnection analysis. Besides GV, Cunningham et al. (2010) and Dewenter and Kruse (2011) represent exceptions.[4] We do not attempt here to provide guidance as to the optimal level of mobile termination rates, and we do not conduct any welfare analysis. Rather, our main scope is more limited but nevertheless relevant for policy. We want to see if we can find support in the data for some basic predictions from the literature on the impact on mobile customers' bills due to the regulation of termination rates. Should we find this evidence, then one way of reading our results is that

[4] Cunnigham et al. (2010) also find evidence of the waterbed effect in a cross-section of countries. This is also the conclusion of Dewenter and Kruse (2011), although they follow an indirect approach, as they test the impact of termination regulation on diffusion of mobile telephony, rather than looking directly at the impact on mobile prices. Since the waterbed effect predicts that high termination rates should be associated with low mobile prices, it also predicts that diffusion will be faster in those markets with high termination rates, which is what Dewenter and Kruse (2011) find. Growitsch et al. (2010) instead find no evidence of the waterbed effect using an alternative dataset (Merrill Lynch). However, they derive prices of mobile consumers by dividing total (voice service-based) revenues by minutes, when total revenues include also the revenues from termination of calls. So, they essentially regress price on a component of price (termination rates) and without appropriately correcting for this endogeneity problem, unsurprisingly, they find a positive relationship. Hence, we believe that Growitsch et al. (2010) do not find the waterbed effect not because they are using a different dataset, but because their empirical implementation is incorrect. More empirical works are emerging now in the related field of "two-sided" markets, e.g., Jin and Rysman (2010).

the more theoretical approaches are indeed very useful in assisting regulators and policy makers when regulating termination rates.

The whole paper rests on the idea that mobile termination regulation affects both F2M calls and M2M calls. Regulation typically works via the setting of caps, i.e., operators may actually set termination charges below the cap, if they wish to do so. In fact, the literature that we review below makes such a distinction, finding that, while mobile firms always have an incentive to set unregulated "high" F2M termination charges, under some circumstances they would set profit-maximising "low" M2M termination charges. If that was the case, then regulation would be binding only on F2M charges, and its effects would show up only via the direct waterbed effect. However, in practice, regulation is binding both for F2M and M2M termination rates, as mobile operators would find it impossible to sustain differences in their termination rates, because of arbitrage possibilities. In other words, either both M2M and F2M termination rates are forced by regulation to be set at the same level, or arbitrage possibilities force them to be so, as discussed in Armstrong and Wright (2009). France provides a particularly fitting example of the close relationship between these two wholesale termination charges, and the possibility of arbitrage. Prior to 2005, M2M termination was set using a bill-and-keep system. With bill-and-keep, calls are billed to customers, but termination charges are forgone on a reciprocal basis, without any billing process between telecom providers. Effectively, bill-and-keep corresponds to zero M2M termination charges. These (zero) charges were much lower than the termination charges for F2M calls set at the time. The discrepancy in the rates attracted arbitrageurs, using the so-called GSM gateways. Basically, under the bill-and-keep regime, fixed operators could cut their costs by routing all the F2M traffic via a GSM gateway, and by doing so avoid the F2M termination charge, and instead take advantage of bill-and-keep interconnection between mobile GSM operators.[5] As a response to this, the French mobile operators abandoned the bill-and-keep system, and effectively set the rates for termination of M2M calls to the *same* level of F2M calls. Arbitrage thus limits, or even eliminates, the ability to set differential (lower) rates for terminating M2M calls compared to F2M calls. As regulatory authorities across the EU and

[5] In more detail, a GSM gateway is a mobile phone installed at a fixed location. It is equipped with SIM-cards of various national mobile operators. Fixed line subscribers can call that GSM gateway on a value-added service number to save money on direct F2M calls. The GSM gateway forwards the call to the operator who runs the mobile telephone number the fixed subscriber wants to call. The operator of the GSM gateway just incurs the cost of a mobile on-net call as the GSM gateway automatically chooses the "correct" SIM-card. The business model is thus built on arbitrage between retail prices for F2M calls (and indirectly rates for mobile call termination) on the one hand and retail prices for mobile on-net calls on the other hand. In France, GSM gateways are called "hrisson" ("hedgehog").

the rest of the world pushed mobile termination rates downwards over time, probably driven by the desire to make F2M calls cheaper, they also had *de facto* an impact on M2M calls.

The paper is organized as follows. In section 2 we re-assess the waterbed effect question, taking into account that the overall impact of regulation of termination rates will balance both effects arising from F2M and M2M calls. While the first effect should push up mobile retail prices, the latter is less clear, and will depend on the type of tariff. Section 3 describes our empirical strategy and section 4 discusses the data used. Sections 5 and 6 present the results and section 6 concludes.

2. The theory of two-way access charges and the waterbed effect

To fix ideas, follow the call made by a customer of the fixed network F to a customer of the mobile operator M. This call, to be completed, uses network M as its termination segment. In all European countries, and also in most of the world, there is a calling party pays system (CPP) in place.[6] Under CPP, the call is paid for by the caller to the mobile phone, not by the mobile phone owner. Operator F thus must buy termination services only from operator M as no other operator can complete this call. Therefore, the termination segment of the call presents itself as an economic bottleneck for the buying operator F.

This distortion implies that the mobile operator is typically able to set termination charges at the monopoly level, independently of the intensity of competition in the market for subscribers. The level of termination charges is determined by the same trade-off made by a monopoly firm: by setting higher termination prices it increases the unit margin it can earn, but it also reduces the quantities of calls received.

This problem has been extensively analyzed in the literature, which has concluded that there is a need to regulate mobile termination charges (Gans and King, 2000; Armstrong, 2002; Wright, 2002). This has been the main concern of regulatory authorities and, indeed, many regulators have intervened to cut termination rates.

What is the effect of a cut of mobile termination charges, below the level that would have been set by unregulated mobile firms? Consider again the example of F calling M. Clearly, the price of F2M calls would become cheaper after a cut of termination charges. This is arguably the core aspect regulators have typically been interested in. However, there is also

[6] The U.S. is a noticeable exception in that there is a RPP (receiving party pays) system in place. Interconnection rates are very low, not because of market forces, but because of the intervention of the FCC (for instance, termination on a mobile network is regulated at the same long-run incremental cost of termination on an incumbent fixed network).

another effect predicted by all the theoretical models: the total bill paid by M will go up as a result of the cut of the termination charge. This is the "waterbed effect".

The idea behind the waterbed effect is intuitive. The mobile network is a platform that chooses two sets of prices, those for making calls (paid by own customers) and those for terminating calls (paid by other customers).[7] Since a mobile network is a bottleneck for received calls, money can be made over termination. Thus, each potential mobile customer comes with a termination rent. This does not imply, however, that mobile firms will necessarily make supernormal profits overall. In fact, if there is enough competition among mobile networks, then competition will exhaust this rent, and operators will offer subsidized prices to their mobile customers. Here, the subsidy is paid by fixed users F, which are charged high prices, to the benefit of mobile customers M. If regulation cuts somehow the termination rent, then the subsidy to mobile customers will be reduced too. In the limiting case, no subsidy could be given at all to consumers if regulation eliminates entirely any termination rent. The bill paid by M will then go up.

As shown by several authors, a waterbed effect exists under quite general market conditions.[8] The prediction from the theory can be stated as:

$$(1) \qquad \frac{dP}{dT^F} < 0 ,$$

where P is the average total bill of a mobile customer for a given usage profile, and T^F is the F2M termination rate. Since T^F affects only the price of F2M calls,[9] there is no obvious effect on call prices, while most of the waterbed effect would arise from the fixed component paid by the user, at least for those customers on a post-paid deal. Eq. (1) is the main prediction tested by GV, namely that lower termination rates induced by regulation should be associated with higher retail bills of mobile customers.

[7] In this paper we concentrate on voice calls, although our arguments apply also to other forms of communications enabled by mobile devices, e.g., text messages. See Andersson et al. (2009) and Basalisco (2010) for an empirical analysis of the interaction between voice and text messages.
[8] See in particular Wright (2002), section V, and GV, section 2.1.
[9] The "other" way of a bi-directional communication, from the mobile network M to the incumbent fixed network F, has always been regulated in every country, at the long-run incremental cost of the fixed network. Thus a change on the mobile termination rate has no impact on the cost that M pays to terminate calls to F.

2.1 M2M calls and the structure of tariffs

The call termination problem described in the previous sections is relevant when the market of callers from fixed networks is separate from the market of receivers on mobile networks. However, mobile firms also interconnect with each other. There is therefore another termination rate, for M2M calls, that we have to take into consideration. In this section we first analyze the impact of M2M termination rates on mobile retail prices, when considered completely in isolation from F2M termination rates that we dealt with in section 2. We then put these two sets of results together.

Let us start with M2M calls. Imagine mobile operators M1 and M2 compete for the same customer base that both originates and terminates calls. As long as operators M1 and M2 command some market share, operator M1 needs interconnection with M2 to terminate the calls that M1's customers destine to M2's customers and vice versa. There is a sort of "double coincidence of wants" that potentially makes the bottleneck problem less problematic. In a symmetric situation, termination charges may even be thought to be irrelevant since M1 pays M2 the same amount it receives from M2. However, this reasoning is not entirely correct. When termination charges are negotiated jointly, two kinds of potential problems emerge:

a) Operators can agree to set access charges at a level that eliminates any effective competition among them; and
b) Termination-based discrimination creates forms of externalities that may be used to affect the intensity of competition.

As extensively analyzed by the literature on "two-way" access charges following Armstrong (1998) and Laffont et al. (1998), different results arise according to the type of tariffs offered by competing mobile firms.[10] Take the following multi-part tariff as a reference point:

$$(2) \qquad P(F, p_{on}, p_{off}) = F + p_{on}q_{on} + p_{off}q_{off}$$

[10] See Hoernig (2009) and Harbord and Pagnozzi (2010) for a comprehensive treatment of the most recent literature, with a particular emphasis on the implications for the waterbed effect. In particular, while most of the theoretical literature concerns duopoly models, Hoernig (2009) shows how the basic predictions that we formulate below do generalise to models with an arbitrary number of sufficiently symmetric networks.

where P is again the average total bill of a mobile customer for a given usage profile, F is the fixed fee of the customer's multi-part tariff, p_{on} is the on-net price for calls made to customers belonging to the same network, p_{off} is off-net price for calls made to customers belonging to other networks, q_{on} is the average on-net traffic, and q_{off} is the average off-net traffic.

When firms compete in simple *linear* prices (which are relevant for pre-paid cards), collusive retail prices can be sustained using high termination charges because of a "raise-each-other's cost" effect. To see this, imagine what happens when operators charge monopoly retail prices to customers. This can be an equilibrium only if no one has a unilateral incentive to deviate. If one firm deviates from the monopoly retail charges by undercutting the rival, it induces its subscribers to call more. Since parts of the calls made are destined to the rival's network, the effect of a price cut is to send out more calls than it receives from the rival. The resulting net outflow of calls has an associated deficit that is particularly burdensome if the termination charge is high. This will discourage under-pricing in the first place. If we call T^M the termination rate between mobile networks, in the case of competition in linear prices we have the following prediction of an increase of termination rates (starting, say, from termination rates set at cost as a benchmark):

$$(3) \qquad \frac{dP}{dT^M} > 0,$$

and a similar positive effect on profits, while there is obviously no prediction on the fixed component F since we are dealing with linear tariffs.

This collusive result disappears when firms compete in *multi-part* tariffs (which are relevant particularly for post-paid contracts). When firms compete in uniform two-part tariffs (which do not distinguish between calls placed on-net and off-net), there is a "profit neutrality" result of termination charges on profits. It is still true that a high termination charge feeds into high retail call charges. However, all the profits generated from termination are used to lower the fixed component. Hence, in this case, the waterbed effect would be neutral on profits and on the total bill; however it would still be at work on the fixed component of the two-part tariff:[11]

[11] Where P in the first inequality is the total bill of a mobile customer that includes both the fixed fee as well as the variable price per call paid.

(4) $$\frac{dP}{dT^M}=0,\frac{dF}{dT^M}<0,\frac{dp_{on}}{dT^M}=0,\frac{dp_{off}}{dT^M}>0.$$

Finally, when firms can discriminate between on-net and off-net calls, they can reach higher profits by setting low (below cost) termination charges. This is because tariff-mediated externalities are generated any time the termination charge is set different from its cost, thereby generating differences between on-net and off-net prices. Firms can exploit this, and would compete less aggressively *for* the market when termination charges are set below cost. Essentially, customers prefer to belong to small networks in this case, as they would place relatively more off-net calls, which are cheaper than on-net calls. When instead termination charges are set above cost, off-net prices increase but the competitive externality effect is particularly strong on the fixed fee and this is the prevailing effect on the bill:

(5) $$\frac{dP}{dT^M}<0,\frac{dF}{dT^M}<<0,\frac{dp_{on}}{dT^M}=0,\frac{dp_{off}}{dT^M}>0.$$

How does this discussion fit with the regulation of F2M termination rates? In that case, recall that our prediction was simply given by eq. (1), i.e., $\frac{dP}{dT^F}<0$.

As said in the Introduction, in practice F2M calls can be converted into M2M calls by some special equipment (GSM gateways, see footnote 5 for details about the arbitrage technique). Then, if there are large discrepancies between T^F and T^M, there can be arbitrage possibilities. Even if regulation only caps termination rates in general, in that M2M rates could be set lower if mobile operators wished to do so, arbitrage implies that these two charges will be set at the same level. Thus regulation, even if it formally sets a cap only, it effectively affects T^F and T^M, which will be both set at the same (capped) level. The "pure" waterbed effect from F2M calls can be then confounded by the indirect strategic M2M effects we described above.

Thus imagine that regulation affects all termination charges, either because operators would have set all termination charges above the regulated level, or because any difference would otherwise attract arbitrageurs to exploit the differential. The main waterbed prediction given by eq. (1) would then be additionally affected by the effects summarized by the various eq. (3)-(5), according to the relevant structure of mobile tariffs. We consider each case in turn.

Let us start from the case of competition in linear prices. As far as M2M rates are concerned, this is when the theory predicts that firms would collude by setting "high" termination rates. Thus, if regulation cuts also M2M rates, then firms can collude "less", and bills will go down from this side, which contrasts the pure waterbed effect.

We turn next to competition in two-part tariffs when there is no discrimination between on-net and off-net prices. The theory predicts that the higher the termination rate, the more expensive calls per minute, but the lower the fixed fee. Thus the effect on the fixed component of an increase of the termination rate is negative, which reinforces the waterbed effect that would be already arising from F2M calls. The total bill and profits are instead unaffected as far as M2M calls are concerned (while there is still the "pure" waterbed effect arising from F2M calls).

Finally, consider when firms compete in multi-part discriminatory tariffs. If M2M termination is set equal to F2M termination, it will be set "high" compared to the otherwise collusive one for M2M calls alone. Regulation of termination, by cutting this rate, would therefore get *closer* to the profit-maximising M2M charge. Therefore, we have additional effects which strengthen the waterbed on the total bill, in particular via the impact on the fixed fee of the multi-part tariff paid by the customer.

2.2 Empirical predictions

Table 1 below summarizes the theoretical discussion. The column 'F2M' reports the standard pure waterbed effect (our focus in section 2), when F2M calls are insulated from M2M calls. The column 'M2M' reports the theoretical predictions arising from M2M calls alone (our focus in section 2.1). The column 'Total Effect' reports the overall effect arising when a single termination rate effectively affects all types of calls, which is the empirically-relevant case in the presence of arbitrage. As it can be seen, the waterbed effect on the total bill is reinforced for post-paid contracts, and shows particularly via the impact on the fixed fee. On the contrary, there is a countervailing force for pre-paid deals.

In our data, we have price information divided into pre-pay and post-pay contracts. Pre-paid cards can reasonably be approximated by linear charges in the relevant range, in contrast with more sophisticated schemes (non-linear, i.e., with quantity discounts) that correspond more closely to post-pay contracts. Within post-pay contracts, we also have a further split between the fixed amount and the variable amount spent on calls. Thus, by looking at the structure of tariffs, we may get an additional idea on whether mobile termination regulation has also an additional impact via M2M calls. For contracts which can be approximated by a

multi-part tariff, we can split the waterbed effect on the total bill and on the fixed component of the multi-part tariff. If M2M calls play a role, then the waterbed effect should be even stronger on the fixed fee. When firms offer simple linear prices, proxied by pre-paid deals, instead, the waterbed effect is diluted by the collusive effect.

All in all, the waterbed predictions are quite robust, also when M2M calls are brought into the picture. The additional empirical predictions on the waterbed effect that we bring to a test in this paper are on the type of contracts and on the structure of prices. Since regulation of mobile termination rates has an impact on both F2M and M2M calls together, we formulate the following two hypotheses:

H1. The waterbed effect is stronger for post-paid contracts and weaker for pre-paid deals.

H2. Among post-paid contracts, the waterbed effect should prevail particularly via a change of the fixed component of the contract.

3. Empirical specification

The most natural way to analyze the impact of regulation on retail prices in different countries over time is through a difference-in-difference specification:

$$(6) \qquad \ln P_{ujct} = \alpha_{ujc} + \alpha_t + \beta_1 \text{Regulation}_{jct} + \varepsilon_{ujct}$$

The dependent variable in (6) is the logarithm of the total bill ($\ln P_{ujct}$) for the usage profile u = {low, medium, high} of operator j in country c in quarter t. The main variable of interest, Regulation_{jct}, is a binary indicator variable that takes the value one in the quarters when mobile termination rates are regulated.[12]

We estimate equation (6) separately for pre-paid and post-paid users. For post-paid users, we also estimate a variant of equation (6) where the dependent variable, instead of being the total bill P_{ujct}, is divided between the fixed fee Fixed_{ujct} and the variable component Voice_{ujct},

[12] In GV we explicitly model the impact of termination regulation on retail prices, also distinguishing between countries that have introduced substantial price cuts in termination rates and countries that have regulated termination too but only mildly, showing that the waterbed effect is positive and significant in all cases. Unfortunately, the dataset used for the current paper is a much smaller one (less than a third of the data in the "best deals" case) forcing us to utilize a simpler specification, where regulation only enters as a binary indicator.

of the multi-part tariff. The fixed fee corresponds to traffic-insensitive charges of the bill, while the variable component accounts for all traffic-sensitive charges (where naturally $P_{ujct} = Fixed_{ujct} + Voice_{ujct}$).

Regression (6) constitutes a difference-in-difference model, where countries that introduced the regulation are the "treated" group, while non-reforming countries (always regulated or always unregulated) are the "control" group. Due to the inclusion of usage-country-operator and time fixed effects, the impact of regulation on prices is identified from countries that introduced this regulation and measures the effect of regulation in reforming countries compared to the general evolution of prices or profits in non-reforming countries. The "waterbed" prediction is that, *ceteris paribus*, the coefficient on regulation should have a positive sign in (6).

This difference-in-difference specification allows us to control for time-invariant country-operator characteristics that may influence both regulation and prices. Importantly, it allows us to control for cost differences across mobile operators due to differential access to spectrum frequencies (e.g., some operators have access to 900 MHz spectrum, others only to 1800 MHz) or differences in the cost of network deployment. It also accounts for differences among the consumer profiles (e.g., the intensity of competition for heavy users may differ from competition for light users). Furthermore, the specification also accounts for common global trends, such as changes in technological progress and general awareness and success of mobile services. Therefore we ask if, over and above these effects, regulation of mobile termination rates had an impact on bills of mobile subscribers.

There are three important assumptions underlying our empirical specification: (a) exogeneity of the regulation variable, (b) any bargaining (or lobbying) process between firms and the regulatory authority did not alter the overall impact of regulation on prices, (c) regulation was non-selectively imposed across countries. GV discuss extensively the theoretical justification and empirical validity of these assumptions. Since we utilize part of their dataset for this paper, we refer the interested reader to the discussion in GV and do not repeat the arguments here.

4. Data

Our data come from two main sources. Firstly, we use Cullen International (which collects all termination rates for official use of the European Commission) and various other industry and regulatory publications, to identify the dates in which regulation was introduced across

countries and operators. Overall, operators from twenty four countries[13] are included in our sample.

The second data source is from Teligen, which provides quarterly information on the total bills (and its components: fixed and voice) paid by mobile consumers across operators and countries between 2002Q3 and 2006Q1. Teligen collects and compares all available tariffs of the two largest mobile operators for thirty OECD countries. It constructs three different hypothetical consumer usage profiles (heavy, medium and low) based on the number of calls and messages, the average call length, and the time and type of call. These consumer profiles are then held fixed when looking across countries and time. Therefore, our unit of observation is the total bill charged to a consumer type, at a certain quarter, by an operator in a country who may or may not be regulated.

Teligen reports information on the "best deals" available to each consumer profile each quarter from these mobile operators. These best deals are the cheapest overall tariff for each profile, which could be either pay-as-you-go (pre-paid) or monthly subscription (post-paid) contracts. Teligen also reports separately information on the cheapest pre-paid and the cheapest post-paid contracts, again for each profile. Essentially, the "best deals" are the overall envelope of the best pre-paid and the best post-paid deals.[14]

To make comparisons homogenous, all consumer prices were converted to euros using the Purchasing Power Parities (PPP) currency conversions published by the OECD. However, none of our results depends on this transformation. Table 2 provides the summary statistics for the key variables used.

The Teligen dataset has two main advantages regarding our empirical question. First, by fixing the calling profiles of customers, it provides us with information on the best choices of these customers across countries and time. Second, the total bills reported in this dataset include much of the relevant information for this industry, such as inclusive minutes, quantity discounts, etc. However, this richness of information comes at the cost of having data for

[13] The countries in the sample include: Australia, Austria, Belgium, Czech Republic, Denmark, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey and UK.

[14] Somehow in line with the intuition, low-usage profiles are typically best served by pre-paid deals, while post-paid contracts are better suited for heavy-usage profiles. However, there are significant exceptions in the data. As can been seen in the first panel of Table 2 (Best Deals), the split between post-paid and pre-paid contracts overall is almost equal in size.

only the two biggest operators of every country at each point in time (although they cover 80 percent of the market on average in our data). This reduces the variability and makes identification of our variables of interest harder, especially given that the biggest mobile operators in a given country are often regulated in similar way. A final important limitation of the Teligen data is that these are not actual end user bills, but hypothetical baskets based on a number of assumptions.[15] However, the very fact that it is a hypothetical basket based on a number of characteristics (number and length of calls, etc.) that are fixed *a-priori* is also its strength, because it allows a meaningful comparison across time and countries.[16]

Our results also have to be qualified as termination rents could be exhausted with non-price strategies as well, i.e., increasing advertising, or giving handset subsidies that we cannot control for. However, we do not expect handset subsidies effects to be relevant at all for pre-paid customers, while in some countries operators practice inter-temporal subsidies for post-paid subscriber, whereby short-run losses are incurred to get long-run profits from captive customers. Notice that these could eventually be *additional* channels through which the waterbed effect might manifest itself.

5. Empirical analysis on the tariff structure and waterbed effect

We now present the empirical results on the differential impact of the waterbed effect according to the tariff structure. Following the previous theoretical discussion, we examine in detail the impact of regulation of mobile termination rates on pre-paid deals and post-paid (monthly) contracts. When the regulation of termination rates affects all types of calls, both from fixed and from/to mobile networks, the waterbed effect is expected to be stronger for contracts, and weaker for pre-paid deals.

Table 3 presents the results.[17] The data for the first four columns consist of the best possible deals for each user profile among all contracts available, both pre-paid and post-paid. This means that, for a given consumer profile, the tariff chosen is the cheapest overall for that profile, no matter whether a pre-paid or post-paid deal.

[15] The Appendix (available from the authors upon request) contains a detailed description of these assumptions.

[16] The only alternative cross-country data available is the Merrill Lynch dataset. It contains aggregate information on total voice service-based revenues for all the operators in a country. However, there are two key problems with this data. First, the revenue data includes also the revenues from termination rates. Second the total revenue is a very aggregate measure of "real world" behaviour and it does not allow like-to-like comparison of tariffs (as we cannot distinguish things like inclusive minutes, quantity discounts, etc.). These two problems pose some serious identification and endogeneity issues in examining the waterbed phenomenon. Finally, its aggregate nature does not allow researchers to distinguish between pre-paid and post-paid contracts and the likely channels through which the waterbed effect operates.

[17] All reported standard errors are based on a generalized White-like formula, allowing for country-operator-usage level clustered heteroskedasticity and autocorrelation (Bertrand et al., 2004).

Column (1) shows that the introduction of regulation had a significant positive effect on the total bill of post-paid contracts. In line with the theory, we find evidence of a strong waterbed effect (the bill increases by 13.4% after the introduction of regulation over the period) which is very similar to the equivalent estimate of 13.3% reported in GV (Table 1, column (1)).[18] This is the increase in the total bill due to regulation of termination rates experienced by mobile consumers in our sample. Then, in columns (2) and (3), we run separate specifications using as dependent variables either the fixed fee ($\ln Fixed_{ujct}$) or the variable component ($\ln Voice_{ujct}$) of the multi-part tariff of the monthly post-paid contract respectively. Results from these two columns suggest that the waterbed phenomenon is mainly caused by a change in the fixed rather than the variable component in these contracts. The impact of regulation on the fixed fee of post-paid contracts is positive and strongly significant, whereas it is insignificant for the variable component. Hence, results on the post-paid contracts of the best deals available, reported in the first three columns, verify the existence and magnitude of the waterbed phenomenon and seem to confirm our second hypothesis (H2) that, if M2M prices are also affected by regulation, that will show up particularly via a change in the fixed fee.

Column (4) reports the effect of regulation on the prices of the pre-paid contracts of the best deals available in our sample. The estimated coefficient indicates the existence of an equally strong waterbed effect (11.4%). Although this is smaller than the one for post-paid contracts (13.4%), their difference is insignificant,[19] not verifying in full our first hypothesis (H1).

However, there are important reasons to believe that distinguishing more sharply between pre-paid and post-paid customers is important. Customers on long-term contracts may be looking only at similar long-term deals, and may not be interested in a temporary pre-paid subscription, even if this turned out to be cheaper for a while. Switching among operators takes time and for a business user this might not be a very realistic option, even in the presence of number portability. Conversely, customers on pre-paid cards may have budget constraints and do not want to commit to long-term contracts where they would have to pay a fixed monthly fee for one or more years. Again, these customers may want to look only at offers among pre-paid contracts. For these reasons, we also investigated whether there is a

[18] The small difference between the two results stems from some differences in the sample size. For this paper we only look at monthly contracts that clearly have both a fixed and a variable component (voice), while we have excluded the contracts made of only a fixed component (e.g., contracts with unlimited or "all inclusive" bundled offers) as the theory's predictions only apply to pricing plans with a clear fixed and variable component.

[19] $F(1, 115) = 0.04$, $prob>F = 0.849$.

difference in the waterbed effect between pre-paid and post-paid users, when each type of user is limited in her choices exclusively *within* the same type of contracts. The last four columns in Table 3 examine the results for such "constrained" post-paid (columns (5)-(7)) and pre-paid (column (8)) users.

Column (5) confirms the existence of a strong waterbed reaction to regulation within post-paid contracts: the total bill for monthly post-paid contracts even increases by 15.9%. Columns (6) and (7) provide evidence that this overall effect stems mainly from a change in the fixed rather than the variable component of these contracts. This verifies again our earlier conclusion on the validity of the second hypothesis.

Finally, column (8) indicates that regulation also had a positive impact on pre-paid prices. However, the estimated coefficient is not significant now indicating that, when looking within all pre-paid deals in our sample, regulation had a more uncertain impact on average. Most importantly though, the magnitude of the waterbed effect (5.1%) for pre-paid deals is significantly[20] smaller than the one for post-paid contracts, confirming our first hypothesis. To the extent that one is prepared to accept that customers who typically subscribe to pre-paid cards do not look around for post-paid contracts, and vice versa, then the empirical results are in line with the theoretical predictions.

Results are robust to the inclusion of other time-varying regressors. During this period, many countries have licensed new operators, as new spectrum became available. Specifically, we have also included the (log) number of competitors as a proxy for the competitive intensity in each market. Our main results remain unchanged:[21] the waterbed effect is stronger for post-paid contracts and among post-paid contracts, it operates via a change of the fixed component of the contract. The impact of competition on the customers' bills is always negative and in most cases significant, in line with the intuition. Intriguingly, for post-paid contracts, the total effect of competition comes especially via a reduction of the voice component, and less from a reduction of the fixed fee which is negative but not significant. This is in line with Hoernig's (2009) model, where, at least for the symmetric case, he finds that voice call prices decrease with the number of competing firms. In contrast, he also shows how the effect on the fixed fee is ambiguous and cannot be signed in general. Most

[20] $F(1, 115) = 15.87$, prob>F = 0.000.

[21] Results available from the authors upon request. We also experimented using the (log) of the Herfindahl-Hirschman Index, instead of the number of competitors, and results are essentially unchanged. We additionally experimented by adding market penetration as an additional time-varying regressor. However, its impact was always statistically insignificant.

significantly, though, these results confirm that waterbed channel effects are not confounded with any other important time-varying variable.

6. Dynamic effects on post- and pre-paid contracts

Although both datasets seem to confirm our second hypothesis, the evidence in favour of the first hypothesis that the waterbed should be stronger for post-paid contracts than pre-paid deals is less clear cut. When we compared the effect of regulation on prices paid by the "constrained" post-paid users to those paid by pre-paid users (in columns (5) and (8) of Table 3), there is an unambiguous difference in the level of the waterbed effect. The coefficient on regulation on pre-paid deals is not statistically significant, implying that there is no waterbed effect on average for these contracts in our sample. According to the theory (see the second row in Table 1) this may indicate that the pure waterbed effect is exactly compensated by less "collusive" environment due to lower termination rates. We find this result quite stimulating and in this subsection we investigate the dynamic effects of regulation on prices for the two types of contracts.

Economic intuition and market reality suggest that the effect of regulation on prices might not be instantaneous. Termination rates are typically regulated over some periods using "glide paths", in which charges are allowed to fall gradually towards a target over that period. This adjustment path is known and anticipated by operators. However, there could also be some inertia. For example, due to contract restrictions a significant part of consumers might be locked with an operator. In this case, the operator would not need to immediately adjust its price schedule, as the possibility of consumers switching to a different operator is small. Hence, we would like to investigate whether firms anticipated regulation (possibly by strategically manipulating their prices before the actual implementation of the regulation) and indeed whether the effect of regulation was short-lived (a one-off event) or had any persistent long-term effects.

To quantify these dynamic effects of the waterbed phenomenon, we define binary indicators for six, non-overlapping, quarters around the introduction of regulation and a final binary variable isolating the long-run effect of regulation. Our specification is still a difference-in-difference model, but now we allow for flexible time-varying effects of regulation on prices for both types of contracts:

$$(7) \qquad \ln P_{ujct} = \alpha_{ujc} + \alpha_t + \beta_1 D^{T-3}_{jct} + \beta_2 D^{T-2}_{jct} + \ldots + \beta_6 D^{T+2}_{jct} + \beta_7 D^{T+3}_{jct} + \varepsilon_{ujct}$$

where $D^{T-3}_{jct} = 1$ in the third quarter before regulation, $D^{T-2}_{jct} = 1$ in the second quarter before regulation, and similarly for all other quarters until $D^{T+3}_{jct} = 1$ in the third quarter after regulation and in all subsequent quarters. Each binary indicator equals zero in all other quarters than those specified. Hence, the base period is the time before the introduction of regulation, excluding the anticipation period (i.e., four quarters before regulation backwards). This approach accounts for probable anticipation effects (as captured by D^{T-3} to D^{T-1} binary indicators) as well as short- (captured by D^{T} to D^{T+2}) and long-run effects (captured by D^{T+3}).[22] We estimate this model separately for post- and pre-paid deals using the same data as in columns (5) and (8) in Table 3, when each type of user is limited in her choices within the same type of contracts.

Figure 1 plots the regression coefficients on these binary indicators from equation (7) together with their 95% confidence interval. Regression coefficients three quarters up to and including the date of regulation are insignificant indicating that regulation has no effect on prices before its introduction. It is the *actual* implementation of the regulation that has a significant impact on prices as revealed by the immediate increase on the coefficients just after regulation (waterbed at T+1: 18%). Regulation is binding right from the beginning and, as it tightens up over time, the waterbed effect increases. As we can see in Figure 1, regulation also seems to have a large and very significant long-run waterbed effect (the coefficient estimate on D^{T+3}, which quantifies the effect of regulation on prices post the third quarter after its introduction). Most importantly, it emerges that mobile prices for post-paid contracts seem to respond continuously with every tightening of the termination rates.

Figure 2 plots the regression coefficients together with their 95% confidence interval from equation (7) for pre-paid contracts. The dynamic effect for pre-paid contracts is much more intriguing. As we can see, the inaction before the introduction of regulation is followed by a short-lived (for period T) non-significant decrease in prices and then a continuous non-significant increase in prices for the next two quarters (periods T+1 and T+2). There is, however, an overall positive and significant long-run waterbed effect on these prices too.[23]

Notice also the massive increase in the variance associated with these coefficients for pre-paid deals, after the introduction of regulation. Mobile operators seem to have reacted

[22] See Laporte and Windmeijer (2005) for a discussion of this approach.

[23] The coefficient on D^{T+3} is around 17%. Note that this coefficient is not directly comparable to the previous estimates of the waterbed effect, as it incorporates the effect not only of the introduction of regulation, but also of the progressive tightening of termination rates.

differentially regarding the pricing of these contracts shortly after the introduction of regulation. At the beginning, they seem on average to reduce the prices charged to these customers, possibly trying to lure customers into their networks (with the hope of them upgrading later to monthly subscribers) or potentially as a loss making, short-term strategy against smaller firms that either remained unregulated or were not regulated at the same rates.[24] In addition, cuts in termination rates might have disrupted collusive equilibria as predicted by the literature on two-way access charges and linear retail pricing strategies, initiating more turbulent periods of competition. In any case, the strong and positive long-run coefficient illustrates that mobile operators eventually abandoned any such strategies and raised the prices even for the pre-paid customers, which is another manifestation of the power of the waterbed effect.

The different behaviour between pre-paid and post-paid consumers could also be related to other micro-phenomena that we cannot directly test. To the extent that pre-paid users receive fewer calls, termination rents from receiving calls would be less relevant for mobile operators and therefore the waterbed effect would play a much reduced role in determining their retail prices. However, anecdotal evidence seems to suggest the opposite, in that pre-paid consumers predominantly use their phones for incoming calls, and therefore regulation of termination charges should induce a strong waterbed effect, but much diluted by their reduced collusive role, as we have argued above.

On the usage side, fixed-to-mobile substitution could also have played a role, as some consumers do substitute more expensive F2M calls for cheaper M2M (especially if the latter are on net, when caller and recipient subscribe to the same mobile operator). This would mean that, as time progresses, the M2M effects should have gained increasingly more weight relative to the F2M effects of reduced termination rates (see Vogelsang, 2010). To the extent that this phenomenon was common both to pre-paid and to post-paid customers, our fixed effects would capture it. If instead it acted differentially, then one would need more micro data to tease it out.

[24] These pricing strategies were making pre-paid contracts the "best deals" overall in some quarters. This might also explain why we get such a strong waterbed effect on pre-paid "best deals" in column (4) of Table 3 relative to its insignificant estimated waterbed effect in column (8), when we look at the full sample of pre-paid contracts.

7. Conclusions

The identification of the bottleneck-monopoly problem whenever a fixed line customer calls a mobile customer led to the introduction of regulation of termination rates in many countries, with the principal aim of reducing the prices of fixed-to-mobile calls. A consequence of this regulatory intervention was, ceteris paribus, the increase in the level of prices for mobile customers, also known as the waterbed effect.

In this paper we re-assess the waterbed effect question, taking into account that the overall impact of regulation of termination rates will balance both effects arising from fixed-to-mobile calls and mobile-to-mobile calls. While the first effect unambiguously should push up mobile retail prices, the latter is less clear, and will depend on the type of tariff the customers subscribe to. We summarize the large literature on access charges and network competition and we derive two testable implications: (i) that the waterbed effect would be stronger for post-paid rather than pre-paid contracts, and, (ii) that among post-paid contracts, the waterbed effect should prevail particularly via a change of the fixed component of the contract. Our empirical analysis takes into account the structure of mobile tariffs and lends robust support for both hypotheses.

These results have some important implications. To our knowledge, this is the first paper to derive and test hypotheses based on the literature on two-way access prices. The empirical findings strongly corroborate predictions on customers' bills obtained directly from theoretical models. The evidence presented here highlights the importance of indirect channels, whereby regulation affects the nature of the strategic interaction among operators. We therefore endorse the current use of theoretical models of network competition when, for instance, deciding on the optimal regulation of termination rates, as these models shape observable parameters in a way consistent with the data.

The empirical literature to which we contribute, however, falls short of computing, from the data, what the optimal level of intervention should be, possibly because of the nature of these studies (cross-country comparisons, rather than empirical structural models at a single-country level with more detailed information especially about demand parameters). This is a fruitful area for future research. The waterbed effect points to a trade-off between cheaper prices to those calling mobile phones and increased charge levels to mobile subscribers. The associated welfare changes should be estimated precisely in order to inform regulators and policy makers when they intervene. An alternative is to calibrate theoretical models with realistic demand and supply parameters (see Harbord and Hoernig, 2010). Given that this is the first attempt to bring some of the results of the two-way access prices literature to data,

there is large room for improvement. We think that empirically testing more theoretical predictions is a fruitful avenue for future research. Mobile telephony is certainly a good testing ground, but other two-sided industry examples abound, such as video games, credit cards, internet advertising, internet portals, etc. Better understanding of these phenomena is a necessary ingredient towards building more elaborate structural models that would allow us to calculate welfare effects and to do policy analysis in a complete way.

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APPENDIX – DATA DESCRIPTION

This Appendix contains a detailed data description, Table A2 with the timing of the termination rate regulation and Table A3 with some robustness results.

We obtained mobile operator's prices from Teligen (2002Q3-2006Q1), which reports quarterly information on the total bills paid by consumers across OECD countries based on three usage profiles (high, medium and low). Teligen calculates these total bills across countries and for each hypothetical usage profile so that they take into account registration or installation charges, monthly rental charges, a number of SMS messages per month and it also takes into consideration any inclusive minutes (or SMS messages) or call allowance value included in monthly subscriptions. For each of the operators covered, a set of packages is included so that the cheapest package offered by the operator can be calculated for each of the three usage profiles. In particular, the principles followed in calculating all baskets (high, medium and low) include:

- Registration or installation charges with 1/3 of the charges, i.e. distributed over 3 years.
- Monthly rental charges, and any option charges that may apply to the package, or package combination.

The call and message volumes for each usage profile are shown in the first two columns of Table A1.

TABLE A1 – TELIGEN MOBILE BASKETS

	Call and SMS volume		% of total number of calls				Minutes per call		
	Outgoing call/month	SMS per month	Fixed Local area	Fixed National area	On-net mobile	Off-net mobile	Dur Fixed National	Dur Mobile On-net	Dur Mobile Off-net
Low user	25	30	28%	14%	40%	18%	1.6	1.4	1.4
Medium user	75	35	24%	12%	43%	21%	2.1	1.9	1.9
High user	150	42	26%	14%	42%	18%	2.2	2.0	2.1

Only national calls are included in the profiles, with four different destinations:

- Local area fixed line calls. This is used to accommodate the tariffs that have separate charges for the local area. When such charges are not available, this proportion of calls is included in the National.
- National fixed line calls. This covers all fixed line calls outside the local area, except in cases as noted above.
- Same network mobile calls (On-net). This includes all calls made to mobiles in the same mobile network as the caller.
- Other network mobile calls (Off-net). This includes calls to all other mobile networks in the caller's country. When the charges are different depending on destination network, the market shares based on subscribers are used for weighting the charges.

The distributions per destination for each basket are shown in columns 3-6 of Table A1. A further split, by usage profile, is made in terms of times (peak/off-peak) and days (weekdays/weekend), which is not reported for the sake of brevity.

Three separate call durations are taken into account, respectively for local and national fixed line calls, same network mobile calls (On-net), and other network mobile calls (Off-net). Call durations for each basket are shown in the last three columns of Table A1.

Any inclusive minutes are deducted from the basket usage before starting the calculation of usage cost. The inclusive minutes are assumed to be used up with the same calling pattern that is described in the basket, i.e., the same peak/off-peak ratio and the same distribution across destinations. Where the inclusive minutes are clearly limited to specific destinations or times of day this will be taken into account. No transfer of unused minutes is taken into account.

Finally, it should be noted that the information reported by Teligen does not include handset subsidies.

TABLE A2 – REGULATION CHRONOLOGY

Country	Year
Poland	1997Q1
UK	1998Q1
Belgium	1999Q2
Austria	2000Q2
Italy	2000Q2
Japan	2000Q2
Spain	2000Q2
Norway	2001Q2
Sweden	2001Q2
Denmark	2001Q4
Hungary	2002Q1
Portugal	2003Q4
France	2004Q2
Australia	2005Q2
Czech Republic	2005Q2
Germany	2005Q2
Slovak Republic	2005Q2
Switzerland	2005Q4
Ireland	2006Q2
Luxembourg	2006Q2
New Zealand	2006Q2
Turkey	2006Q2
Netherlands	2006Q3
Greece	2006Q4

Notes: Counties in bold are the ones experienced a change in regulation during our sample. In contrast, countries in italics remain unregulated, whereas the rest of the countries were always regulated during our sample period using the Teligen price data.

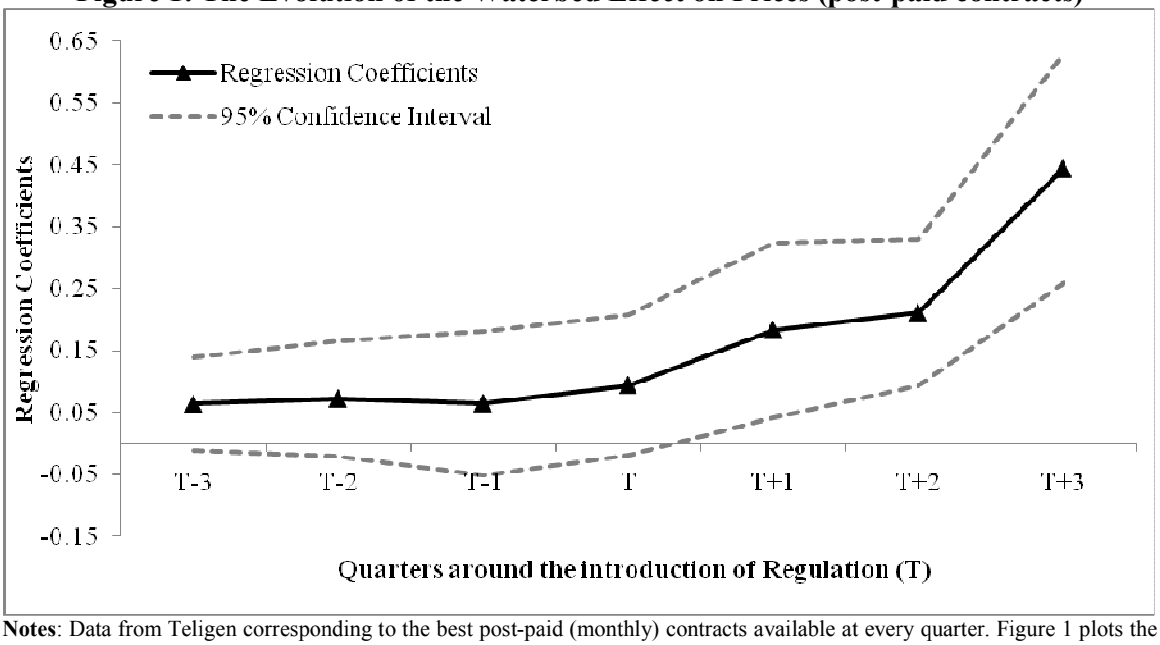
TABLE A3 – TARIFF STRUCTURE AND WATERBED EFFECT - ROBUSTNESS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Dependent variable	lnP_{ujct}	$lnFixed_{ujct}$	$lnVoice_{ujct}$	lnP_{ujct}	lnP_{ujct}	$lnFixed_{ujct}$	$lnVoice_{ujct}$	lnP_{ujct}
	Best deals (Monthly subscriptions)			Best deals (Pre-paid)	Monthly subscriptions			Pre-paid
Waterbed Effect	*13.4%*			*11.8%*	*16.8%*			*5.7%*
$Regulation_{jct}$	0.134**	0.760***	-0.011	0.118***	0.168***	0.716***	0.063	0.057
	(0.064)	(0.245)	(0.083)	(0.041)	(0.052)	(0.167)	(0.063)	(0.052)
$ln(competitors)_{ct}$	-0.397*	-1.214	-0.445**	-0.043	-0.298**	-0.337	-0.450***	-0.070
	(0.202)	(0.875)	(0.193)	(0.179)	(0.145)	(0.649)	(0.140)	(0.176)
Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Country-Operator-Usage FE	yes	yes	yes	yes	yes	yes	yes	yes
Observations	468	468	468	499	718	718	718	1568
Clusters	63	63	63	74	80	80	80	138
Within-R^2	0.382	0.174	0.428	0.161	0.361	0.184	0.409	0.147

Source: Author's calculations based on the Teligen data (2002Q3-2006Q1) corresponding to the best deals available at every quarter (columns 1-4), deals available to post-paid subscribers only (columns 5-7) and the deals available to pre-paid customers only (column 8). In all cases the data has been restricted to post-paid contracts that have both a variable and a fixed component and the variable component is larger than the fixed (for both pre-paid and post-paid subscribers).

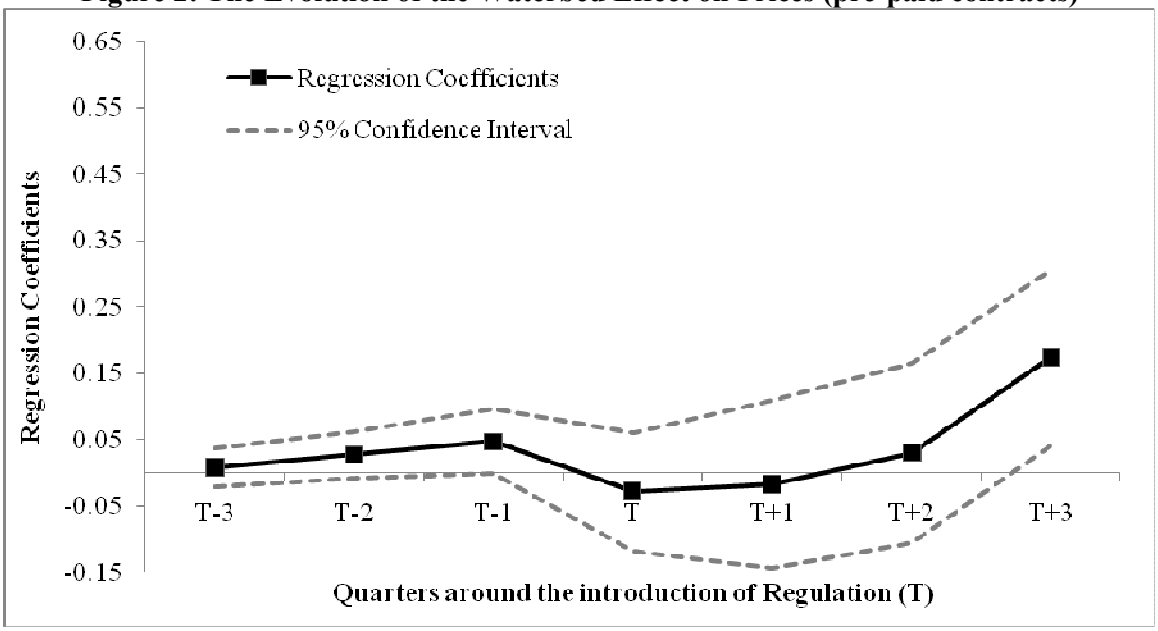
Notes: The dependent variable is either the logarithm of the PPP adjusted total bill paid by consumers with different usage at every quarter for post-paid subscriptions (columns 1 and 5) or pre-paid contracts (columns 4 and 8) or the logarithm of the PPP adjusted fixed fee (columns 2 and 6) or variable component (columns 4 and 7) paid by consumers with different usage at every quarter for post-paid subscriptions. Information on the number of competitors was taken from the Global Wireless Matrix of Merrill Lynch, which is also available on a quarterly basis (2000Q1-2006Q1). All regressions include country-operator-usage and a full set of year binary indicators. Standard errors clustered (i.e. robust to heteroskedasticity and autocorrelation of unknown form) at the country-operator-usage level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

Figure 1: The Evolution of the Waterbed Effect on Prices (post-paid contracts)



Notes: Data from Teligen corresponding to the best post-paid (monthly) contracts available at every quarter. Figure 1 plots the regression coefficients from equation (7) for six, non-overlapping, binary variables around the introduction of regulation and a final binary variable isolating the long-run effect of regulation. Hence, the base period is the time before the introduction of regulation, excluding the anticipation period (i.e., four quarters before regulation backwards). The dependent variable is the logarithm of the PPP adjusted total bill paid by consumers with different usage at every quarter. Confidence interval is based on standard errors clustered (i.e. robust to heteroskedasticity and autocorrelation of unknown form) at the country-operator-usage level.

Figure 2: The Evolution of the Waterbed Effect on Prices (pre-paid contracts)



Notes: Data from Teligen corresponding to the best pre-paid (pay-as-you-go) contracts available at every quarter. Figure 2 plots the regression coefficients from equation (7) for six, non-overlapping, binary variables around the introduction of regulation and a final binary variable isolating the long-run effect of regulation. Hence, the base period is the time before the introduction of regulation, excluding the anticipation period (i.e., four quarters before regulation backwards). The dependent variable is the logarithm of the PPP adjusted total bill paid by consumers with different usage at every quarter. Confidence interval is based on standard errors clustered (i.e. robust to heteroskedasticity and autocorrelation of unknown form) at the country-operator-usage level.

TABLE 1 – PREDICTIONS ON THE WATERBED EFFECT FOLLOWING AN INCREASE IN MOBILE TERMINATION RATES

	F2M calls (pure waterbed)	M2M calls (additional effect)	Total Effect
(Linear tariffs, i.e., pre-paid cards)			
Total bill	-	+	Ambiguous
(Multi-part tariffs, i.e., post-paid contracts)			
No on-net/off-net discrimination			
Total bill	-	0	-
Fixed fee	-	-	--
Variable part	0	+	Mildly +
On-net/off-net discrimination			
Total bill	-	-	--
Fixed fee	-	--	---
Variable part	0	+	Mildly +

TABLE 2 – SUMMARY STATISTICS

Variable	Observations	Mean	Standard Deviation	Min	Max
		Teligen (Best deals)			
lnP_{ujct}	504	5.202	1.544	1.067	7.365
$lnFixed_{ujct}$	504	3.454	1.808	-1.538	6.496
$lnVoice_{ujct}$	504	4.877	1.569	0.621	7.357
$Regulation_{jct}$	504	0.679	0.467	0	1
lnP_{ujct}	545	4.944	1.440	0.114	7.492
$Regulation_{jct}$	545	0.563	0.496	0	1
		Teligen (Post-paid)			
lnP_{ujct}	792	5.142	1.540	0.888	7.551
$lnFixed_{ujct}$	792	3.487	1.735	-1.538	6.496
$lnVoice_{ujct}$	792	4.802	1.579	0.258	7.357
$Regulation_{jct}$	792	0.654	0.476	0	1
		Teligen (Pre-paid)			
lnP_{ujct}	1670	5.554	1.688	0.114	7.989
$Regulation_{jct}$	1670	0.599	0.490	0	1

Source: Author's calculations based on the Teligen data (2002Q3-2006Q1) corresponding to the best deals available at every quarter (first panel), deals available to post-paid monthly subscribers only (second panel) and deals available to pre-paid customers only (third panel).

Notes: The first panel (Best deals) provides summary statistics on the key variables used in Table 3 (columns (1)-(4)), the second panel (Post-paid) provides similar information for the variables used in columns (5)-(7), and the third panel (Pre-paid) provides summary statistics on the variables used in column (8).

TABLE 3 – TARIFF STRUCTURE AND WATERBED EFFECT

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Dependent variable	lnP_{ujct}	$lnFixed_{ujct}$	$lnVoice_{ujct}$	lnP_{ujct}	lnP_{ujct}	$lnFixed_{ujct}$	$lnVoice_{ujct}$	lnP_{ujct}
	Best deals (Post-paid)			Best deals (Pre-paid)	Post-paid contracts			Pre-paid
Waterbed Effect	*13.4%*			*11.4%*	*15.9%*			*5.1%*
$Regulation_{jct}$	0.134**	0.763***	-0.008	0.114***	0.159***	0.667***	0.066	0.051
	(0.064)	(0.240)	(0.085)	(0.040)	(0.052)	(0.166)	(0.063)	(0.052)
Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Country-Operator-Usage FE	yes	yes	yes	yes	yes	yes	yes	yes
Observations	504	504	504	545	792	792	792	1670
Clusters	68	68	68	78	88	88	88	147
Within-R^2	0.361	0.158	0.415	0.147	0.329	0.160	0.391	0.139

Source: Author's calculations based on the Teligen data (2002Q3-2006Q1) corresponding to the best deals available at every quarter (columns (1)-(4)), deals available to post-paid subscribers only (columns (5)-(7)) and the deals available to pre-paid customers only (column (8)). In all cases the data has been restricted to post-paid contracts that have both a variable and a fixed component and the variable component is larger than the fixed (for both pre-paid and post-paid monthly subscribers).

Notes: The dependent variable is either the logarithm of the PPP adjusted total bill paid by consumers with different usage at every quarter for post-paid subscriptions (columns (1) and (5)) or pre-paid contracts (columns (4) and (8)) or the logarithm of the PPP adjusted fixed fee (columns (2) and (6)) or variable component (columns (4) and (7)) paid by consumers with different usage at every quarter for post-paid subscriptions. All regressions include country-operator-usage and a full set of year binary indicators. Standard errors clustered (i.e. robust to heteroskedasticity and autocorrelation of unknown form) at the country-operator-usage level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

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