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Evaluating a Decade of Mobile Termination Rate Regulation

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Abstract
We re-consider the impact that regulation of call termination on mobile phones has had on mobile customers' bills. Using a large panel covering 27 countries, we find that the "waterbed" phenomenon, initially observed until early 2006, becomes insignificant on average over the 10-year period, 2002-2011. We argue that this is related to the changing nature of the industry, whereby mobile-to-mobile traffic now plays a much bigger role compared to fixed-to-mobile calls in earlier periods. Over the same decade, we find no evidence that regulation caused a reduction in mobile operators' profits and investments.

Key words: Mobile telephony, termination rates, waterbed effect
JEL: D12; D43; L5; L96; L98

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1. Introduction

Mobile (or cellular) communications markets have been growing at an impressive rate over the last two decades, with worldwide subscriptions increasing from a few million in the 90s to seven billion users in 2013 on all continents.[4] Competition in the industry has been quite vigorous, and regulators have not interfered much with the workings of the market. In particular, and contrary to fixed telephony networks, retail prices directly set by regulators are virtually unknown in mobile telephony.

This view is possibly too simplistic, as regulators have also dealt extensively with matters related to mobile telephony, but in a way which is less visible to end users. An important question is whether the design of regulation of the early days is still valid in the light of the dynamic development of this industry.[5]

Regulators in particular worry about inter-network (termination) charges for calls to mobile networks, and starting in the early 2000s have repeatedly intervened over the years to cut these charges with the aim to improve competition and reduce prices to final consumers. However, both academics and mobile operators have argued that reducing the level of mobile termination rates can potentially increase, instead of decrease, the level of prices for mobile subscribers, causing what it was termed as the "waterbed" effect. In our earlier work (Genakos and Valletti, 2011), using data for the period 2002-2006, we showed that, indeed, countries that introduced regulation that cut the termination rates caused a significant waterbed effect, whereby a ten percent reduction in mobile termination rates led to a 5% increase in mobile retail prices, varying between 2%-15% depending on the estimate. In other words, cuts in termination rates before 2006 had led to the possibly adverse consequence of increasing the yearly bill per mobile subscriber by roughly 25 euros (varying from 10 to 82 euros), or some 750 million euros (varying from 300 to 2,400 million) extra in total in our sample.

The introduction of the New Regulatory Framework for electronic communications by the European Commission in 2002, where mobile termination was defined as a relevant market, meant that over time all EU countries imposed various differential cuts to termination

[4] World Telecommunication/ICT Indicator Database, International Telecommunications Union, 2013.

[5] An issue that we do not consider here are barriers to entry, which are mainly due to a limited number of licenses granted by national authorities, reflecting a scarcity in the spectrum of electromagnetic frequencies that are needed to operate a mobile telephony network. This physical restriction has been overcome to some extent in recent years due to the creation of "mobile virtual network operators" (MVNOs), which are independent firms who do not own a physical network but rather rent airtime on existing ones.

rates. The debate among regulators and mobile operators on the likely benefits and costs of termination rate regulation became even more intense, with our work being featured as a "weapon" against any tightening of such regulation.[6] At the same time though, the telecommunications market was undergoing a fundamental change, whereby mobile voice traffic had overcome fixed line call volumes, changing the economic forces that gave rise to the waterbed effect in the previous years.

In this paper we summarize these new theoretical arguments related to the underlying changes in mobile-to-mobile and fixed-to-mobile traffic volumes, and we empirically re-visit our earlier analysis, using an extended dataset covering 27 countries from 2002 until the end of 2011. Our new results demonstrate that the waterbed effect is not present anymore on average across the whole sample. Delving deeper into the possible channels, we uncover, in line with theory, that the distinguishing feature for this change is the importance of calls made from and to mobile phones relative to calls made to mobile phones from fixed lines. The ratio of mobile to fixed traffic is key in our findings. Countries that introduced termination rate regulation when mobile traffic was high did not experience any waterbed effect. On the contrary, countries that introduced the same regulation at a time of low mobile traffic experienced the waterbed effect overall: retail prices first increased substantially, as we found in Genakos and Valletti (2011), but then this effect considerably decreased over time due to the growing importance of mobile-to-mobile traffic. Finally, we do not find any evidence that profits of mobile operators have been affected by regulatory cuts in termination rates.

Our results have important policy consequences. The fact that mobile penetration nowadays is very high in most developed countries, and that mobile-to-mobile traffic far exceeds fixed-to-mobile traffic volumes, means that regulators should now be less worried about possible adverse or unintended short-run consequences of regulatory cuts to mobile termination charges. The absence of the waterbed effect now implies that further termination charges cuts will decrease the price of calls to mobile phones, which will benefit consumers. Nor there is any strong indication that these cuts have considerably weakened the mobile operators' position to survive or to compete by making new investments.

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[6] When responding to the European Commission's 2008 Recommendation on further cuts to mobile termination rates, Vodafone, the largest mobile operator in Europe, explicitly mentioned our work on the waterbed effect (available, at the time, in a draft form) and went as far as to argue that such further cuts would result in a decrease in mobile ownership within the EU-27 by almost 40 million users. See http://ec.europa.eu/information_society/policy/ecomm/doc/termination_rates/library/public_consult/termination_rates/vodafone.pdf

The rest of the paper is organised as follows. In Section 2, we describe the main issues related to mobile interconnection. In particular, we highlight how results from the extant literature differ when calls are made from fixed to mobile networks, as opposed to calls within the mobile industry. Section 3 presents the empirical framework, while Section 4 describes our data. Section 5 discusses the empirical results, split between the effects that regulation had on customers' bills and on mobile operators' profits. Section 6 concludes.

2. Interconnection and call termination

Telecommunications networks sell wholesale services (also called "termination") to each other, as a call which is initiated on a network must obviously also be answered, and not necessarily on the same network. These termination services are not directly visible to end users, but have an impact on their bills.

In the early days of mobile telephony, the largest amount of traffic directed to mobile phones would come from fixed networks. The economics literature highlighted how, even in settings where mobile operators compete against each other vigorously, competition does not help to keep fixed-to-mobile (F2M) termination rates low.[7] This situation has been called one of "competitive bottlenecks": Mobile operators have the ability and incentives to set monopoly prices in the market for F2M calls (as the price there is paid by callers on the fixed line, not by own mobile customers), but the rents thus obtained might be exhausted via cheaper prices to mobile customers in case competition among mobile operators is vigorous.

The intuition for the monopoly pricing result for the F2M market is simple: Imagine F2M termination rates were set at cost; then one mobile operator, by raising its F2M termination rate, would be able to generate additional profits that it could use to lower subscription charges and attract more customers. While the mobile sector would therefore not necessarily be making any excess profits overall, an inefficiently low number of F2M calls would be made.

Given the strong case for regulatory intervention, it is not surprising that many countries have decided to intervene to cut these rates. Indeed, all EU member states, as well as several other countries, have done so, to the benefit of consumers calling mobile phones. The

[7] See Gans and King (2000), Armstrong (2002), and Wright (2002).

"market analysis" performed under the European Regulatory Framework for Communications adheres to this logic: Each mobile network is a monopolist on termination of calls to its own customers and therefore has the market power to raise wholesale prices significantly above cost.

By cutting termination rates, regulators have benefited those fixed users calling mobile phones from the fixed networks. However, reducing the level of F2M termination rates can potentially increase the level of prices for mobile subscribers, causing what is known as the "waterbed" (or "seesaw") effect. The *negative* relationship between F2M termination rates and prices paid by mobile consumers is a rather strong theoretical prediction that holds under many assumptions about the details of competition among mobile operators.[8]

These predictions, though, are only valid for F2M calls. Over the last decade most countries have witnessed a strong growth of the mobile sector that has now overtaken fixed telephony. Given these developments it is worth asking if the economics of mobile-to-mobile (M2M) calls are the same, and whether the rationale for intervention has changed or not.

The economics literature has analysed those issues in detail. To make the analysis sharper, a large part of the literature on competition between mobile networks is concerned primarily with their interconnection and the setting of the corresponding wholesale prices, therefore ignoring calls received from the fixed network, which were instead the focus of the earlier studies. The seminal works of Armstrong (1998), and Laffont *et al.* (1998) considered the question of whether mobile networks could achieve collusive outcomes in the retail market by jointly choosing the M2M termination rate. This research question should be seen in the light of the broader issue of whether competition between firms owning communications infrastructures should involve only minimal regulation, such as an obligation to give access and negotiate over the respective charges, or whether wholesale prices should be regulated directly. A concern is that wholesale rates might be set in such a way as to relax competition in the retail market, i.e., that termination rates could be used as an instrument of "tacit" collusion.

What the more recent literature found is that the answer depends on several nuances of the models employed. A reduction in M2M termination causes directly a reduction in the costs for all calls made to customers belonging to a different mobile network (the so-called

[8] See Armstrong (2002), Wright (2002), and Genakos and Valletti (2011).

"off-net" calls). But there are also subtle strategic effects, often depending on the types of tariffs used: With linear tariffs, i.e., tariffs that only charge for each call made, networks would coordinate on termination rates above cost in order to raise the cost of stealing each other's clients. In this case, lowering M2M termination rates would actually make the industry more competitive, therefore reducing bills. In this scenario, one would expect a *positive* relationship between termination rates and customers' bills. This is in stark contrast with the unambiguous waterbed effect that would arise from F2M calls.

Hence, the economics of F2M termination are quite different from the economics of M2M termination. But, in practice, the two are related. A relation arises in two ways: 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).

This has important consequences for the way customers' bills would change as a consequence of regulations that cuts termination rates. In the Appendix, we present a simple Hotelling model of duopoly competition in the mobile industry, alongside calls being received from the fixed network, and show that the total bill of a mobile customer can be summarised as follows:

(1) Bill = cost + Hotelling parameter – "rent from F2M calls" + "effect of M2M competition".

The first term on the RHS refers to the total cost of supplying mobile telephony services to a user. The second term is a standard term reflecting the intensity of (horizontal) competition between networks. The third and fourth terms are what we discussed above, and they both depend on termination rates. The lower the termination rate, the lower the termination rent from F2M calls, therefore causing a waterbed effect: The bill should *increase* as a consequence of a regulatory cut in termination rates. However, this very same cut will also impact on the last term. While in general its sign depends on model details, it suffices here to say that there are plausible circumstances that make the last effect *opposite* to the waterbed prediction. An example was given above (competition in linear tariffs), but there are several other mechanisms that generate the same predictions.[9] Since regulation

[9] An expression akin to eq. (1) can be found, e.g., in the model of Armstrong and Wright (2009) that we take as a reference point (see their eq. (12)). Other models that would generate a similar prediction on bills include those of Hoernig *et al.* (2014) who model calling circles, Hurkens and Lopez (2014) who consider customers' expectations, and Jullien *et al.* (2013), who deal with heterogeneous mobile calling patterns. For surveys on the existing literature, see Armstrong (2002), Gans *et al.* (2005), and Hoernig and Valletti (2012).

affects both the last two terms, our aim is to try to capture the overall effect on the total bill coming from regulatory cuts in mobile termination rates.

3. Empirical Framework

For our empirical analysis, we employ an instrumental variable regression framework, similar to our earlier research (Genakos and Valletti, 2011):

(2) $\ln P_{ujct} = \alpha_{ujc} + \alpha_t + \beta_1 \ln(MTR)_{jct} + \varepsilon_{ujct}$,

(3) $\ln \Pi_{jct} = \alpha_{jc} + \alpha_t + \beta_1 \ln(MTR)_{jct} + \varepsilon_{jct}$.

Eq. (2) tests the impact of regulation of mobile termination rates (MTR) on customers' bills, while eq. (3) tests the impact regulation has on mobile operators' profits. More in detail, the dependent variable in eq. (2) is the logarithm of (euros PPP adjusted) retail prices ($\ln P_{ujct}$) paid by a customer with the usage profile u = {low, medium, high} and subscribing to mobile operator j in country c in quarter t. The dependent variable in eq. (3) is the logarithm of earnings before interest, taxes, depreciation and amortization (EBITDA), which is defined as the sum of operating income and depreciation and is our proxy for profits ($\ln \Pi_{jct}$). Time fixed effects (α_t) and usage-operator-country fixed effects (α_{ujc}) control for time-invariant global trends and for usage-operator-country characteristics, respectively. The main variable of interest, $\ln(MTR)_{jct}$, is the logarithm of the (euros PPP adjusted) mobile termination rates charged by mobile operators for terminating calls on their networks.

The key idea is to use termination rate regulation as an instrument that directly impacts only MTRs and not customers' bills. In our earlier work (Genakos and Valletti, 2011) we argue extensively on the exogeneity of regulation with respect to mobile bills (pp. 10-14). We recall here the important point that regulators do not have any legal power to intervene on retail prices in the mobile industry, and conduct a wholesale market analysis of mobile call termination only. Hence, both retail prices and termination rates were freely chosen by mobile operators *before* the introduction of regulation and should be considered endogenous. After the introduction of regulation though, MTRs were capped by regulators through glide paths that were always binding for mobile operators. In other words, *after* regulation is applied, the MTR becomes exogenous as it is set by the regulators and not the mobile operators themselves.

As an example, consider the MTRs set by the telecommunications regulator in France (ARCEP).[10] Regulation was introduced in 2004, where mobile termination to the two largest firms (Orange and SFR) was capped at 14.94 €cent/min, while the latest entrant in the market (Bouygues) was capped at 17.89 €cent/min. All operators indeed set their termination rates at the maximum level allowed by the cap. In every year since then, the regulator has further cut MTRs, allowing some differentiation between the largest incumbents and the smallest entrant, until 2011Q3 when all operators' MTRs were capped at the same rate of 2 €cent/min. This is a huge change in just seven years, showing an example of how the binding glide paths set by the regulators have been decreasing fast over time. We exploit both differences in the timing of the enactment, but also differences in the toughness of the implementation of the regulation across and within countries.[11] First, we use a binary indicator (0/1) to signify the exact timing of the start of regulation for every operator in each country (Regulation_{jct}). The impact of regulation on prices through the MTR is identified from countries that introduced the regulation and measures the effect of regulation in reforming countries compared to the general evolution of prices in non-reforming countries. This simple indicator is very powerful when examining the years around the change in regulation. However, its identification power deteriorates towards the end of our dataset when all the countries have introduced such regulation. For instance, in the French case illustrated above, a binary variable equal to one over the seven-year period 2004-2011 would not be able to capture the actual toughness of regulation at the intensive margin. Using the binary indicator is not enough because prices do not simply respond to the initial step decrease in MTRs, but also to a continuous and fast sliding path. To capture this underlying phenomenon, we also employ an index of regulation that varies over time depending not only when each country introduced this regulation, but also how "tough" the regulatory authorities were in cutting MTRs. Our index of regulation is defined as:

$$(4)\quad MaxCountryMTR\,\text{index}_{jct} = \begin{cases} 0 \text{ if } MTR_{jct} \text{ is unregulated,} \\ \dfrac{MaxMTR_c - MTR_{jct}}{MTR_{jct}} \text{ if } MTR_{jct} \text{ is regulated,} \end{cases}$$

where $MaxMTR_c$ is the highest MTR allowed in country c one quarter before the introduction of regulation, capturing the level that MTRs would achieve in the absence of

[10] http://www.arcep.fr/index.php?id=8080

[11] On the rationale as to why regulation varies across operators within a country, see Dewenter and Haucap (2005).

regulatory interventions. The absolute level of the index is not of particular concern when comparing countries, as we control for time-invariant country-operator-usage fixed effects, as well as time fixed effects that account for common global trends.

4. Data

We matched three different data sources for our analysis. First, we used Cullen International to get information on mobile termination rates. Using this source and various other industry and regulatory publications, we were also in a position to identify the dates in which regulation was introduced across countries and operators, and the level of regulated rates (see, Table 1). Second, we used Teligen to obtain quarterly information on the total bills paid by consumers across operators and countries (2002Q3-2011Q4). Teligen collects and compares all available tariffs of the two largest mobile operators for thirty OECD countries. It constructs three different consumer usage profiles (large, medium and low) based on the number of calls and messages, the average call length and the time and type of call.[12] A distinction between pre-paid (pay-as-you-go) and post-paid (contract) tariffs is also accounted for, as this is an important industry characteristic. These consumer profiles are then held fixed when looking across countries and time. Third, we used quarterly information taken from the Global Wireless Matrix of the Bank of America Merrill Lynch dataset (henceforth, BoAML). BoAML compiles basic operating metrics for mobile operators in forty-six countries. For our purposes, we used the reported earnings margin before interest, taxes, depreciation and amortization (EBITDA).[13] Table 2 provides some key summary statistics.

The Teligen dataset has two main advantages. First, by fixing *a priori* the calling profiles of customers, it provides us with information on the best choices of these customers across countries and time. Second, the prices reported in this dataset include much of the relevant information for this industry, such as inclusive minutes, quantity discounts, discounts to special numbers, etc. (although it does not include handset subsidies). However, this richness of information comes at the cost of having data for only the two biggest operators of every country at each point in time. This reduces the variability and makes identification of our

[12] Note that these are hypothetical profiles and not actual customer bills.
[13] All consumer prices, termination rates and revenue data were converted to euros using the Purchasing Power Parities (PPP) currency conversions published by the OECD to ease comparability. None of our results depends on this transformation.

variables of interest harder.[14] Moreover, examining a decade long of consumer behaviour in such a dynamic industry such as the telecommunication industry, would perhaps call into question the stability of the customer profiles throughout the whole period. Indeed, Teligen adjusted the calling profiles of its customers in 2006 and we will also use this dataset to examine the robustness of our results.

5. Results

Results from our baseline model (2) are reported in Table 3. In column (1) we replicate our earlier results: For the period 2002Q3-2006Q1, we found a statistically significant waterbed effect when employing the binary indicator for regulation.[15] Column (2) applies the same approach to the whole sample (2002Q3-2011Q4). The picture now changes quite dramatically, despite a trebling of the sample size. The waterbed effect is now statistically indistinguishable from zero. Most importantly though, the binary indicator of regulation does not seem to be a valid instrument in the first stage. This is somehow expected since, as argued above, the identification power of the binary indicator diminishes over time as all the countries become regulated and underestimates the tightening of regulatory cuts over time. For this reason, in the next two columns we employ the MaxCountry index of regulation. In column (3), looking at the period 2002-2006, there is a positive and significant waterbed effect, in line with our earlier results, thus reassuring on the validity of the MaxCountry index of regulation. The effect becomes insignificant when looking at the whole sample in column (4). Notice that the first-stage coefficient is in both cases negative and significant, capturing the continuous tightening of the regulation. We conclude that a decade of regulation has cut termination rates, but did not have any adverse impact on mobile bills to final customers on the whole.[16]

[14] The BoAML dataset, which gathers information from companies' accounts, includes instead every mobile operator in a country.

[15] See, Genakos and Valletti (2011), Table 1, column 1.

[16] Also notice that the Pre-paid dummy always gets a negative sign, statistically significant in columns (3) and (4), reflecting that pre-paid bills are lower than post-paid bills.

In Table 4 we conduct several robustness checks.[17] First, Teligen updated in 2006 the way it calculates baskets of services. In particular, from 2006Q2, Teligen reports information both about a "new" basket that it found more relevant for market comparisons, as well as the "old" basket employed in earlier periods. Hence, in the second half of our data (2006Q2-2011Q4), we can see if differences might arise by employing different weights in the customers' profiles. The answer is no: Results persist in both cases; see columns (1) and (2). Employing both the "old" and the "new" Teligen baskets produces very comparable results, whereby the first stage coefficient is negative and significant, but the second stage impact on MTRs is statistically not different from zero.

Second, in the expanded dataset, new countries not previously monitored are included. These correspond to Estonia, Finland and Slovenia (about 200 observations in total). To check if results are driven by a composition effect, we exclude these countries. Results in column (3) are virtually identical to those in Table 3, column (4). Hence, the vanishing of the waterbed effect does not seem to be driven by having included a particular set of countries.

As a third exercise, we consider the extent to which results are driven by the treatment group. In Genakos and Valletti (2011), we had a set of countries that were always regulated, a set that were always unregulated, and a set of countries that experienced a change of regulation during the period. The latter set of countries is the treatment group in our earlier work.[18] In the new dataset, all countries get regulated – sooner or later. In column (4), we compare the set of countries that got regulated post-2006 ("new treatment group")[19] with the control group that was always regulated throughout the period – hence excluding the treatment group of Genakos and Valletti (2011). Results indicate that the waterbed effect is not present for this set of countries. Finally, in column (5) we compare the evolution of prices in countries that introduced the MTR regulation before 2006 ("old treatment group") to the evolution of prices in countries that were regulated, hence excluding the countries that were unregulated until 2006. Results seem to indicate that the waterbed effect is still present for this set of countries, even though it has been reduced significantly over time.[20] Hence, there seems to be a distinctive behaviour between countries that introduce termination rate

[17] We also considered an alternative index of regulation instead of the MaxCountry index. We constructed an index called *MaxAll*, similar to eq. (4), but where we replace the $MaxMTR_c$ in the numerator of the RHS with the highest MTR among *all* countries at a given period *t*. This index has more time variation. Results are reported in Table A1 and remain qualitatively the same (see supplementary material).
[18] The set comprises Australia, France, Germany, Portugal and Switzerland.
[19] The set comprises Greece, Ireland, Luxembourg, Netherlands, New Zealand and Turkey.
[20] The second stage coefficient in Table 4, column (5) is less than half that of Table 3, column (3).

regulation earlier to the countries that did that later on. In line with the theoretical arguments presented above, our conjecture is that this difference is not random, but stems from the increasing importance of M2M relative to F2M calls. We explore this hypothesis below.

4.1 Industry evolution

The picture in the telephony market that emerges in recent years is very different from the one in early years, where we had found in our previous work the existence of a waterbed effect. The evolution of the UK market provides an interesting case study. According to Ofcom, the UK's regulator, in 2005 the volume of F2M calls was 15.7 bn minutes, comparable with 16 bn minutes of M2M off-net calls. By 2012, F2M calls were 9.4 bn minutes, less than one fourth of the 43 bn minutes of M2M off-net calls.[21] From these figures, it is also immediately apparent how relevant the stakes are: A cut in termination rates of 1 penny per minute, when multiplied by several billions of minutes of communications every year, produces large transfers of money in the industry. Therefore, according to the theoretical predictions summarised by eq. (1), what should matter for the overall effect of regulation of termination rates on mobile customers' bills, is the relative weight that F2M calls have compared to M2M calls. The larger the share of M2M calls, the lower the waterbed effect that could even change sign.

To investigate this we collected additional information on traffic patterns in the telephony industry to see how these changed over time. First, we collected annual information on the ratio of mobile to total outgoing voice traffic[22] from the Body of European Regulators for Electronic Communications (BEREC) and the reports published by the EU Electronic Communications Market indicators. Using this information, Figure 1 looks at mobile traffic as a percentage of the total outgoing traffic and reports the change in this percentage between 2005 and 2010 for almost all the countries in our sample.[23] The UK example is by no means an outlier: The average increase of the mobile traffic percentage was 63% across all countries, indicating the strong trend from fixed to mobile usage. In addition, we also

[21] See "Communications Market Report: UK", Ofcom 2013.
[22] This is defined as (M2F + M2M)/(F2M + M2M + M2F + F2F) where each term is expressed in minutes.
[23] For Luxembourg and New Zealand we could only find information for 2008 and 2009, so we do not report them in the graph.

collected similar information on the ratio of mobile (M2F + M2M) to total (F2M + M2M + M2F) outgoing voice traffic[24] on a quarterly basis from the market research company Analysys Mason Ltd. We also looked at other measures (e.g., the percentage of mobile subscribers of the whole telephony industry), and at other periods. They are not reported here for the sake of brevity, but they all show an unmistakable pattern: Fixed telephony has been declining over time in its importance compared to mobile telephony as far as voice and text communications are concerned.[25] As a consequence, the waterbed effect should have been overtaken by competitive effects within the mobile industry.

Using these new datasets, we calculated the ratio of mobile to total traffic at the time of the introduction of MTR regulation across all countries. We then split the sample into those countries with above and below median mobile to total traffic ratio, and compare the evolution of prices in those countries using as a control the countries that were always regulated. Table 5 reports the results. Using the BEREC/EU information we find a positive and significant waterbed effect in column (1) for those countries that introduced the MTR regulation when they had a below median mobile to total traffic ratio, but no waterbed effect in column (2) for those countries that introduce the same regulation when they had an above median similar ratio. Columns (3) and (4) repeat the same exercise using the Analysys Mason information. Again, countries with below median ratio seem to experience a positive and significant waterbed effect, which disappears for those with a high mobile total traffic ratio. Notice that in all columns the first stage effect of a cut in MTRs on prices is always negative and significant.

4.2 Impact on profits

We finally looked at the impact of regulation of termination rates on mobile operators' profits. Operators often challenge, and vehemently so, regulatory cuts in court. They argue that regulatory cuts will reduce their profitability and, more importantly, will diminish their incentives to invest in the industry, e.g., via technology improvements and upgrades. The operators' behaviour is however mixed in this respect, as these views are not shared by all, especially as some operators have argued that, on the contrary, reduced termination rates will be pro-competitive since they will reduce asymmetric treatments between on-net and off-net calls.

[24] Hence, excluding F2F voice traffic from the total traffic. The new ratio is defined as (M2F + M2M)/(F2M + M2M + M2F), where each term is expressed in minutes.
[25] Fixed telephony, however, still performs other fundamental roles – in particular it provides the main infrastructure for broadband communications.

We do not find any statistically relevant result.[26] MTR regulation did not seem to affect profits either way over the entire period. We also tested if there was any differential impact of regulation of termination rates on the profits of "large" vs "small" operators (we defined as "small" any other than the two biggest operators in each country). On the one hand, smaller operators typically have more outgoing than incoming off-net traffic, so they might benefit from cuts that will reduce their net outgoing payments. On the other hand, smaller operators have been allowed for some time higher (asymmetric) termination rates, thus a cut in termination rates might be tougher for them. Again, we find *no* differential impact of regulation of termination rates on the profits of small and large operators. The effects are not significantly different from zero.

On balance, we do not find evidence that profits of mobile operators have been affected by regulatory cuts in termination rates. Data, however, are considerably noisier than the price basket data, and results should therefore be taken with caution. It is in fact possible that regulation *did* have a negative effect on profits, but our data do not capture the fact that mobile operators have also been effective at reducing their cost base at the same time. For instance, policies like cell site sharing, or exploiting economies of scope between voice and data (migration from 2G to 3G services) occurred over the same period as MTR regulation became tighter. To the extent that these cost reductions applied differentially between markets over time, then our time dummies would not properly account for them. This issue requires further investigation, which largely depends on having access to better data on the operators' accounts.

6. Conclusions

We have conducted an assessment of regulation of mobile termination rates over the last decade (2002-2011), using a large sample of mobile operators which have been subject to various degrees of regulation over time. Our new results qualify in an important way our earlier findings (Genakos and Valletti, 2011) which were obtained using a similar approach, but employing a dataset valid only until 2006.

[26] Results are reported in Table A2 (see supplementary material).

We have found that the waterbed effect has essentially unwound over time. While, in the earlier periods, regulatory cuts in termination rates also produced an increase in mobile customers' bills, this does not hold on average using the more recent data. We demonstrate that this is due to the diminishing importance of fixed-to-mobile calls relative to mobile-to-mobile calls. This is in line both with theoretical predictions and with actual industry trends.

The implications of our results are strong. Earlier regulation of termination rates had to find the right balance between the benefits that would accrue to fixed users calling mobile phones and the negative impact on mobile phone users. This was quite a difficult exercise. We show that this trade-off only emerges if the fixed-to-mobile calls traffic is significantly larger than the mobile-to-mobile traffic. Since the trend in all countries is towards an increase in mobile-to-mobile traffic, the case for intervention is now more compelling as unintended consequences of regulation, such as the waterbed effect, are less likely to arise.

Clearly, regulatory cuts cannot continue forever since rates are reaching the natural limit of the incremental costs.[27] Regulation in the EU is therefore close to an end, in that it cannot get any tighter than it currently is, though it cannot be removed as otherwise operators could respond by increasing termination rates again. However, the regulatory battleground is still very much open elsewhere – in particular in African and Latin American countries, where termination rates are typically much higher than in the EU. As also in these countries the mobile industry has surpassed fixed telephony in terms of subscribers and call volumes, our results suggest that competitive effects within the mobile industry should now prevail over the waterbed effect.

The impact of regulation has also to account for the impact it has on firms' profits and their incentives to invest. Possible short-run benefits from wholesale regulation must always be confronted with their long-run consequences. We found scant evidence that profits have been reduced by regulation. We also pointed out as a caveat that available price data are typically richer than information about operators' profits. It would be very interesting to find more granular data at the firm level in order to investigate if this type of regulation actually induced firms to take actions that affected their network costs or the quality of their offerings.

[27] Currently, mobile termination rates are approaching 1 eurocent/min in the EU, down from an average of 13 eurocents/min in 2005. Source: BEREC. A system of "bill-and-keep", where calls are exchanged among all operators at a zero marginal cost, is the lowest possible MTR that can be eventually applied.

Appendix

The purpose of this section is to present a model that generates the tension between F2M and M2M calls, as described by eq. (1) in the main text. Our aim is to show a possibility result under very simple assumptions. To do so, we propose a model that builds directly on Armstrong and Wright (2009) and Hurkens and Lopez (2013).

Imagine a setting with one fixed network and two competing mobile networks, denoted as firms 1 and 2. There is a total mass of n_F users on the fixed network. The two mobile firms compete for a continuum of mobile consumers of mass n_M. Each firm i = 1, 2 charges consumers a fixed fee f_i and can discriminate between calls made on-net (i.e., made to customers belonging to the same network i) and off-net (i.e., made to customers belonging to the rival network j). Firm i's marginal on-net price is denoted as p_{ii} and the off-net price is denoted as p_{ij}. Mobile consumers' utility from making calls of length q is given by a concave, increasing and bounded utility function $u(q)$. Call demand $q(p)$ is defined by $u'(q(p)) = p$. The indirect utility derived from making calls at price p is $v(p) = u(q(p)) – pq(p)$, where $v'(p) = – q(p)$.

Each mobile firm is assumed to incur a marginal cost c_O of originating a call and a marginal cost c_T of terminating a call, so the actual marginal cost of a M2M call is given by $c_O + c_T$. In addition, there is a fixed cost f of serving each mobile subscriber, which includes, e.g., the subscriber's handset and the billing costs. If calls are made off-net, the sending firm does not incur the termination cost c_T, but pays its rival a *termination charge*, denoted by a. Instead, termination costs c_T are borne by the receiving firm, which gets a from the sending firm.

As for F2M calls, there are also the same costs c_O for origination and c_T for termination of calls. The fixed network, again, has to pay the termination charge a instead of the termination costs, which are borne by the receiving network. We assume that there are $q(P)$ minutes of F2M calls to each subscriber on network i (mobile customers only receive calls from the fixed network), where P denotes the F2M per-minute price. We also assume that P is given by $P = c_O + a$. As discussed by Armstrong and Wright (2009), such pricing could arise as a result of the regulation of the fixed network or competition between fixed networks.[28]

[28] Note that, when $P = c_O + a$, a regulation that cuts the termination rate a obviously confers benefits to those calling mobile phones from the fixed network. We are instead interested here to see the impact of this regulation on mobile customers.

If x_i denotes mobile firm i's market share, its total profits are given by

$$\text{(A1)}\quad \pi_i = n_M x_i \{[f_i - f + x_i(p_{ii} - c_O - c_T)q(p_{ii}) + (1 - x_i)(p_{ij} - c_O - a)q(p_{ij})] + (1 - x_i)(a - c_T)q(p_{ji}) + (a - c_T)n_F q(c_O + a)\}.$$

The expression is made of several terms in the curly bracket. The first terms, grouped in the square bracket, correspond to profits from own customers who subscribe and make both a fraction x_i of on-net M2M calls and a fraction $1 - x_i$ of off-net M2M calls. The other two terms correspond to profits from termination, respectively from M2M off-net calls and from F2M calls.

To close the model, we follow Hurkens and Lopez (2013) and assume that mobile networks are differentiated à la Hotelling. Consumers are uniformly distributed on the segment [0, 1], while the two networks are located at the two ends of this segment ($x_1 = 0$ and $x_2 = 1$). We assume full participation so that each consumer subscribes to the network that yields the highest net utility. A consumer located at x and joining network i obtains a net utility given by

$$w_i - t|x - x_i|,$$

where t is the customary "transportation cost" which measures the degree of horizontal differentiation between the two networks, and w_i is the value to a consumer subscribing to network i. In particular, given that consumers call each other with the same probability, the surplus from subscribing to network i (gross of transportation costs) equals

$$w_i = n_M[x_i^e v(p_{ii}) + x_j^e v(p_{ij})] - f_i,$$

where x_i^e is the expected market share of firm i. Market share of network i is thus given by

$$\text{(A2)}\quad x_i = \frac{1}{2} + \frac{w_i - w_j}{2t}.$$

We solve for the equilibrium where firm i (and similarly, j) maximise its profits (A1) with respect to the multi-part tariff $\{p_{ii}, p_{ij}, f_i\}$, subject to (A2), and where consumers' expectations are self-fulfilled at equilibrium, that is, $x_i^e = x_i$.

The symmetric equilibrium is actually quite simple to characterise (for further details about existence, see Hurkens and Lopez, 2013). Because of the multi-part nature of the tariff, call prices are set at the "perceived" marginal costs, i.e., $p_{ii} = c_O + c_T$ and $p_{ij} = c_O + a$. The fixed fee is equal to $f_i = f + t - (a - c_T)q(a + c_T)n_F$. The total bill of a mobile consumer is then

(A3) $$Bill = f_i + n_M\left[x_i p_{ii} q(p_{ii}) + (1 - x_i)p_{ij}q\left(p_{ij}\right)\right] =$$
$$f + t - (a - c_T)q(a + c_T)n_F + \frac{n_M[(c_O + c_T)q(c_O + c_T) + (c_O + a)q(c_O + a)]}{2}.$$

This expression shares the features of eq. (1) in the main text. The bill reflects fixed costs to supply the service (*f*), and the intensity of competition as described by the transportation cost (*t*). There are then two terms which directly depend on the termination charge a. One term represents the waterbed effect coming from F2M calls: If termination regulation cuts a, and thus reduces the rents from F2M calls, the bill will go up. This effect is bigger the larger the fixed network, as captured by n_F. Finally, the last term produces an opposite effect: The lower a, the cheaper will be off-net M2M calls, thus reducing the customer's bill. This effect prevails as the mobile network gets larger, as captured by n_M.

Let us define $F(a) \equiv (a - c_T)q(a + c_T)$ and $M(a) \equiv \frac{(c_O+c_T)q(c_O+c_T)+(c_O+a)q(c_O+a)}{2}$. It is for sure $F'(a) > 0$ and $M'(a) > 0$, as long as *a* is set close to cost. Then (A3) becomes

(A4) $$Bill = f + t - F(a)n_F + M(a)n_M,$$

which forms the basis for our empirical specification. The total impact of regulation on the bill is

(A4) $$\frac{\partial Bill}{\partial a} = -F'(a)n_F + M'(a)n_M.$$

The sign varies as follows: $\frac{\partial Bill}{\partial a} \gtreqless 0 \Leftrightarrow \frac{n_F}{n_M} \lesseqgtr \frac{M'}{F'}$. The overall waterbed effect in this model thus depends on the ratio n_F/n_M. If this ratio is large, the waterbed effect is predicted and bills will go up as a consequence of a regulation which cuts termination charges. If this ratio is small, the waterbed effect will vanish and can even change sign.

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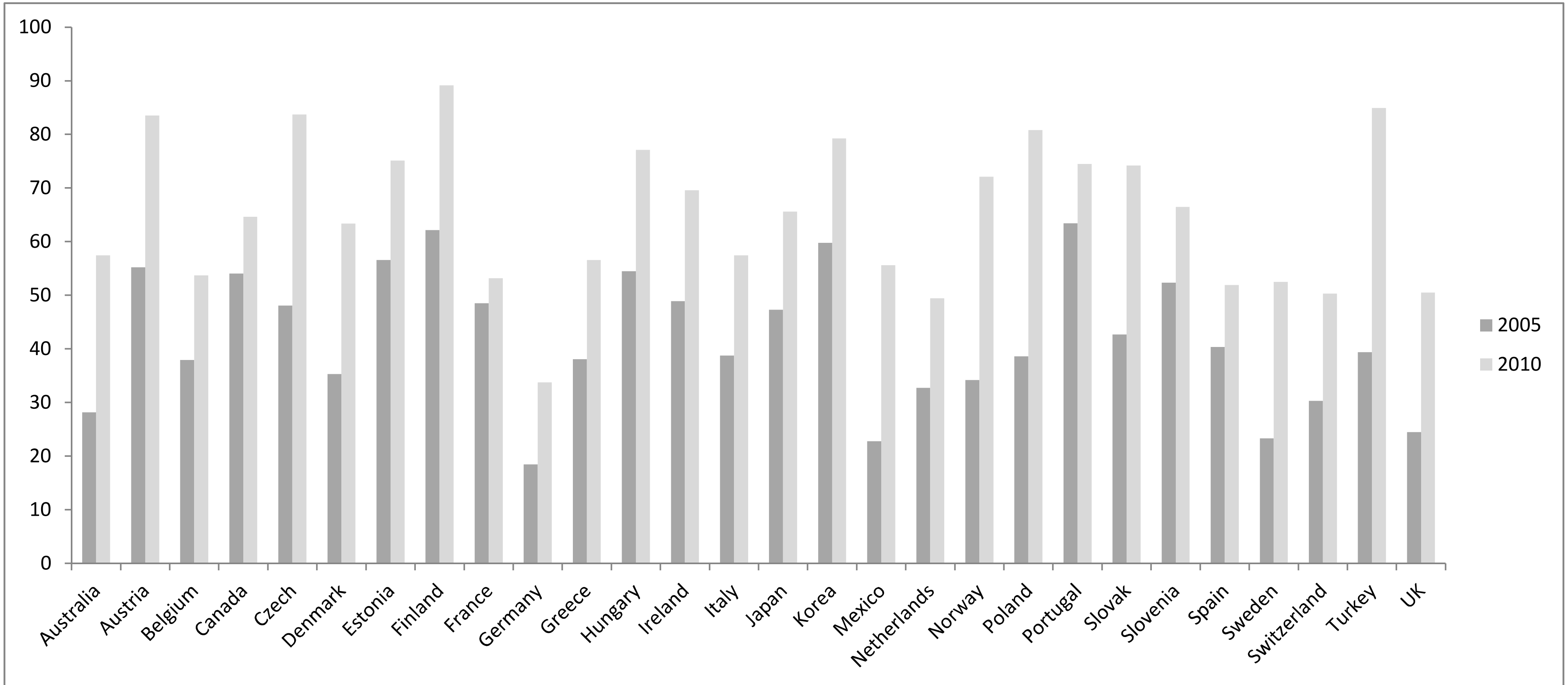
FIGURE 1: MOBILE AS A PERCENTAGE OF TOTAL OUTGOING TRAFFIC



Notes: The figure presents information on the percentage of mobile traffic as a percentage of the total outgoing traffic in the whole telecommunications industry (fixed-to-fixed, mobile-to-fixed, fixed-to-mobile and mobile-to-mobile traffic).

Source: Authors' calculations based on information from European Commission (Electronic Communications Market Indicators – Digital Agenda Scoreboard), Body of European Regulators for Electronic Communications (BEREC).

TABLE 1 - REGULATION CHRONOLOGY

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

Notes: The table presents information on when the termination rate regulation was introduced in a country (column "Year"), and the way these countries were treated within our sample period using the Teligen price data (column "Comment").
Source: Authors' calculations based on information from Cullen International, the European Commission and Regulatory Authorities by country.

TABLE 2 - SUMMARY STATISTICS

Variable	Observations	Mean	Standard Deviation	Min	Max
			Teligen dataset		
$\ln P_{ujct}$	5283	5.711	0.741	3.480	7.509
$\ln(MTR)_{jct}$	5283	2.270	0.518	0.694	3.292
$Regulation_{jct}$	5283	0.867	0.340	0	1
MaxCountry MTR $index_{jct}$	5283	0.436	1.131	0	8.780
			Always regulated countries		
$\ln P_{ujct}$	2922	5.652	0.770	3.480	7.391
$\ln(MTR)_{jct}$	2922	2.238	0.546	0.698	3.243
			Old treatment countries		
$\ln P_{ujct}$	1086	5.831	0.675	4.119	7.197
$\ln(MTR)_{jct}$	1086	2.279	0.524	0.694	3.292
$Regulation_{jct}$	1086	0.782	0.413	0	1
MaxCountry MTR $index_{jct}$	1086	1.276	1.561	0	8.780
			New treatment countries		
$\ln P_{ujct}$	1275	5.743	0.714	3.863	7.509
$\ln(MTR)_{jct}$	1275	2.337	0.432	0.993	3.199
$Regulation_{jct}$	1275	0.635	0.482	0	1
MaxCountry MTR $index_{jct}$	1275	0.719	1.452	0	7.710
			Bank of America Merrill Lynch dataset		
$\ln EBITDA_{jct}$	2260	-1.161	0.448	-4.749	-0.536
$\ln(MTR)_{jct}$	2260	2.273	0.529	0.693	3.454
$Regulation_{jct}$	2260	0.847	0.360	0	1
MaxCountry MTR $index_{jct}$	2260	0.475	1.138	0	8.780

Notes: The above table provides summary statistics on the key variables used in Tables 3-4 and A2 (supplementary material) based on the Teligen data corresponding to the best deals available at every quarter, the BoAML dataset and the matched MTRs.
Source: Authors' calculations based on the Teligen, Cullen and BoAML matched datasets.

TABLE 3 - WATERBED EFFECT THROUGH MTR

	(1)	(2)	(3)	(4)
Estimation method	IV	IV	IV	IV
Dependent variable	lnP_{ujct}	lnP_{ujct}	lnP_{ujct}	lnP_{ujct}
Time Period	2002-2006	2002-2011	2002-2006	2002-2011
$ln(MTR)_{jct}$	-1.189***	2.663	-0.760***	-0.083
	(0.408)	(4.465)	(0.209)	(0.112)
$Pre\text{-}paid_{jct}$	-0.066	-0.052	-0.056**	-0.094***
	(0.050)	(0.077)	(0.026)	(0.022)
Usage-Country-Operator FE	yes	yes	yes	yes
Time FE	yes	yes	yes	yes
Instrument	$Regulation_{jct}$	$Regulation_{jct}$	*MaxCountry MTR* $index_{jct}$	*MaxCountry MTR* $index_{jct}$
1st Stage Coef.	-0.112***	0.022	-0.329***	-0.138***
	(0.026)	(0.039)	(0.025)	(0.009)
1st Stage R^2	0.052	0.001	0.168	0.267
1st Stage F-test	18.28	0.32	179.19	235.59
	[0.000]	*[0.575]*	*[0.000]*	*[0.000]*
Observations	1749	5283	1749	5283
Clusters	153	195	153	195

Notes: The dependent variable is the logarithm of the euros PPP adjusted total bill paid by consumers with different usage at every quarter. The instrumental variable *Regulation* is a binary indicator that takes the value one in the quarters when mobile termination rates are regulated. The instrumental variable *MaxCountryMTR* is an index that takes larger values the more regulated a mobile operator is compared to the MTR prior to regulation in that country. *P-values* for diagnostic tests are in brackets and italics. Standard errors clustered at the country-operator-usage level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.
Source: Authors' calculations based on the Teligen data corresponding to the best deals available at every quarter.

TABLE 4 - WATERBED EFFECT THROUGH MTR - ROBUSTNESS

	(1)	(2)	(3)	(4)	(5)
Estimation method	IV	IV	IV	IV	IV
Dependent variable	$\ln P_{ujct}$	$\ln P_{ujct}$	$\ln P_{ujct}$	$\ln P_{ujct}$	$\ln P_{ujct}$
Time period	2006-2011	2006-2011	2002-2011	2002-2011	2002-2011
	old basket	new basket	excluding Estonia, Finland and Slovenia	new treatment group	old treatment group
$\ln(MTR)_{jct}$	0.005	0.079	-0.087	0.096	-0.319***
	(0.116)	(0.135)	(0.113)	(0.181)	(0.105)
Pre-paid_{jct}	-0.097***	-0.053**	-0.093***	-0.083***	-0.079***
	(0.028)	(0.026)	(0.022)	(0.027)	(0.024)
Usage-Country-Operator FE	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes
Instrument	*MaxCountry MTR* index_{jct}	*MaxCountry MTR* index_{jct}	*MaxCountry MTR* index_{jct}	*MaxCountry MTR* index_{jct}	*MaxCountry MTR* index_{jct}
1^{st} Stage Coef.	-0.129***	-0.072***	-0.139***	-0.134***	-0.118***
	(0.009)	(0.023)	(0.009)	(0.010)	(0.011)
1^{st} Stage R^2	0.293	0.038	0.272	0.174	0.162
1^{st} Stage F-test	190.58	9.77	225.5	196.45	126.5
	[0.000]	[0.002]	*[0.000]*	*[0.000]*	*[0.007]*
Observations	3534	3534	5085	4197	4008
Clusters	186	186	177	159	153

Notes: The dependent variable is the logarithm of the euros PPP adjusted total bill paid by consumers with different usage at every quarter. The instrumental variable *Regulation* is a binary indicator that takes the value one in the quarters when mobile termination rates are regulated. The instrumental variable *MaxCountryMTR* is an index that takes larger values the more regulated a mobile operator is compared to the MTR prior to regulation in that country. *P-values* for diagnostic tests are in brackets and italics. Standard errors clustered at the country-operator-usage level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

Source: Authors' calculations based on the Teligen data corresponding to the best deals available at every quarter.

TABLE 5 - THE EFFECT OF MOBILE TRAFFIC ON WATERBED

	(1)	(2)	(3)	(4)
Estimation method	IV	IV	IV	IV
Dependent variable	lnP_{ujct}	lnP_{ujct}	lnP_{ujct}	lnP_{ujct}
Time period	2002-2011	2002-2011	2002-2011	2002-2011
Mobile relative to total traffic	Low	High	Low	High
$ln(MTR)_{jct}$	-0.321***	0.099	-0.285**	-0.031
	(0.104)	(0.183)	(0.114)	(0.159)
$Pre\text{-}paid_{jct}$	-0.081***	-0.081***	-0.098***	-0.065**
	(0.024)	(0.028)	(0.026)	(0.027)
Usage-Country-Operator FE	yes	yes	yes	yes
Time FE	yes	yes	yes	yes
Instrument	*MaxCountry MTR* $index_{jct}$	*MaxCountry MTR* $index_{jct}$	*MaxCountry MTR* $index_{jct}$	*MaxCountry MTR* $index_{jct}$
1st Stage Coef.	-0.119***	-0.134***	-0.124***	-0.125***
	(0.011)	(0.009)	(0.012)	(0.009)
1st Stage R^2	0.162	0.174	0.114	0.222
1st Stage F-test	126.83	205.61	105.85	172.02
	[0.000]	*[0.000]*	*[0.000]*	*[0.007]*
Observations	4203	4002	4209	3996
Clusters	159	153	165	147

Notes: The dependent variable is the logarithm of the PPP adjusted total bill paid by consumers with different usage at every quarter. Columns (1) and (2) utilize information on mobile to total traffic from the Body of European Regulators for Electronic Communications (BEREC), whereas the last two columns use similar information from the market research company Analysys Mason (see, section 5.1 in the main text for more details). The instrumental variable *MaxCountryMTR* is an index that takes larger values the more regulated a mobile operator is compared to the MTR prior to regulation in that country. *P-values* for diagnostic tests are in brackets and italics. Standard errors clustered at the country-operator-usage level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

Source: Authors' calculations based on the Teligen data corresponding to the best deals available at every quarter.

SUPPLEMENTARY MATERIAL

TABLE A1 - WATERBED EFFECT THROUGH MTR

	(1)	(2)	(3)	(4)
Estimation method	IV	IV	IV	IV
Dependent variable	$\ln P_{ujct}$	$\ln P_{ujct}$	$\ln P_{ujct}$	$\ln P_{ujct}$
Time Period	2002-2006	2002-2011	new treatment group	old treatment group
$\ln(MTR)_{jct}$	-0.986***	-0.118	-0.031	-0.284**
	(0.365)	(0.116)	(0.207)	(0.119)
Pre-paid_{jct}	-0.061	-0.094***	-0.083***	-0.080***
	(0.047)	(0.022)	(0.027)	(0.024)
Usage-Country-Operator FE	yes	yes	yes	yes
Time FE	yes	yes	yes	yes
Instrument	*MaxAll MTR* index_{jct}	*MaxAll MTR* index_{jct}	*MaxAll MTR* index_{jct}	*MaxAll MTR* index_{jct}
1^{st} Stage Coef.	-0.116***	-0.113***	-0.094***	-0.105***
	(0.027)	(0.013)	(0.019)	(0.011)
1^{st} Stage R^2	0.072	0.197	0.102	0.140
1^{st} Stage F-test	18.09	80.09	23.43	93.16
	[0.000]	*[0.000]*	*[0.000]*	*[0.000]*
Observations	1749	5283	4197	4008
Clusters	153	195	159	153

Notes: The dependent variable is the logarithm of the PPP adjusted total bill paid by consumers with different usage at every quarter. The instrumental variable *Regulation* is a binary indicator that takes the value one in the quarters when mobile termination rates are regulated. The instrumental variable *MaxAllMTR* is an index that takes larger values the more regulated a mobile operator is compared to the highest MTR charged in any country at a given period. *P-values* for diagnostic tests are in brackets and italics. Standard errors clustered at the country-operator-usage level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.
Source: Authors' calculations based on the Teligen data corresponding to the best deals available at every quarter.

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SUPPLEMENTARY MATERIAL

TABLE A2 - WATERBED EFFECT THROUGH MTR (PROFITS)

	(1)	(2)	(3)
Estimation method	IV	IV	IV
Dependent variable	$lnEBITDA_{jct}$	$lnEBITDA_{jct}$	$lnEBITDA_{jct}$
Time Period	2002-2011	small operators	large operators
$ln(MTR)_{jct}$	-0.053	0.088	-0.071
	(0.105)	(0.320)	(0.100)
Country-Operator FE	yes	yes	yes
Time FE	yes	yes	yes
Instrument	*MaxCountry MTR* $index_{jct}$	*MaxCountry MTR* $index_{jct}$	*MaxCountry MTR* $index_{jct}$
1st Stage Coef.	-0.140***	-0.190***	-0.129***
	(0.017)	(0.063)	(0.017)
1st Stage R^2	0.264	0.351	0.246
1st Stage F-test	68.13	9.12	56.84
	[0.000]	*[0.009]*	*[0.000]*
Observations	2260	358	1902
Clusters	73	16	57

Notes: The dependent variable is the logarithm of the EBITDA for each operator in a given country at every quarter. The instrumental variable *MaxCountryMTR* is an index that takes larger values the more regulated a mobile operator is compared to the MTR prior to regulation in that country. *P-values* for diagnostic tests are in brackets and italics. Standard errors clustered at the country-operator level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

Source: Authors' calculations based on the BoAML dataset.