Testing the "waterbed" effect in mobile telephony*

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Abstract

This paper examines the impact of regulatory intervention to lower termination rates of calls to mobile phones. Under quite general conditions of competition, theory suggests that lower termination charges will result in higher prices for mobile subscribers, a phenomenon known as the "waterbed" effect. Using a uniquely constructed panel of more than twenty countries over six years, we document empirically the existence and magnitude of this effect. Our results suggest that the waterbed effect is strong but not full. We also show how the waterbed effect depends on competition and on the level of penetration of mobile telephony.

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1. Introduction

What is a "waterbed" effect? Pressing down on one part of the bed causes another part to rise. The waterbed effect we are interested in this paper concerns the regulation of one of the prices set by a multi-product firm. If regulation pushes down one price, is it natural to expect a response in other prices?

This is interesting in the context of mobile telephony for at least two interrelated reasons. Firstly, mobile telephony pricing is not regulated, with the exception of termination rates of calls to mobile phones. These are the prices charged to people calling a particular subscriber, they are not paid by mobile subscribers themselves. Why should a change in the termination rate, which affects, say, a fixed user calling a mobile user, cause a "waterbed" with respect to any one of the prices paid by a mobile user? Secondly, these termination rates have been regulated in recent years, so we can see empirically whether the "waterbed" effect exists and assess its magnitude.

Let us first give some theoretical background on the issue of termination of fixed-to-mobile calls. The literature describes this as a problem of "competitive" bottlenecks (see, e.g., Armstrong, 2002, and Wright, 2002). Imagine a stylised situation where the mobile sector is assumed to be perfectly competitive (i.e., operators do not make any super-normal profit) and mobile operators charge two-part tariffs to mobile customers with identical preferences (for instance a monthly fee and a charge per minute for every call made). Also assume, for the sake of simplicity, that mobile users only call fixed users and receive calls only from them. Then operators would compete to attract customers by setting each call origination charge equal to its marginal cost and set the monthly fee to divide the surplus created between the operator and its customers. These results ensue since there is no reason for mobile operators to set outgoing call charges above cost: marginal cost pricing is efficient and firms have another instrument (the rental fee) to eventually extract profits.

If, as assumed, the mobile industry is perfectly competitive, operators would earn zero extra-profits. Any increase in termination profits (for instance because the termination charge is set above its cost) would simply be passed to mobile subscribers via lower fixed charges. However, even if there are no extra profits in equilibrium, each firm will have a unilateral incentive to set the termination charges of calls it receives from fixed users at the monopoly level. In fact, mobile operators will want to maximise termination profits so as to subsidise their mobile subscribers as much as possible. If one operator did not set them at the monopoly level (but the rival did), it will be at a disadvantage and mobile customers will all go to the rival since the latter could offer a better deal. We can thus conclude that, even with perfect competition for mobile users, there is little competition for providing access to mobile subscribers. This remark suggests that if mobile operators are free to determine termination rates, they will set charges that extract all possible surplus from fixed users. Thus, even when there are no extra rents overall, a skewed price structure would arise.

Two considerations follow from the analysis we briefly sketched above. First, mobile customers come with a termination rent. If there is competition for the market, this rent is exhausted via making prices to mobile customers cheaper. Second, the smaller this rent, ceteris paribus, the higher the price to mobile customers. This is the waterbed effect.

The previous analysis also alluded to the fact that unregulated termination rates would result in a "skewed" pricing structure. No matter how intense competition for mobile customers is, there is no downward pressure on termination rates to these customers. There is room for possible welfare-improving regulatory intervention. These termination rates, therefore, have attracted the attention of regulators in recent years, and all countries are moving towards reducing these rates by regulation.

In regulatory debates into mobile termination rates, there has been considerable discussion about whether such an effect would exist, and if so, how large it would be. The first debate started in the UK in 1997 with the original investigation by the Monopolies and Mergers Commission (now Competition Commission).[1] Another example is the New Zealand Commerce Commission which, in its investigation (2005), initially took the position that mobile subscription prices would rise in response to a cut in termination rates only if mobile firms operated subject to a zero-profit condition. The Commission was subsequently convinced that the waterbed effect is a more general phenomenon, but there remained doubts about the importance of such an effect. The most recent termination rate proposals by Ofcom in the UK consider the issue of the waterbed in order to analyse the impact of regulation of call termination. Ofcom acknowledge the importance of the waterbed effect, but question

[1] The "waterbed" term was used there for the first time by late Paul Geroski who was chairman of the Commission at the time of the investigation.

whether the effect is "complete", arguing that this can only be the case if the retail market is sufficiently competitive.[2]

It has proved difficult to appreciate the existence of the waterbed effect with casual empiricism. Over time, mobile rates (those paid by mobile subscribers) have been decreasing quite steadily in virtually every country, despite the regulation of mobile termination rates. At the same time, though, the industry has become more competitive, with additional entry, tougher competition, etc., exerting a countervailing force. See, as an example, Figure 1 for the behaviour of prices in France. While termination rates have been cut steadily over the years, prices to medium user customers have remained more or less constant. Does this imply there is no waterbed effect? Not necessarily as competition in the industry might also have intensified. Other trends such as economies of scale due to growth in traffic volumes may also mask the impact of the waterbed on subscription prices.

[Figure 1]

The literature on this topic is essentially theoretical and deals with the need and effects of regulation of mobile termination rates (in addition to the works of Armstrong and Wright already mentioned, see also Valletti and Houpis, 2005, and Hausman and Wright, 2006). There is no empirical (econometric) study, other than simple computations and anecdotal evidence presented during investigations. An objective of this paper is to conduct for the first time a test of the waterbed effect. If the effect exists, its magnitude is also a measure of how competitive the market is. Although the waterbed would be present also with a monopolist if the industry is growing (because the monopolist would want to subsidise some mobile subscribers, to the extent that these additional subscribers are called by fixed users, therefore generating termination revenues), clearly the termination rent could not be kept by the mobile operator if competition for the market is intense.

This work is also related to an emerging literature on "two-sided" markets that studies how platforms set the structure of prices across the two sides of the business (see Armstrong, 2006, and Rochet and Tirole, 2006). Telecommunications networks are examples of two-sided markets: providing communication services to their own

[2] See "Mobile call termination, Proposals for consultation", Ofcom, September 2006.

customers over the same platform and providing connectivity to their customer base to other networks. The two markets are linked: more subscribers on the network means more opportunities for users of other networks to make calls. Whenever we look at two-sided markets, the structure of prices (i.e., who pays for what) is fundamentally important for the development of the market. In mobile telephony, typically it is only senders that pay (under the Calling Party Pays system), while receivers do not. This is why termination rates are not the locus of competition and, if left unregulated, they will be set at the monopoly level.[3] This is also a case where the mobile firms sell two goods with interdependent demand: at any given termination rate, the volume of fixed-to-mobile calls that an operator receives depend on the number of mobile subscribers on its network. In a sense, mobile subscribers and fixed-to-mobile calls are complements, as an increase in the number of subscribers will cause an increase in the volume of fixed-to-mobile calls.).[4] Our work therefore also contributes to the more general understanding of two-sided markets. Recent empirical works on two-sided markets include Rysman (2004, on yellow pages; 2007 on credit cards), Argentesi and Filistrucchi (2006, on newspapers), and Kaiser and Wright (2006, on magazines).

The rest of the paper is organized as follows. In section 2 we present two simple models of mobile telephony, one under full competition and one under pure monopoly, with the purpose of showing that the waterbed effect is a natural phenomenon which is expected to arise under general circumstances. Section 3 describes our empirical strategy and discusses the data employed. Section 4 presents the main results on the evidence of the waterbed effect. Section 5 discusses the timing of MTR regulation. Section 6 contains several extensions. Section 7 concludes.

2. Two simple models of the waterbed effect

In this section we discuss two very simple and related models that show how the waterbed effect can emerge under a rather wide range of circumstances. The first is a model under perfect competition and the waterbed effect arises from the zero-profit

[3] The U.S. is a noticeable exception in that there is both a RPP (receiving party pays) system in place and, in addition, termination rates on cellular networks are regulated at the same level as termination rates on fixed networks. For this reason, the U.S. is not included in our sample. Most of the mobile world is under a CPP system.

[4] It is important to be very careful with the use of standard definitions taken from normal “one-sided” markets. In this example, the notion of complementarity between mobile subscribers and fixed-to-mobile calls is more controversial if one starts instead with a price increase of mobile termination.

condition. The second model analyzes a monopoly situation; still the waterbed effect arises via an increase in the 'perceived' marginal cost of each customer.

Let us start with a stylized scenario of perfect competition. Imagine a mobile network operator that makes money from two possible sources:

- Services to own customers. These include subscription services and outgoing calls, i.e., calls made by own subscribers. All these services are bundled together and cost P to the customer, i.e., P is the total customer's bill. Let N be the total number of customers that an operator gets at a price P.
- Incoming calls. These are calls received by own customers but made by other customers belonging to other networks. The total quantity is denoted by Q_I and the corresponding price received by the mobile operator (the MTR) is denoted by T and is regulated.

For ease of exposition, we assume that all calls received are from fixed users (calls from other mobile users could be easily accommodated in this framework). Thus the demand for incoming calls to mobile subscribers coincides with the demand for (outgoing) fixed-to-mobile calls. The profit of the operator is:

$$\pi = (\underbrace{P}_{\text{bill}} - c)N + \underbrace{TQ_I}_{\substack{\text{termination}\\ \text{rents}}}$$

where c denotes the total cost per customer (this cost includes the handset, and the cost of the bundle of calls and services offered to the customer), while there are no other costs from receiving and termination calls.

We assume that the mobile industry is perfectly competitive. The firm does not make any extra rent on any customer. The bill therefore is

$$P = c - TQ_I / N = c - \tau ,$$

where $\tau = TQ_I / N$ is the termination rent per customer. In other words, under perfect competition any available termination rent is entirely passed on to the customer via a reduction in its bill. Since the overall profit does not change with the level of MTR (it is always zero), we can differentiate the zero-profit condition for the operator, leading to $\frac{\partial (P-c)N}{\partial T} = -\frac{\partial TQ_I}{\partial T}$ which can be re-written in elasticity terms as

$$N(1+\lambda\varepsilon_N)\frac{\partial P}{\partial T} = -Q_I(1+\varepsilon_I)$$

where $\varepsilon_N = \frac{\partial N}{\partial P}\frac{P}{N}$ and $\varepsilon_I = \frac{\partial Q_I}{\partial T}\frac{T}{Q_I}$ are respectively the elasticity of mobile subscription and the elasticity of fixed-to-mobile calls, and $\lambda = (P-c)/P = -\tau/(c-\tau)$. We can now obtain an expression for the waterbed effect, expressed in elasticity terms as:

$$(1) \qquad \varepsilon_W = \frac{\partial P}{\partial T}\frac{T}{P} = -\frac{TQ_I}{PN}\frac{1+\varepsilon_I}{1+\lambda\varepsilon_N} = \frac{1+\varepsilon_I}{1/\lambda+\varepsilon_N}.$$

The elasticity of incoming calls ε_I is negative and likely to be less than 1 in absolute value.[5] Also, $\varepsilon_N < 0$ and the termination rent is typically small compared to the overall cost per customer, so $\lambda < 0$ too, and the overall sign of the RHS of eq. (1) is negative, i.e., we should indeed expect a waterbect effect involving a negative relationship between outgoing prices to mobile users and incoming termination prices.

Eq. (1) was derived under the assumption of a "full waterbed" since any termination rent is simply passed on to the customer. Hence, if there is a full waterbed, profits should not be affected by the level of T. Still, a full waterbed effect does not imply a straightforward magnitude of the elasticity ε_W. By inspection of (1),

[5] In a previous version of this work, and using data for Vodafone's companies for which we have detailed information about fixed-to-mobile quantities, we estimated ε_I around -0.22. We recall once more that MTRs are regulated: it is well known that a monopolist will otherwise set the price to the point where demand becomes elastic. Therefore, if left alone, the mobile operator would push up the MTR price and obtain higher termination rents. This elasticity refers to the demand for incoming calls from the point of view of the operator, when T is changed. The elasticity of fixed-to-mobile calls with respect to the end user price, P_F, can be written as $\varepsilon_F = \frac{dQ_I}{dP_F}\frac{P_F}{Q_I} = \frac{dQ_I}{dT}\frac{T}{Q_I}\frac{P_F}{T}\frac{dT}{dP_F} = \varepsilon_I\frac{P_F}{T}\frac{dT}{dP_F}$. Therefore, the elasticity with respect to the retail price is equal to the elasticity with respect to the MTR (ε_I), times a "dilution factor" P_F/T and a "pass-through rate" dT/dP_F. In the case of the UK, Ofcom have assessed a dilution factor of approximately 1.5 (see "Mobile call termination, Proposals for consultation", Ofcom, September 2006). Similar levels around 1.5 can be found in other European countries. Ofcom also believes that pass-through of the termination may be less than complete (i.e., $dP_F/dT < 1$, or $dT/dP_F > 1$), since BT's price regulation applies to a whole basket of services. However, in other European countries the fixed network retention ($P_F - T$) is itself directly regulated (e.g., the case in Belgium, Greece, Italy and the Netherlands).

the elasticity of the waterbed effect could be above or below 1, in absolute value, depending on the relative sizes of (a) termination revenues relative to costs (τ vs. c, which determines the level of λ); and (b) price elasticities for subscriptions and incoming calls ($|\varepsilon_N|$ vs. $|\varepsilon_I|$).

A similar argument can be made in the case of pure monopoly. N(P) denotes the subscription demand for mobile services, driven as before by the total price P of the bundled mobile services. $Q_I(N, N_F, T)$ denotes the total amount of fixed-to-mobile calls, which is assumed to depend on the number of fixed users, number of mobile users, and the call price paid – directly affected by the termination charge.

The monopolist maximises with respect to P:

$$\pi = (P - c)N(P) + TQ_I(N(P), N_F, T)$$

The first-order condition gives:

$$\left[P - c + T\frac{\partial Q_I}{\partial N}\right]\frac{\partial N}{\partial P} + N = 0\,,$$

or in elasticity terms:

(2) $$\frac{P - \left(c - T\dfrac{\partial Q_I}{\partial N}\right)}{P} = \frac{P - C}{P} = \frac{1}{|\varepsilon_N|}\,,$$

where ε_N is the elasticity of subscription demand. In other words, the formula above is the classic inverse elasticity rule once one considers the "perceived" marginal cost C per customer, which includes the termination rents (with a minus sign). Each time a customer is attracted, it comes with a termination rent. The higher the rent, the lower the perceived marginal cost. If regulation cuts termination rents below the profit maximising level, this is 'as if' marginal costs went up, and retail prices will go up too. In other words, a waterbed effect is expected also under monopoly. This increase in the perceived marginal cost exists with perfect competition as well. The only difference is that the elasticity of the waterbed effect under competition was obtained by differentiating the zero-budget constraint, while now it is derived by totally differentiating the monopolist's first-order condition.

To make some further inroads into the monopoly case, we assume that each fixed user calls each mobile user with the same per-customer demand function q(T), that is $Q_I = NN_F q_I(T)$. Then (2) simplifies into

$$(3) \qquad \frac{P-(c-\tau)}{P}=\frac{1}{|\varepsilon_N|},$$

where $\tau = TN_F q_I$ is again the termination rent per mobile customer with c > τ. Assuming a constant-elasticity demand for subscription, from (3) the elasticity of the waterbed effect is

$$(4) \qquad \varepsilon_W = \frac{\partial P}{\partial T}\frac{T}{P} == \frac{1+\varepsilon_I}{-c/\tau+1},$$

which is negative. What is the impact on total profits? By substitution one gets in equilibrium

$$\pi = \frac{PN}{|\varepsilon_N|}, \text{ or } \log\pi = \log P + \log N - \log|\varepsilon_N|.$$

We can thus decompose the elasticity of profits with respect to T (assuming a constant elasticity of subscription demand) into a "waterbed" effect and a "subscription" effect. Since the last effect is $\frac{\partial N}{\partial T}\frac{T}{N} = \frac{\partial N}{\partial T}\frac{P}{N}\frac{\partial P}{\partial T}\frac{T}{P} = -|\varepsilon_N|\varepsilon_W$, we obtain overall:

$$\varepsilon_\pi = \frac{\partial\pi}{\partial T}\frac{T}{\pi} = \varepsilon_W(1-|\varepsilon_N|),$$

which is positive as the monopolist will always set the price in the elastic portion of demand. Higher termination rates should be associated with higher profits to the extent that the firm enjoys substantial market power.

Notice that our approach relies on having a market which is “uncovered” in the sense that there is always some customer that does not buy any mobile service. This may be questionable in mobile telephony where penetration rates now exceed 100% in many countries. While this does not cause any problem in the case of perfect competition, the monopoly example would change. Instead of relying on the analysis of the first order condition that leads to (2), a monopolist that wants to cover entirely a “saturated” market would choose a price P in order to satisfy the participation constraint of the customer with the lowest willingness to pay. In this limiting situation, a waterbed effect will not exist for a monopolist.

To sum up, we have presented two very simple and related models. They are admittedly unrealistic to describe a complex world such as mobile telephony, but appealing in the sense that they both generate rather easily the waterbed effect, which should therefore be robust to introducing complexities in models which should be a better and more realistic description of the industry. Our main predictions that we will bring to an empirical test are therefore that:

1. A waterbed effect exists. Lower termination rates induced by regulation should be associated with higher retail prices to mobile customers. We also warned against a too simplistic interpretation of the waterbed price elasticites, since in general one should not expect a 1:1 effect even in a model with perfect competition, since demand elasticities and cost shares will have an impact too.
2. For low levels of market penetration, the impact on retail prices, via the waterbed effect, exists independently from the level of competition. On the one hand, when the industry is perfectly competitive, exogenous changes in termination rates have no impact on profits. On the other hand, when the industry is not competitive, profits are negatively affected by regulatory cuts in termination rates.
3. For high levels of market penetration, we expect an increase in competition to make the waterbed effect stronger in a competitive market, but not so when the market is dominated by a monopolist. The waterbed effect is always expected to be in operation under competition for any level of market penetration. However, in the limiting case when the market is fully covered, the monopolist sets its prices just to ensure that the last customer subscribes to the services, in which case termination rates have no impact on mobile retail

prices. Therefore, when relating the magnitude of the waterbed effect to the intensity of competition, we will want to control for the market penetration in a given market, since this is a good proxy for subscription demand elasticity at different stages of the product life cycle of mobile telephony.

3. Econometric Specification and Data

3.1 Estimation Strategy

Our empirical strategy is conducted in two steps. In the first step, the analysis is based on the following regression equations:

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

(5a) $\ln EBITDA_{jct} = \alpha_{jc} + \alpha_t + \beta_1 \text{Regulation}_{jct} + \varepsilon_{jct}$

The dependent variable in (5) is the logarithm of (PPP adjusted) outgoing prices ($\ln P_{ujct}$) for the usage profile u = {low, medium, high} of operator j in country c in quarter t. The dependent variable in (5a) is the logarithm of earnings before interest, taxes, depreciation and amortization ($\ln EBITDA_{jct}$) of operator j in country c in quarter t. EBITDA is defined as the sum of operating income and depreciation and we use it as a proxy for profits. The main variable of interest, Regulation_{jct}, is a binary indicator variable that takes the value one in the quarter the regulation of fixed to mobile termination rates was introduced and in all the periods following.

Both regressions constitute 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 (or profits) 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 (5) and a negative or zero effect in (5a) depending on whether the market is competitive or not.

This difference-in-difference specification allows us to control for time-invariant country-operator characteristics that may influence both regulation and prices or profits. Furthermore, the specification also accounts for common global trends.

However, one important concern regarding this difference-in-difference specification is that the unbiasedness of the estimator requires strict exogeneity of the regulation variable. In particular, our results would be biased if countries and operators which have witnessed slower decrease in prices (including fixed-to-mobile prices) than comparable countries are more likely candidates for regulation. The direction of causation here would be reversed: *because* of high retail prices, then fixed-to-mobile termination rates are regulated.

There are two ways we can address this concern. Firstly, according to theory, the intensity of competition should *not* matter as to whether or not to regulate MTRs. Unregulated MTRs are always “too high”, independently from the level of competition (though the level of competition might affect the optimal level of regulated MTR). In principle, therefore, we should expect every country to regulate MTRs sooner or later, which is indeed what we observe in the data. Secondly, what we observe empirically is the exact opposite of the above prediction. Figure 2 plots the average (time and usage-country-operator demeaned) prices in countries that have experienced a change in regulation, six quarters before and after the introduction of regulation. As we can see, compared to prices in the rest of the world, average prices in countries that experienced a change in regulation were actually lower before the introduction of regulation. Moreover, in line with our predictions, the introduction of regulation has a clear positive impact on prices (the waterbed effect) that becomes stronger as regulation becomes progressively more binding over time. Hence, classical reverse causality seems to be less of a concern in our context.

[Figure 2]

Most importantly for establishing causality, the regulation variable should be “random”. This (non-selectivity) assumption is quite restrictive because regulatory intervention does not occur randomly, but is the outcome of a long economic and political process. However, the regulatory process across countries regarding mobile termination rates has been driven in practice by legal and institutional aspects. The UK has been at the forefront of this debate and started regulating MTRs already back in 1997. Other countries followed suit. Importantly, the European Commission introduced a New Regulatory Framework for electronic communications in 2002. The Commission defined mobile termination as a relevant market. Procedurally, every

Member State (EU 15 at the time) was obliged to conduct a market analysis of that market and, to the extent that market failures were found, remedies would have to be introduced. Indeed, all the countries that completed the analysis did find problems with no single exception, and imposed (differential) cuts to MTRs (typically, substantial cuts to incumbents and either no cut or only mild cuts on entrants). Hence, the timing of the introduction of regulated termination rates, but also their allocation across mobile operators and the severity with which they were imposed has been driven by this regulatory process and varied widely across countries with no systematic pattern. We also estimate a variant of (5) and (5a), allowing for flexible time-varying effects of regulation on prices (Laporte and Windmeijer, 2005) with the aim of distinguishing among any anticipation, short run and long run effects.

Moreover, conditional on (usage-)country-operator and time fixed effects, the regulation variable should be uncorrelated with other time-varying factors. In other words, the main criticism of our framework is that we do not allow for joint country-time fixed effects. A spurious correlation pointing towards a high waterbed would arise if, for example, a country is not regulated but is competitive and has low prices, while another country is regulated with low MTR but is also quite concentrated, so it has high prices: we attribute econometrically higher prices to the waterbed (via regulation), even if - in principle - the waterbed effect did not exist at all. While this may not be very plausible (typically, countries with low MTRs are also competitive, at least anecdotally, which should give rise to the opposite bias), it is important to bear in mind this caveat when interpreting our results. In addition, we tried to alleviate this data limitation problem as possible by splitting our sample of countries into three macro regions (Western Europe, Eastern Europe, and Rest of the World) and introducing regional-time control variables. Despite this not being the ideal solution, as we will demonstrate in the next section, our results become stronger.

A final consideration with the difference-in-difference estimators is that they exacerbate the downward bias in the standard errors arising from positive residual autocorrelation. Thus, following the solution proposed by Bertrand, Duflo, and Mullainathan (2004), all reported standard errors are based on a generalized White-like formula, allowing for (usage-)operator-country level clustered heteroskedasticity and autocorrelation.

Before we discuss the various datasources, it should be stressed that using only a binary indicator for regulation is quite restrictive. It does not allow us to distinguish between countries that have introduced substantial price cuts in MTRs and countries that have regulated MTRs too but only mildly. For this reason, we also experiment with two other measures of the impact of regulation.

In the spirit of Card and Kruger (1994), we construct two additional indexes. The first one is:

$$MaxMTR\,\text{index}_{jct} = \begin{cases} 0 \text{ if } MTR_{jct} \text{ is unregulated} \\ \dfrac{MaxMTR_{ct} - MTR_{jct}}{MTR_{jct}} \text{ if } MTR_{jct} \text{ is regulated} \end{cases}$$

In other words, when the country is unregulated, the index takes a value of zero. If instead the country is regulated, we construct an index that takes larger values the more regulated a mobile operator is, compared to the operator that is regulated the least in the same country and period.

This index takes advantage not only of the different timing of the introduction of regulation across countries, but also of the widespread variation on the rates imposed across operators within countries. This variation in regulated MTRs was particularly evident in countries where there was a large asymmetry between the "large" incumbents and the "small" entrants. While from a theoretical point of view the "monopoly bottleneck" problem exists independently from the size of an operator, in practice, regulators have been more reluctant in cutting the MTRs of the new entrants. They did this most likely with the idea of helping entrants secure a stronger position in the market. Thus new entrants have been either unregulated for many periods (while the incumbents were regulated at the same time), or they have been regulated nominally but only very mildly, while much more substantial price cuts were imposed on the incumbents. Hence, in this index, the highest MTR within a country at every period becomes the benchmark for comparing how tough regulation has been on the rest of the firms.

Our second additional regulation index is based on the same principle, but restricts the sample to only those countries for which we know with certainty that there is at least one fully unregulated operator. For example, UK was among the first countries to introduce termination rates regulation, but throughout this period mobile operator 3 (Hutchison) was left completely unregulated. Thus, for the purposes of this index we use the termination rates that this firm was charging as a benchmark for all the other firms. This exercise severely restricts our sample size, but makes the identification even more transparent and exogenous. Hence, the second index is:

$$UnregulatedMTR\text{ index}_{jct} = \begin{cases} 0 \text{ if } MTR_{jct} \text{ is unregulated} \\ \dfrac{UnregulatedMTR_{ct} - MTR_{jct}}{MTR_{jct}} \text{ if } MTR_{jct} \text{ is regulated} \end{cases}$$

In other words, the index takes the value of zero when the country is unregulated. If instead the country is regulated, we construct an index comparing the rate each operator is regulated to the one charged by the unregulated firm in the same country and period. Both these indexes, allow us to get different measures of the severity of regulation in each country and period.

Finally, in the second step, our analysis is based on the following instrumental variable regression models:

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

(6a) $\ln EBITDA_{jct} = \alpha_{jc} + \alpha_t + \beta_1 \ln(MTR)_{jct} + \varepsilon_{jct}$

where we instrument MTRs using the regulation binary variable. The idea here is to estimate the waterbed effect on prices directly through the MTRs using regulation as an instrumental variable. Regulation is a valid instrumental variable as it is not expected to influence prices other than the impact it induces via MTRs. This is because regulation acts on prices only indirectly via reducing MTRs, while regulators do not intervene in any other direct manner on customer prices.

3.2 Data

For the purpose of our analysis we matched three different data sources. Firstly, we use Cullen International to get biannual information on mobile termination rates. Cullen International is considered the most reliable source for MTRs and collects all European termination rates for official use of the European Commission. Because all the other datasets used are in quarterly format, we extrapolate the mobile termination rates where necessary to get the same frequency. Using this source and various other industry and regulatory publications, we were also in a position to identify the dates in which regulation is being introduced across countries and operators.

Secondly, quarterly information on the total bills paid by consumers across operators and countries is obtained from Teligen. 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. A distinction between pre-paid (pay-as-you-go) and post-paid (contract) is also accounted for. These consumer profiles are then held fixed when looking across countries and time.

Thirdly, we use quarterly information taken from the Global Wireless Matrix of the investment bank Merrill Lynch (henceforth, ML). ML compiles basic operating metrics for mobile operators in forty-six countries. For our purposes, we use the reported average monthly revenue per user (ARPU) and the earnings margin before interest, taxes, depreciation and amortization (EBITDA). Through this source we also obtain information on market penetration and number of mobile operators in each country, together with the number of subscribers and their market shares for each operator.

All consumer prices, termination rates and revenue data were converted to euros using the Purchasing Power Parities (PPP) currency conversions published by the Organization for Economic Cooperation and Development (OECD) to ease comparability. None of our results depends on this transformation. More detailed data description, together with summary statistics of the main variables can be found in the appendix.

The various datasources have different strengths and weaknesses regarding our empirical question. 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 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 for every country at each point in time. For instance, if a country, such as the UK, had five mobile operators, possibly regulated differentially over time, only two observations per customer profile would be available. This reduces the variability and makes identification of our variables of interest even harder, especially given that the biggest mobile operators are often regulated at the same rate. In other words, our estimates are probably a lower bound of the "true" waterbed effect, given that we lack price information on all mobile firms operating in each market.

On the contrary, the ML dataset provides us with information on actual revenues rather than prices. The dependent variables that we use are primarily EBITDA (a measure of profit and cash flow) and ARPU (which includes all revenues, including revenues from MTR). These are aggregate measures encompassing all revenues associated with mobile voice services. Therefore, they have to be interpreted more as measures of an operator's revenues and profitability rather than the total customer bill. Both these measures suffer from endogeneity problems which could introduce bias and inconsistency in our results, hence they need to be interpreted with caution. However, this dataset contains information on almost all mobile operators in each country and hence it allows us to exploit more within-country variation.

4. Benchmark Results

Table 1 reports our benchmark results from specification (5) using as the dependent variable the price information from Teligen. The data for this table essentially allows the best possible deal for an exogenous user profile to be chosen among all possible contracts available, both pre-paid and post-paid.[6] For that reason, we also add a binary variable (Pre-paid_{jct}) indicating whether the best deal was on a pre-paid contract or not.[7] The elasticity is 0.133 and strongly significant in column 1, where we utilize the simplest specification with a binary indicator for regulation. That means that the introduction of regulation of MTRs increased bills to customers by 13% on average. Notice also that the coefficient on pre-paid is negative but insignificant, indicating

[6] We will later check if results change if one constraints customers' choices either to pre-paid or monthly contracts.

[7] It is important to mention that the MTR for terminating calls is applied uniformly and does not distinguish, say, between calls to heavy users on contracts and calls to low users on prepaid. However, the waterbed price reaction of the mobile firm to changes in MTR can in principle differ by type of user or call, since their profile of received calls can differ, or the intensity of competition can differ by type of user too.

that prices on the best deal pre-paid contracts were no different than those on monthly contracts.

In column 2 we use the *MaxMTR* index and obtain again strong evidence of the waterbed effect. However, the elasticity's magnitude is now 5% (0.29×0.163 = coef. × mean value of *MaxMTR*), considerably smaller than before. Similarly, in column 3 when we severely restrict our sample to only those countries we know with certainty they had at least one unregulated mobile operator, we still get a positive and significant effect of 2% (0.127×0.150 = coef. × mean value of *UnregulatedMTR*). Notice also that the coefficient on pre-paid becomes now negative and significant, indicating that pre-paid customers were getting significantly better deals from the two main mobile operators when they were faced with an unregulated competitor. Most likely incumbents were trying to use these deals to attract customers and to put pressure on the prices charged by their unregulated competitors.

Finally, for reasons already discussed in the previous section, in the last two columns we estimate an even more restrictive version of our model by allowing for regional-time fixed effects. Essentially, our sample of countries can be naturally divided into three macro regions: Western Europe, Eastern Europe and Rest of the World (Australia, New Zealand and Japan). Western European countries have been all subject to the New Regulatory Framework adopted by the European Commission, while other Eastern European countries have only recently been subject to regulation with the accession of new member States. Controlling for these regional effects in columns 4 and 5, results in an even stronger waterbed effect, without reducing its statistical significance.[8]

Next, we look at the impact of regulation on profitability measures using specification (5a). Table 2 reports the effect on EBITDA, while we relegate similar results on the impact on ARPU to the Appendix. Column 1 shows that regulation had a negative effect on profit margins, although the data is considerably noisier. Using our two indexes, instead of the binary regulation variable (columns 2 and 3), reveal again a negative relationship, though the effect is not statistically significant. In columns 4 and 5, the inclusion of the regional-time fixed effects again increases the magnitude of the coefficients without affecting much their statistical significance. If

[8] We do not report the results of column (3) with the regional-country dummy because the Western Europe region dummy includes all the countries that had one operator being not regulated.

markets were fully competitive there should be no impact on profits. Thus these results suggest that there seem to be limits to how intense competition is.

In our second step, using specifications (6) and (6a) we report the results from the IV regressions in Table 3. The first three columns use the Teligen data as before, whereas the last three columns examine the effect on EBITDA. First stage results across all columns confirm that regulation is an appropriate instrument. Column 1 shows that that regulation through MTR has indeed a negative and significant effect on prices. The magnitude of the elasticity of the waterbed effect is above 1.[9] Over the period considered, regulation has cut MTR rates by 10% and, at the same time, has increased bills to mobile customers by 13%.

The magnitude of this waterbed effect may seem high at first sight. The elasticity is lower in columns 2 and 3 using the more sophisticated indexes of regulation, but still negative and highly significant. The effect on accounting profits is positive and significant in column 4, and positive but not significant with the more nuanced measures of regulation. Table 4 provides evidence that the results remain unchanged and if anything become stronger, when we estimate the more restrictive version of our model that includes region-time fixed effects (again, we exclude the *UnregulatedMTR* index, as the Western Europe region includes all the countries that had one operator being not regulated).

Therefore, taken together these benchmark estimates confirm the intuition from our theoretical section that there exists a strong and significant waterbed effect in mobile telephony. However, this effect is not full.

[Tables 1, 2, 3, 4]

5. Timing of the Regulation Effect

The relationship between regulation and prices, however, might not be monotonic. Termination rates are typically regulated over some periods using "glide paths", in which charges are allowed to fall gradually towards a target over the period. The temporal adjustment path is known and anticipated by operators, at least before a new

---

[9] Note that all the results in Tables 1 and 2 can be directly obtained from Table 3. The impact of regulation on prices, for instance, can be decomposed as $\partial P / \partial \text{Regulation} = \dfrac{\partial P / \partial MTR}{\partial MTR / \partial \text{Regulation}}$, where the denominator and the numerator and are obtained from the 1st and 2nd stage respectively in the IV regression.

revision is conducted. On the other hand, there could also be some inertia. For instance, customers may be locked in with an operator for a certain period, therefore there would be no immediate need to adjust mobile prices as these customers would not be lost right away. Alternatively, when termination rates change, it may take some time for operators to adjust retail prices because of various "menu" costs. Hence, ideally we would like to investigate whether firms anticipated regulation (possibly by trying to affect the outcomes of the regulatory process) and indeed whether the effect of regulation was short-lived or had any persistent long term effects. To quantify the dynamic effects of the waterbed effect, we define binary indicators for twelve, non-overlapping, quarters around the introduction of regulation and a final binary variable isolating the long-run effect of regulation. Our specification is as follows:

$$(7) \qquad \ln P_{ujct} = \alpha_{ujc} + \alpha_t + \beta_1 D^{T-6}{}_{jct} + \beta_2 D^{T-5}{}_{jct} + \ldots + \beta_{12} D^{T+5}{}_{jct} + \beta_{13} D^{T+6}{}_{jct} + \varepsilon_{ujct}$$

where $D^{T-6}{}_{jct} = 1$ in the sixth quarter before regulation, $D^{T-5}{}_{jct} = 1$ in the fifth quarter before regulation, and similarly for the other quarters until $D^{T+6}{}_{jct} = 1$ in the sixth quarter after regulation and 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., seven quarters before regulation backwards). This approach accounts for probable anticipation effects (as captured by D^{T-6} to D^{T-1} binary indicators) as well as short (captured by D^{T} to D^{T+5}) and long run effects (captured by D^{T+6}).[10]

Figure 3 plots the regression coefficients on these binary indicators together with their 95% confidence interval. As expected, regulation has no effect on prices six to four quarters before the actual implementation. However, there is some small but statistically significant anticipation of the regulatory intervention three to one quarters before. As discussed before, for the large majority of countries regulation was preceded by a long consultation period between the regulator and the various mobile operators. Our results reveal that operators started adjusting their price schedules slightly upwards even before the actual implementation of the new termination rates.

However, it is the actual implementation of the regulation that has the biggest impact on prices as revealed by the immediate increase on the coefficients after

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

regulation. In other words, regulation is binding and the waterbed effect increases over time. Most importantly, figure 3 shows that regulation seems to have a large long-run waterbed effect. The coefficient estimate on D^{T+6}, which quantifies the effect of regulation on prices post the sixth quarter after its introduction, is strongly significant and implies a long run elasticity of the waterbed effect of 33%.

[Figure 3]

6. Interaction with Competition and Further Evidence

6.1 Competition and Market Penetration

Having established that the waterbed effect exists and has a long run effect, we now want to investigate in greater details how competition affects this phenomenon. Competition is obviously expected to have a direct impact on prices: the more competitive the market, the lower the prices to customers. Besides this effect, however, if termination rates are "high" (e.g., unregulated) or a substantial mark-up is allowed, competition is expected to have an *additional* impact via the waterbed effect: the more competitive the industry, the lower the prices will be, on top of the direct effect, as any termination rent will be passed on to the customers. As discussed in Section 2, a waterbed effect is expected to exist also under monopoly, though the effect is milder as some rents will be kept by the monopolist. However, the waterbed effect is not expected to be very relevant under monopoly when the market is very saturated and the monopolist still has an interest in covering it. Hence, in our empirical specification is crucial to control for subscription penetration levels. Our specification reads:

$$
\begin{aligned}
(8)\quad \ln P_{ujct} = {} & \alpha_{ujc} + \alpha_t + \beta_1 \ln(MTR)_{jct} + \beta_2 \ln(Competitors)_{ct} + \beta_3 \ln(Penetration)_{ct} + \\
& \gamma_1[\ln(MTR)_{jct} \times \ln(Competitors)_{ct}] + \gamma_2[\ln(MTR)_{jct} \times \ln(Penetration)_{ct}] + \\
& \gamma_3[\ln(Penetration)_{ct} \times \ln(Competitors)_{ct}] + \\
& \delta[\ln(MTR)_{jct} \times \ln(Competitors)_{ct} \times \ln(Penetration)_{ct}] + \varepsilon_{ujct}
\end{aligned}
$$

Equation (8) is an extension of our previous specification (6) with the aim to specify a particular channel that might affect the intensity of the waterbed effect. Our proxy for the intensity of competition is simply the number of rival firms ($Competitors_{ct}$) in each country and period. The number of mobile operators in a country can be taken as exogenous as the number of licences is determined by spectrum availability. Over the period considered, several countries have witnessed the release of additional licences. The degree of market saturation/maturity is measured as the percentage of the population with a mobile phone ($Penetration_{ct}$). Our main coefficient of interest is δ, where MTR is interacted both with the intensity of competition and with the degree of market saturation.

Results are reported in Table 5. Column 1 is the baseline waterbed effect, comparable to that of column 1 Table 3, restricted to the sample of firms and countries for which we have information on all these variables. Column 2 shows that competition has the expected effect on prices, which are lower when there are more competing firms. Column 3[11] introduces the competition interaction first and is positive but insignificant. However, column 4[12] has all the simple interaction terms, while column 5[13] has also the double-interacted term. This column 5 is the one we discuss. The waterbed effect is now decomposed into several terms. Most importantly, we do find that, when penetration is high and for a given MTR, then markets with more competitors show a stronger waterbed effect than markets with fewer competing firms (δ = -0.895). This confirms our theoretical predictions where we pointed out the need to control for penetration levels when comparing competitive markets with concentrated ones.

In addition to this main result, the waterbed effect exists in any market as β_1 is still negative and very significant. The other results are also somehow reassuring. We still find that competition has a negative direct impact on prices, besides any waterbed effect (β_2 = -0.344). Prices are also systematically lower in more mature markets (β_3 = -3.228). When MTR is simply interacted with competition, not controlling for penetration levels, there is no statistically significant relationship. We also find positive and significant coefficients in front of the simple interaction between MTR and saturation (γ_2 = 1.422) and in front of the simple interaction between the number of competitors and market saturation (γ_3 = 2.346). While we do not want to make too much of these additional results, we notice that the a positive γ_2 may be due to the fact

[11] IVs: regulation, and interactions of regulation with the other exogenous variables, namely competitors and penetration, plus the number of own products for each mobile operator in the market (a la Berry et al., 1995) and interactions of the residuals from the regression: logMTR on competitors, penetration, regulation and all the dummies, with competitors and penetration (Wooldridge, 2002).

[12] IVs: the same as before.

[13] IVs: the same as before, plus the triple interaction of the residuals with competitors and penetration.

that high penetration levels typically involve attracting marginal users who make and receive very few calls. Conversely, markets with low penetration levels are typically made by heavy users for whom the waterbed effect is expected to be strongly at work. Thus a positive coefficient on the interaction term is indeed expected. We do not have any prior on the coefficient γ_3 as there is no strong reason to expect that, once controlling for the number of competitors, the impact of competition should be more or less intense as the market saturates. On the one hand operators may become less capacity constrained and compete more fiercely, on the other hand they may also tend to collude more easily over time in mature markets.

Column 6 confirms the results from the previous column, where we use the *MaxMTR* index as an instrument instead of the binary regulation variable (IVs the same as in column 5, but MaxMTR instead of regulation). Results are unaffected by this and we still find a negative and significant in front of the double interacted term.

We have thus found that, in order to understand how the waterbed effect arises and impacts on prices, essential ingredients are competition, market saturation which may bring a different portfolio of users with different calling patterns, and their interaction. We have also experimented with a different measure of competition, using the HHI index of market concentration instead of the simple number of competing operators. While the δ coefficient is still as expected (this time, positive as an increase in HHI means a lessening of competition), some other results are less stable (see Table A10 in the Appendix). In our panel study, this is the point where we have to stop and point to possible weakness of our reduced-form approach. In order to unravel these mechanisms in a deeper way one would have to conduct a more detailed work, possibly at the country level, using a structural approach.

[Table 5]

6.2 Waterbed Effect on Different Customer Types

In all our specifications, we assumed that a customer could ideally choose the best available contracts at a given point in time, given her/his usage profile. The results are therefore valid if indeed customers behave in this frictionless way. With the introduction of mobile number portability, this possibility should be all the more realistic. However, market analysts tend to distinguish between pre-paid (pay-as-you-go) and post-paid (long-term contract) customers, to the extent that figures on subscriber numbers are often kept separate. 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. Even in the presence of number portability, it takes time to port a number, which may make this option not very practical for a business user. 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.

In Table A7 and A8 in the Appendix we test if there is a difference in the waterbed between pre-paid and post-paid users, when each type of user is limited in her/his choices. Rather intriguingly, we find that pre-paid customers essentially are unaffected by regulation, whereas monthly subscribers bear the bulk of the price increases. This may arise because firms have a more secure relationship with monthly contract subscribers (who tend to stay with the same operator for several years), and so have a greater expectation of receiving future incoming revenues as a result of competing on price for these customers. Post-pay customers also tend to receive more incoming calls, and so become more (less) profitable as termination rates rise (fall). This follows from two facts: (a) post-pay contracts are more attractive to high usage subscribers; and (b) pre-pay customers have higher churn rates and so are less likely to have their numbers known by potential callers.[14] A further factor may be that network operators have a preference to change fixed fees in non-linear contracts rather than pre-pay call price structures which are closer to linear prices.

It is also interesting to run the same exercise we conducted in Figure 3, separately for pre- and post-paid deals. Again, the anticipation of regulation has very little impact on either pre- or post-paid contracts up to two periods before regulation. Monthly customers then experience a change in line with the general unconstrained results (Figure 5). As far as pre-paid customers are concerned (Figure 4), our result of

[14] Vodafone, for example, reports the following churn rates across its major European markets for the quarter to 30 September 2006 (Source: Vodafone):

Markets	Prepaid	Contract	Total
Germany	29.5%	13.5%	22.1%
Italy	22.4%	13.6%	21.7%
Spain	62.5%	13.4%	37.0%
UK	49.9%	18.8%	37.6%

no impact of regulation is now much better qualified. It is not the case that nothing happens. Rather, precisely when regulation starts at T there is a change in the pattern too, with a big increase in the variance. Perhaps operators react immediately to regulation by introducing new tariffs, priced at very low levels. Once the impact of regulation is split into its various components over time, there is a positive long-run effect on these prices too. In any case, recall that these results must be interpreted with caution as they are driven by constraining the choices of customers.

[Figures 4, 5]

7. Conclusions

Our results show that the waterbed effect exists. Over the period considered, with Teligen data we estimated that regulation reduced mobile termination rates by about 10%, and outgoing prices also increased by more than 10%. Our results also suggest that the waterbed effect is high but not full yet: using data from ML we found that accounting measures of profits are positively related to MTR, thus mobile firms suffer from cuts in termination rates. The ML dataset is also probably less reliable than the Teligen dataset, so we take this last conclusion more cautiously. In addition, all these results have to be qualified as termination rents could be also exhausted with non-price strategies, i.e., increasing advertising, or giving handset subsidies that we cannot control for. However, we do not expect handset subsidies effects to be too relevant, for instance, for pre-paid customers, and the test on EBITDA should take these additional factors into account.

There are two important implications that follow from our work. Firstly, mobile telephony exhibits features typical of two-sided markets. The market for subscription and outgoing services is closely interlinked to the market for termination of incoming calls. Any antitrust or regulatory analysis must take these linkages into account either at the stage of market definition or at the stage of market analysis.

Secondly, and related to the previous observation, any welfare analysis of regulation of termination rates cannot ignore the presence of the waterbed effect. Clearly, if the demand for mobile subscription was very inelastic, the socially optimal MTR would be the cost of termination (though the regulation of MTR would impact on the distribution of consumer surplus among fixed and mobile subscribers). If, instead, the mobile market was not saturated and still growing there would be a great need to calibrate carefully the optimal MTR. We acknowledge that this calibration exercise is very difficult and must be done with great caution. It is therefore all the more important that further analysis and effort are spent to understand the behaviour of marginal users that might give up their handsets when the waterbed effect is fully at work.

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5. Appendix

5. 1 Data description

To test the waterbed effect we use a variety of different sources. Regarding the mobile termination rates, we use the biannual data provided by Vodafone using Cullen International and its own internal sources. Cullen International is considered the most reliable source for MTRs and collects all European MTRs rates for official use of the European Commission. The variable identifies those periods in which the MTRs of network operators were constrained to a significant extent by a formal decision taken by a national regulatory authority. Because all the other datasets used are in quarterly format, we extrapolate the mobile termination rates where necessary to get the same frequency.

For firm's prices we use three data sources. Teligen (2002Q3-2006Q1) reports quarterly information on the total bills paid by consumers across countries. The second dataset is the Global Wireless Matrix of Merrill Lynch. This data is available also on a quarterly basis (2000Q1-2005Q3). For our purposes, we use the reported average revenue per user (ARPU) and the earnings before interest, taxes, depreciation and amortization (EBITDA). ARPU is calculated by dividing total revenues by subscribers. EBITDA is defined as the sum of operating income and depreciation and is used to proxy for profit and cash flow.

Variables are described in Table A1. Table A2 gives summary statistics for the Teligen dataset (and the matched MTRs), while Table A4 gives summary statistics for Merill Lynch (and the matched MTRs). Tables A3 and A5 correspond to Tables A2 and A4 respectively, but limited to the sample we use when we analyze the effect of competition, and also include the additional variables used in that exercise.

[Tables A1, A2, A3, A4, A5]

5.2 Additional results

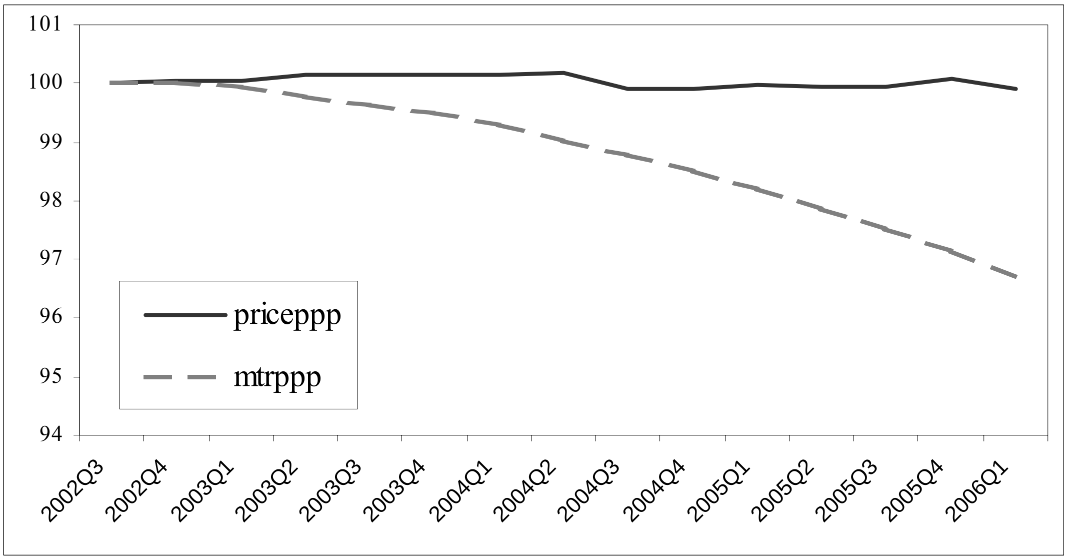
Impact on ARPU. In the main text (Section 3.1) we considered the impact of MTR on EBITDA, taken as a measure of profitability. Alternatively, one can also use ARPU (we recall that this measure also includes termination revenues, and therefore cannot be taken as a measure of customers' prices). Results are shown in Table A6. In line with the results on EBITDA, we find that higher MTR have a somehow positive effect on ARPU, though the results are not significant when we include regional-time dummies. Taken together with the results on EBITDA, we have some evidence that the waterbed effect is not full.

Pre- and post-paid contracts. Table A7 and A8 reports the results discussed in Section 4.2. They are the equivalent to Table 1, split between pre-paid deals (A7) and monthly post-paid contracts (A8). The procedure and interpretation is the same as with Table 1.

Competition. Table A9 reports the results from the first-stage regression of Table 5 (section 4.3). Table A10 reports the full set of results of the impact of competition, using the HHI index of market concentration instead of the number of competitors as a proxy for the intensity of competition in the market.

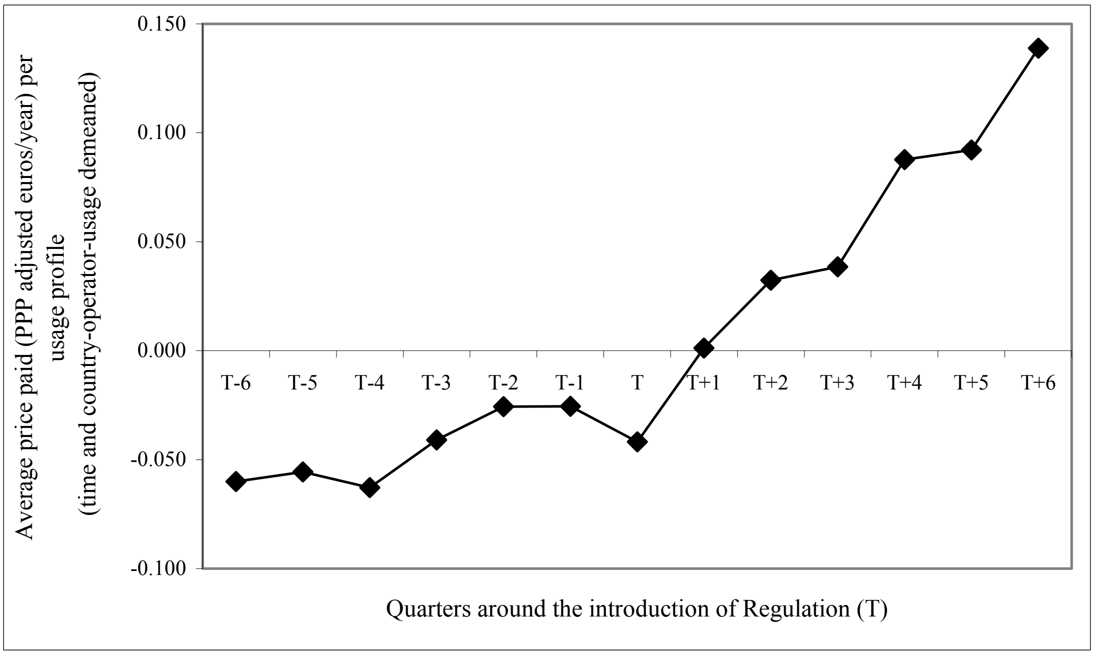
[Tables A6, A7, A8, A9, A10]

Figure 1
Average price and MTR decline (France, Medium User)



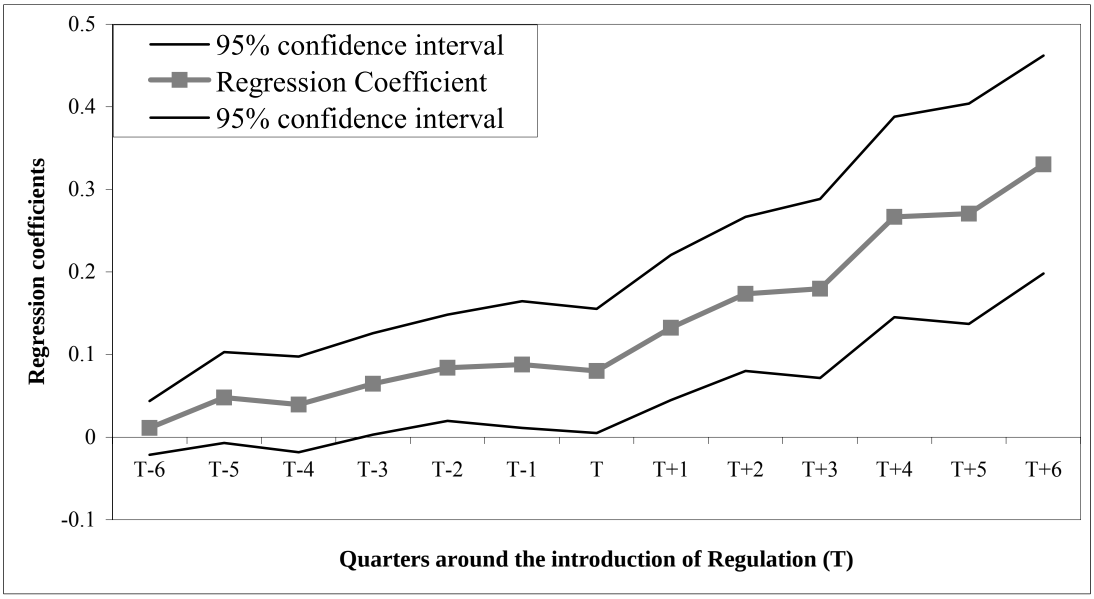
Notes: Figure 1 presents normalized (at the beginning of the period) PPP-adjusted average prices (total bill paid by medium usage consumers) and MTR rates for France based on the Teligen and Cullen International dataset.

Figure 2
Average Price around the introduction of Regulation



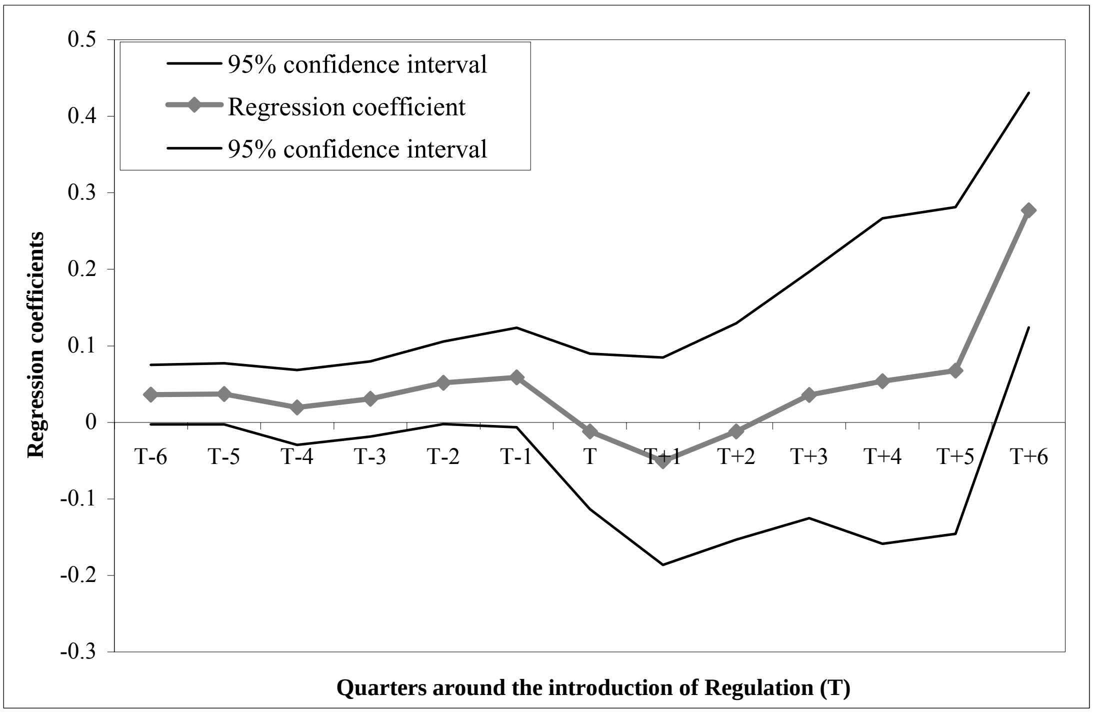
Notes: Figure 2 plots the evolution of time and country-operator-usage demeaned average logarithm of the PPP adjusted price paid per usage profile six quarters before and after the introduction of regulation of fixed-to-mobile termination charges based on the Teligen data corresponding to the best deals available at every period.

Figure 3
The Evolution of the Waterbed Effect



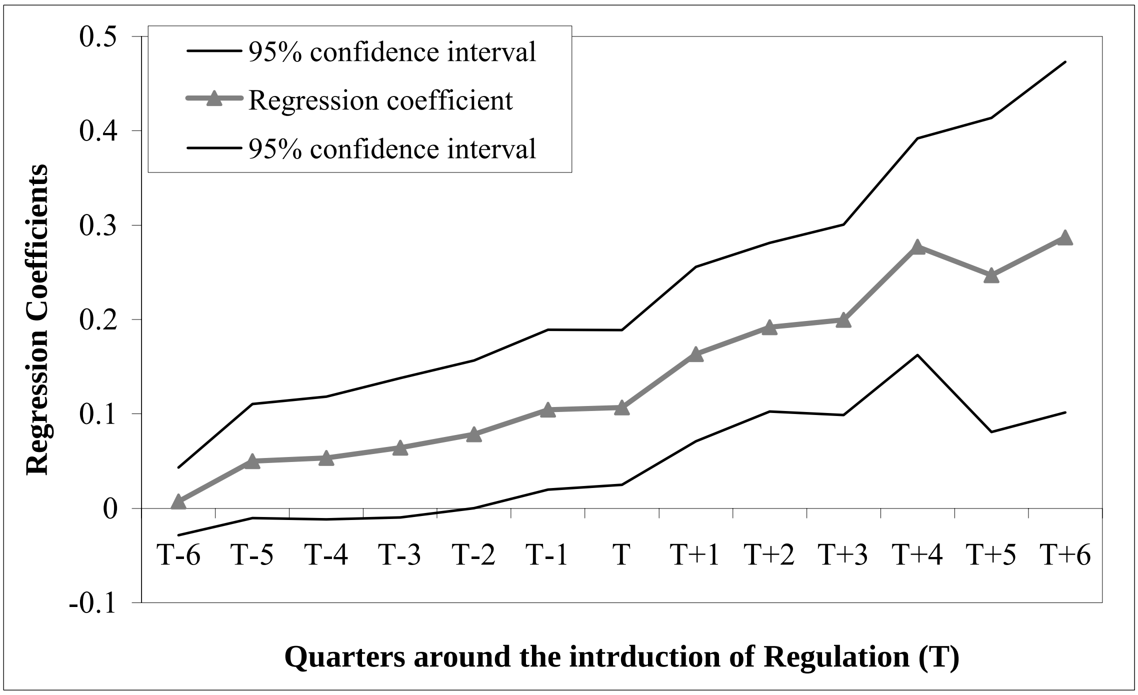
Notes: Figure 3 plots the regression coefficients on binary variables six quarters before and after the introduction of regulation. The dependent variable is the logarithm of the PPP adjusted total bill paid by consumers with different usage based on the Teligen data corresponding to the best deals available at every period. All equations include country-operator-usage and a full set of time dummies. Standard errors are adjusted for heteroskedasticity and autocorrelation of unknown form and clustered by country-operator-usage.

Figure 4
The Evolution of the Waterbed Effect (Pre-Paid)



Notes: Figure 4 plots the regression coefficients on binary variables six quarters before and after the introduction of regulation. The dependent variable is the logarithm of the PPP adjusted total bill paid by consumers with different usage based on the Teligen data corresponding to the best deals available to pre-paid customers at every period. All equations include country-operator-usage and a full set of time dummies. Standard errors are adjusted for heteroskedasticity and autocorrelation of unknown form and clustered by country-operator-usage.

Figure 5
The Evolution of the Waterbed Effect (Monthly Subscription)



Notes: As Figure 4, but based on the best deals available for monthly subscribers at every period.

TABLE 1 – ESTIMATING THE "WATERBED" EFFECT (TELIGEN)

	(1)	(2)	(3)	(4)	(5)
Estimation method	OLS	OLS	OLS	OLS	OLS
Dependent variable	lnP_{ujct}	lnP_{ujct}	lnP_{ujct}	lnP_{ujct}	lnP_{ujct}
$Regulation_{jct}$	0.133***			0.152***	
	(0.033)			(0.033)	
MaxMTR $index_{jct}$		0.290***			0.316***
		(0.068)			(0.066)
UnregulatedMTR $index_{jct}$			0.127**		
			(0.051)		
$Pre\text{-}paid_{jct}$	-0.045	-0.051	-0.127***	-0.052	-0.056
	(0.040)	(0.041)	(0.044)	(0.039)	(0.040)
Observations	1734	1734	450	1734	1734
Country-Operator-Usage	150	150	36	150	150
Within-R^2	0.220	0.234	0.367	0.252	0.267

Notes: The dependent variable is the logarithm of the PPP adjusted total bill paid by consumers with different usage based on the Teligen data corresponding to the best deals available at every period. All equations include country-operator-usage and a full set of time dummies (first three columns) or a full set of region-time dummies (last two columns). All countries in the sample were divided into three macro regions: Western Europe, Eastern Europe and Rest of the World (RoW); see text for more details. Standard errors adjusted for heteroskedasticity and autocorrelation of unknown form and clustered by country-operator-usage are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

TABLE 2 – ESTIMATING THE “WATERBED” EFFECT
(MERRILL LYNCH)

	(1)	(2)	(3)	(4)	(5)
Estimation method	OLS	OLS	OLS	OLS	OLS
Dependent variable	$lnEBITDA_{jct}$	$lnEBITDA_{jct}$	$lnEBITDA_{jct}$	$lnEBITDA_{jct}$	$lnEBITDA_{jct}$
$Regulation_{jct}$	-0.125*			-0.138*	
	(0.070)			(0.076)	
MaxMTR $index_{jct}$		-0.024			-0.054
		(0.133)			(0.139)
UnregulatedMTR $index_{jct}$			-0.148		
			(0.236)		
Observations	1135	1135	319	1135	1135
Country-Operator	67	67	16	67	67
Within-R^2	0.209	0.203	0.281	0.215	0.209

Notes: The dependent variable is the logarithm of the EBITDA from the Merrill Lynch dataset. All equations include country-operator and a full set of time dummies (first three columns) or a full set of region-time dummies (last two columns). All countries in the sample were divided into three macro regions: Western Europe, Eastern Europe and Rest of the World (RoW); see text for more details. Standard errors adjusted for heteroskedasticity and autocorrelation of unknown form and clustered by country-operator are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

TABLE 3 – WATERBED EFFECT THROUGH MTR

	(1)	(2)	(3)	(4)	(5)	(6)
Estimation method	IV	IV	IV	IV	IV	IV
Dependent variable	$\ln P_{ujct}$	$\ln P_{ujct}$	$\ln P_{ujct}$	$\ln EBITDA_{jct}$	$\ln EBITDA_{jct}$	$\ln EBITDA_{jct}$
$\ln(MTR)_{jct}$	-1.207***			1.127*		
	(0.411)			(0.603)		
MaxMTR $index_{jct}$		-0.938***			0.070	
		(0.278)			(0.392)	
UnregulatedMTR			-0.334**			0.620
$index_{jct}$			(0.133)			(0.862)
1st Stage Coef.	-0.110***	-0.310***	-0.382***	-0.111***	-0.335***	-0.239**
	(0.024)	(0.035)	(0.028)	(0.037)	(0.051)	(0.098)
1st Stage R^2	0.044	0.127	0.523	0.045	0.112	0.137
1st Stage F-test	21.83***	78.85***	188.24***	8.90***	43.88***	5.90**
	[0.000]	*[0.000]*	*[0.000]*	*[0.004]*	*[0.000]*	*[0.028]*
Observations	1734	1734	450	1135	1135	319
Clusters	150	150	36	67	67	16

Notes: Columns 1, 2 and 3 utilize the Teligen data as in Table 1. The dependent variable for these columns is the logarithm of the PPP adjusted total bill paid by consumers with different usage for the best deals available. Columns 4, 5 and 6 utilize the Merrill Lynch dataset as in Table 2. The dependent variable for these columns is the logarithm of the EBITDA. All regressions use the “Regulation” dummy as the instrumental variable. All equations include either country-operator-usage (Teligen) or country-operator (Merrill Lynch) and a full set of time dummies. P-values for diagnostic tests are in brackets and italics. Standard errors adjusted for heteroskedasticity and autocorrelation of unknown form and clustered by either country-operator-usage (Teligen) or country-operator (Merrill Lynch) are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

TABLE 4 – WATERBED EFFECT THROUGH MTR (Regional-Time Controls)

	(1)	(2)	(3)	(4)
Estimation method	IV	IV	IV	IV
Dependent variable	$\ln P_{ujct}$	$\ln P_{ujct}$	$\ln EBITDA_{jct}$	$\ln EBITDA_{jct}$
$\ln(MTR)_{jct}$	-1.529***		1.415*	
	(0.496)		(0.757)	
MaxMTR $index_{jct}$		-1.076***		0.187
		(0.283)		(0.473)
1st Stage Coef.	-0.100***	-0.294***	-0.098**	-0.288***
	(0.023)	(0.032)	(0.038)	(0.052)
1st Stage R^2	0.038	0.123	0.040	0.097
1st Stage F-test	18.15***	85.18***	6.47**	30.43***
	[0.000]	*[0.000]*	*[0.013]*	*[0.000]*
Observations	1734	1734	1135	1135
Clusters	150	150	67	67

Notes: Columns 1 and 2 utilize the Teligen data as in Table 1. The dependent variable for these columns is the logarithm of the PPP adjusted total bill paid by consumers with different usage for the best deals available. Columns 3 and 4 utilize the Merrill Lynch dataset as in Table 2. The dependent variable for these columns is the logarithm of the EBITDA. All regressions use the "Regulation" dummy as the instrumental variable. All equations include either country-operator-usage (Teligen) or country-operator (Merrill Lynch) and a full set of region-time dummies. All countries in the sample were divided into three macro regions: Western Europe, Eastern Europe and Rest of the World (RoW); see text for more details. P-values for diagnostic tests are in brackets and italics. Standard errors adjusted for heteroskedasticity and autocorrelation of unknown form and clustered by either country-operator-usage (Teligen) or country-operator (Merrill Lynch) are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

TABLE 5 – COMPETITION AND WATERBED EFFECT

	(1)	(2)	(3)	(4)	(5)	(6)
Estimation method	IV	IV	GMM	GMM	GMM	GMM
Dependent variable	lnP_{ujct}	lnP_{ujct}	lnP_{ujct}	lnP_{ujct}	lnP_{ujct}	lnP_{ujct}
$\ln(MTR)_{jct}$	-1.580**	-1.282**	-0.733**	-0.775***	-0.585***	-1.026***
	(0.587)	(0.525)	(0.285)	(0.235)	(0.223)	(0.220)
$\ln(competitors)_{ct}$		-0.289*	-0.473***	-0.522***	-0.344**	-0.339*
		(0.173)	(0.180)	(0.178)	(0.173)	(0.188)
$\ln(mkt\ penetration)_{ct}$		-0.768	-0.533	-1.785***	-3.228***	-3.707***
		(0.483)	(0.371)	(0.563)	(0.840)	(0.882)
$\ln(MTR)_{jct} \times \ln(competitors)_{ct}$			0.093	0.168*	0.098	0.117
			(0.097)	(0.087)	(0.083)	(0.086)
$\ln(MTR)_{jct} \times \ln(mkt\ penetration)_{ct}$				0.168	1.422***	1.792***
				(0.141)	(0.364)	(0.413)
$\ln(competitors)_{ct} \times \ln(mkt\ penetration)_{ct}$				0.962**	2.346***	2.527***
				(0.441)	(0.557)	(0.587)
$\ln(MTR)_{jct} \times \ln(competitors)_{ct} \times \ln(mkt\ penetration)_{ct}$					-0.895***	-1.191***
					(0.248)	(0.293)
ΔP/Δcompetitors		-1.282	-0.304	-0.345	-0.263	-0.176
ΔP/ΔMTR		-0.289	-0.614	-0.583	-0.498	-0.914
ΔP/Δmkt penetration		-0.768	-0.533	-0.256	0.269	0.007
Observations	1371	1371	1371	1371	1371	1371
Clusters	141	141	141	141	141	141
Sargan-Hansen test of overidentifying restrictions	-	-	4.244	4.418	6.071	3.654
			[0.374]	*[0.220]*	*[0.108]*	*[0.301]*

Notes: The dependent variable is the logarithm of the PPP adjusted total bill paid by consumers with different usage for the best deals available from the Teligen data. All equations include country-operator-usage and a full set of time dummies. P-values for diagnostic tests are in brackets and italics. Standard errors adjusted for heteroskedasticity and autocorrelation of unknown form and clustered by country-operator-usage are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

APPENDIX

TABLE A1 – VARIABLE DESCRIPTIONS

P_{ujct}	total price paid (PPP adjusted euros/year) per usage profile (usage profiles: high, medium and low)
MTR_{jct}	mobile termination rate (PPP adjusted eurocents/minute)
$ARPU_{jct}$	monthly average revenue per user (PPP adjusted euros/month)
$EBITDA_{jct}$	earnings before interest, taxes, depreciation and amortization margin (%)

Notes: The first variable is constructed using the Teligen dataset, the second variable is taken from the Cullen International dataset and the last two variables are from the Merrill Lynch dataset.

TABLE A2 – SUMMARY STATISTICS

Variable	Observations	Mean	Standard Deviation	Min	Max
Teligen Table 1 (Best Overall Deals)					
lnP_{ujct}	1734	5.203	1.708	0.107	7.492
$ln(MTR)_{jct}$	1734	1.800	1.656	-3.246	3.573
$Regulation_{jct}$	1734	0.614	0.487	0	1
MaxMTR $index_{jct}$	1734	0.163	0.237	0	1.127
UnregulatedMTR $index_{jct}$	450	0.150	0.291	-0.137	1.127
$Pre\text{-}paid_{jct}$	1734	0.324	0.468	0	1
Teligen Table 2 (Pre-Paid Best Deals)					
lnP_{ujct}	1686	5.556	1.680	0.114	7.989
$ln(MTR)_{jct}$	1686	1.883	1.574	-3.246	3.573
$Regulation_{jct}$	1686	0.603	0.489	0	1
MaxMTR $index_{jct}$	1686	0.167	0.239	0	1.127
UnregulatedMTR $index_{jct}$	450	0.150	0.291	-0.137	1.127
Teligen Table 3 (Monthly Subscription Best Deals)					
lnP_{ujct}	1734	5.292	1.695	0.107	7.728
$ln(MTR)_{jct}$	1734	1.800	1.656	-3.246	3.573
$Regulation_{jct}$	1734	0.614	0.487	0	1
MaxMTR $index_{jct}$	1734	0.163	0.237	0	1.127
UnregulatedMTR $index_{jct}$	450	0.150	0.291	-0.137	1.127

TABLE A3 – SUMMARY STATISTICS

Variable	Observations	Mean	Standard Deviation	Min	Max
Teligen Table 1 (Best Overall Deals)					
lnP_{ujct}	1371	5.239	1.727	0.107	7.492
$ln(MTR)_{jct}$	1371	1.809	1.694	-3.246	3.573
$Regulation_{jct}$	1371	0.626	0.484	0	1
$ln(competitors)_{ct}$	1371	1.273	0.299	0.693	1.946
$ln(mkt\ penetration)_{ct}$	1371	-0.132	0.153	-0.601	0.167

TABLE A4 – SUMMARY STATISTICS

Variable	Observations	Mean	Standard Deviation	Min	Max
$lnEBITDA_{jct}$	1135	-1.213	0.530	-4.605	-0.545
$ln(MTR)_{jct}$	1135	1.980	1.830	-3.246	3.934
$Regulation_{jct}$	1135	0.560	0.497	0	1
MaxMTR $index_{jct}$	1135	0.115	0.203	0	1.127
UnregulatedMTR $index_{jct}$	319	0.090	0.236	-0.137	1.127
$lnARPU_{jct}$	1247	3.481	0.242	2.592	4.431
$ln(MTR)_{jct}$	1247	2.046	1.785	-3.246	3.934
$Regulation_{jct}$	1247	0.541	0.498	0	1
MaxMTR $index_{jct}$	1247	0.105	0.197	0	1.127
UnregulatedMTR $index_{jct}$	357	0.080	0.225	-0.137	1.127

TABLE A5 – SUMMARY STATISTICS

Variable	Observations	Mean	Standard Deviation	Min	Max
$lnEBITDA_{jct}$	1135	-1.213	0.530	-4.605	-0.545
$ln(MTR)_{jct}$	1135	1.980	1.830	-3.246	3.934
$Regulation_{jct}$	1135	0.560	0.497	0	1
$ln(competitors)_{ct}$	1135	1.305	0.298	0.693	1.946
ln(mkt $penetration)_{ct}$	1135	-0.243	0.229	-1.053	0.167

TABLE A6 – ESTIMATING THE “WATERBED” EFFECT
(MERRILL LYNCH)

	(1)	(2)	(3)	(4)	(5)
Estimation method	OLS	OLS	OLS	OLS	OLS
Dependent variable	$\ln ARPU_{jct}$	$\ln ARPU_{jct}$	$\ln ARPU_{jct}$	$\ln ARPU_{jct}$	$\ln ARPU_{jct}$
$Regulation_{jct}$	-0.020			-0.027	
	(0.024)			(0.024)	
MaxMTR $index_{jct}$		0.084*			0.067
		(0.045)			(0.046)
UnregulatedMTR $index_{jct}$			0.088**		
			(0.042)		
Observations	1247	1247	357	1247	1247
Country-Operator	74	74	18	74	74
Within-R^2	0.300	0.306	0.408	0.335	0.336

Notes: The dependent variable is the logarithm of the PPP adjusted ARPU from the Merrill Lynch dataset. All equations include country-operator and a full set of time dummies (first three columns) or a full set of region-time dummies (last two columns). All countries in the sample were divided into three macro regions: Western Europe, Eastern Europe and Rest of the World (RoW); see text for more details. Standard errors adjusted for heteroskedasticity and autocorrelation of unknown form and clustered by country-operator are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

TABLE A7 – ESTIMATING THE "WATERBED" EFFECT
(TELIGEN Pre-Paid)

	(1)	(2)	(3)	(4)	(5)
Estimation method	OLS	OLS	OLS	OLS	OLS
Dependent variable	$\ln P_{ujct}$	$\ln P_{ujct}$	$\ln P_{ujct}$	$\ln P_{ujct}$	$\ln P_{ujct}$
$Regulation_{jct}$	0.008			0.014	
	(0.057)			(0.058)	
MaxMTR $index_{jct}$		0.154			0.165
		(0.103)			(0.103)
UnregulatedMTR $index_{jct}$			0.006		
			(0.104)		
Observations	1686	1686	450	1686	1686
Country-Operator-Usage	147	147	36	147	147
Within-R^2	0.131	0.139	0.258	0.141	0.150

Notes: The dependent variable is the logarithm of the PPP adjusted total bill paid by consumers with different usage based on the Teligen data corresponding to the best deals available to pre-paid customers at every period. All equations include country-operator-usage and a full set of time dummies (first three columns) or a full set of region-time dummies (last two columns). All countries in the sample were divided into three macro regions: Western Europe, Eastern Europe and Rest of the World (RoW); see text for more details. Standard errors adjusted for heteroskedasticity and autocorrelation of unknown form and clustered by country-operator-usage are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

TABLE A8 – ESTIMATING THE "WATERBED" EFFECT
(TELIGEN Monthly Subscription)

	(1)	(2)	(3)	(4)	(5)
Estimation method	OLS	OLS	OLS	OLS	OLS
Dependent variable	$\ln P_{ujct}$	$\ln P_{ujct}$	$\ln P_{ujct}$	$\ln P_{ujct}$	$\ln P_{ujct}$
$Regulation_{jct}$	0.137***			0.158***	
	(0.032)			(0.032)	
MaxMTR $index_{jct}$		0.318***			0.343***
		(0.066)			(0.064)
UnregulatedMTR $index_{jct}$			0.152**		
			(0.056)		
Observations	1734	1734	450	1734	1734
Country-Operator-Usage	150	150	36	150	150
Within-R^2	0.238	0.256	0.393	0.252	0.291

Notes: The dependent variable is the logarithm of the PPP adjusted total bill paid by consumers with different usage based on the Teligen data corresponding to the best deals available for monthly subscribers at every period. All equations include country-operator-usage and a full set of time dummies (first three columns) or a full set of region-time dummies (last two columns). All countries in the sample were divided into three macro regions: Western Europe, Eastern Europe and Rest of the World (RoW); see text for more details. Standard errors adjusted for heteroskedasticity and autocorrelation of unknown form and clustered by country-operator-usage are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

TABLE A9 – COMPETITION AND WATERBED EFFECT - First Stage Results

$\ln(MTR)_{jct}$						
1st Stage R^2	0.025	0.035	0.120	0.120	0.254	0.277
1st Stage F-test	19.92***	19.30***	15.44***	15.09***	48.47***	33.85***
	[0.000]	*[0.000]*	*[0.000]*	*[0.000]*	*[0.000]*	*[0.000]*
$\ln(MTR)_{jct} \times \ln(competitors)_{ct}$						
1st Stage R^2			0.375	0.373	0.984	0.516
1st Stage F-test			73.06***	89.02***	6825.55***	112.21***
			[0.000]	*[0.000]*	*[0.000]*	*[0.000]*
$\ln(MTR)_{jct} \times \ln(mkt\ penetration)_{ct}$						
1st Stage R^2				0.976	0.481	0.983
1st Stage F-test				1738.28***	133.06***	13641.36***
				[0.000]	*[0.000]*	*[0.000]*
$\ln(MTR)_{jct} \times \ln(competitors)_{ct} \times \ln(mkt\ penetration)_{ct}$						
1st Stage R^2					0.984	0.984
1st Stage F-test					11110.71***	7314.96***
					[0.000]	*[0.000]*

TABLE A10 – COMPETITION AND WATERBED EFFECT

	(1)	(2)	(3)	(4)	(5)
Estimation method	GMM	GMM	GMM	GMM	GMM
Dependent variable	lnP_{ujct}	lnP_{ujct}	lnP_{ujct}	lnP_{ujct}	lnP_{ujct}
$\ln(MTR)_{jct}$	-1.137***	12.091**	11.535**	23.545***	28.008***
	(0.325)	(5.440)	(5.769)	(5.202)	(7.483)
$\ln(HHI)_{ct}$	0.122	3.673**	5.295***	8.038***	7.563***
	(0.609)	(1.620)	(1.743)	(1.745)	(2.059)
$\ln(\text{mkt penetration})_{ct}$	-0.760**	-0.466	16.351**	60.167***	81.523***
	(0.301)	(0.366)	(7.188)	(15.656)	(25.825)
$\ln(MTR)_{jct} \times \ln(HHI)_{ct}$		-1.703**	-1.422**	-2.937***	-3.645***
		(0.692)	(0.709)	(0.644)	(0.963)
$\ln(MTR)_{jct} \times \ln(\text{mkt penetration})_{ct}$			0.445***	-15.912**	-31.221***
			(0.144)	(6.206)	(11.434)
$\ln(HHI)_{ct} \times \ln(\text{mkt penetration})_{ct}$			-2.013**	-7.240***	-9.791***
			(0.851)	(1.882)	(3.091)
$\ln(MTR)_{jct} \times \ln(HHI)_{ct} \times \ln(\text{mkt penetration})_{ct}$				1.957***	3.780***
				(0.752)	(1.372)
$\Delta P/\Delta HHI$	0.122	0.593	2.989	3.215	1.360
$\Delta P/\Delta MTR$	-1.137	-1.882	-0.191	-0.570	-1.876
Observations	1371	1371	1371	1371	1371
Clusters	141	141	141	141	141
Sargan-Hansen test of overidentifying restrictions	13.737	8.397	13.904	9.434	10.336
	[0.003]	*[0.015]*	*[0.008]*	*[0.093]*	*[0.066]*

Notes: The dependent variable is the logarithm of the PPP adjusted total bill paid by consumers with different usage for the best deals available from the Teligen data. All equations include country-operator-usage and a full set of time dummies. P-values for diagnostic tests are in brackets and italics. Standard errors adjusted for heteroskedasticity and autocorrelation of unknown form and clustered by country-operator-usage are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

TABLE A10 – COMPETITION AND WATERBED EFFECT - First Stage Results

$\ln(MTR)_{jct}$					
1^{st} Stage R^2	0.107	0.107	0.163	0.341	0.355
1^{st} Stage F-test	7.73***	7.73***	18.43***	45.08***	43.20***
	[0.000]	*[0.000]*	*[0.000]*	*[0.000]*	*[0.000]*
$\ln(HHI)_{ct}$					
1^{st} Stage R^2	0.237	0.237	0.391	0.518	0.521
1^{st} Stage F-test	27.23***	27.23***	57.57***	49.15***	52.36***
	[0.000]	*[0.000]*	*[0.000]*	*[0.000]*	*[0.000]*
$\ln(MTR)_{jct} \times \ln(HHI)_{ct}$					
1^{st} Stage R^2		0.109	0.162	0.327	0.337

1st Stage F-test	7.40***	15.22***	37.22***	39.96***
	[0.000]	*[0.000]*	*[0.000]*	*[0.000]*
$\ln(MTR)_{jct} \times \ln(\text{mkt penetration})_{ct}$				
1st Stage R^2		0.977	0.984	0.983
1st Stage F-test		2136.18***	8892.52***	10577.14***
		[0.000]	*[0.000]*	*[0.000]*
$\ln(HHI)_{ct} \times \ln(\text{mkt penetration})_{ct}$				
1st Stage R^2		0.954	0.964	0.964
1st Stage F-test		316.84***	2353.59***	1975.01***
		[0.000]	*[0.000]*	*[0.000]*
$\ln(MTR)_{jct} \times \ln(HHI)_{ct} \times \ln(\text{mkt penetration})_{ct}$				
1st Stage R^2			0.982	0.982
1st Stage F-test			6607.09***	7718.04***
			[0.000]	*[0.000]*