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Customer Ignorance, Price Cap Regulation and Rent-Seeking in Mobile Roaming

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Customer ignorance, price cap regulation, and rent-seeking in mobile roaming*

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Abstract

Mobile phone usage when traveling abroad is expensive. In contrast to domestic voice call prices, entry of new firms does not put a downward wholesale and retail price pressure on mobile usage abroad. The network connection switches frequently between available networks, and the choice of network has largely been independent of wholesale prices. As a consequence, the wholesale prices are strategic substitutes. The recent European price cap regulation does not solve this underlying problem, and there may be a permanent need for regulation analogous to what we have for domestic call termination. This should be a cautionary tale to the authorities whose goal is that the price cap regulation should be temporary. We show that there is also a risk that wholesale price cap regulation stimulates wasteful rent-seeking activity.

1 Introduction

As soon as your plane arrives abroad, the charges you face for mobile phone usage become sky-high. Entry of new mobile network providers has been considered as one of the key explanations of the reduction in domestic mobile call charges since the mid 90's. In sharp contrast to this, voice call prices when travelling abroad have not been reduced. In fact, the European Commission (2000) found that mobile phone usage abroad became more expensive during the period from 1997 to 2000.

When consumers use their mobile phones abroad their domestic mobile provider acts as a downstream firm and the foreign network as an upstream firm. The high retail charges are at least partly resulting from high wholesale prices (roaming prices). While collusive behavior and unilateral facilitating

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practices have been used as explanations for high prices, the core problem may be the technological structure for how network selection among available networks in the visited country has been designed. A key technological feature of the wholesale market is random choice of network in the visited country in the sense that the probability that a given network is chosen is independent of wholesale prices. As consumers observe when arriving abroad, network connection switches frequently between different available networks during a stay abroad. As a consequence, consumers will typically neither have complete information on which network they are connected to nor on corresponding retail prices. Thus, they will typically base their consumption on the average retail price, labeled customer ignorance (see Gans and King, 2000, and Wright, 2002).

Since the late 90's policy makers have raised concerns about the high retail and wholesale prices on mobile usage when traveling abroad, and a European regulation on retail and wholesale prices came into force in June 2007 (European Union, 2007). The EU regulation imposes price caps both at the retail and the wholesale level, but does not intend to solve the underlying problem (the way network selection is structured).

Analogous to previous findings, we show that the idiosyncratic features described above give rise to the result that unregulated wholesale prices increase in the number of upstream firms.[1] An upstream firm knows that its wholesale price does not affect the probability of its network being chosen, and an increase in the wholesale price will only affect demand through the change in the average price. This is consistent with the abovementioned observations that roaming charges have not been reduced as more firms have entered the market.

While the wholesale price caps imposed in EU may obviously reduce the firms' abilities to increase wholesale prices, the regulation does not reduce firms' incentives to increase wholesale prices. In fact, we show that the imposed wholesale price cap may increase unconstrained wholesale prices. When the probability that a given network is chosen is independent of wholesale prices (random network selection), wholesale prices become strategic substitutes. A wholesale price cap that is binding for a fraction of the upstream firms, will therefore induce unconstrained upstream firms to increase their wholesale charges.

Wholesale price-cap regulation may also give upstream firms incentives to involve in wasteful rent-seeking activities, e.g. excessive capacity investments. We show that a binding price-cap regulation may induce upstream firms to engage in rent-seeking activities à là a Tullock (1980) contest. In our stylized model there are no incentives for rent-seeking investments without regulation. When a binding wholesale price-cap regulation is imposed, there will be a positive shift in the upstream firms' rent-seeking incentives. Since customer ignorance and random network selection lead to wholesale price levels beyond monopoly pricing, firms will profit from price-cap regulations that move wholesale price levels towards the monopoly price. On the other hand, when the total roaming revenue pie increases, rent seeking will increase, explaining why rent seeking is nega-

[1] See Ambjørnsen and Wasenden (2005) and Lupi and Manenti (2008). This result resembles Gans and King (2000), who analyze customer ignorance in the market for mobile call termination (see also discussion below).

tively correlated with price cap levels beyond the monopoly price. Therefore, for higher price-cap levels the degree of rent seeking may in fact be stimulated as wholesale prices are regulated down.

New technology has improved the ability to steer traffic to preferred networks, and thereby make network selection dependent on wholesale prices. An industry-wide adoption of such technology may obviously alter the outcome, and wholesale prices will probably become strategic complements.[2] However, consumers still experience that network connection switches frequently between different available networks, and it is still reasonable to assume that at least a significant portion of the consumers base their demand on the average price from available networks. This should also be taken into account when evaluating the European price-cap regulation, and, for the sake of the argument, we continue to assume that network selection is independent of wholesale prices when we scrutinize the current price-cap regulation.

The consumers may also endogenously select which network to connect to abroad (labeled manual network selection). If the downstream firm sets retail prices that depend on which network the consumer is connected to in the visited country, this may obviously give the consumers an incentive for manual selection of preferred networks. In an environment where consumers manually select network connection, the outcome will be significantly altered. Analogous to traffic-steering by downstream firms to one preferred network, manual network selection by the consumers will probably turn wholesale prices into strategic complements. However, the majority of consumers do not use this opportunity (Oftel, 2002), and if the price-cap regulation has reduced price variations, this will further reduce consumers' incentives for manual network selection.

The European price-cap regulation has up to now had a striking impact on the retail price structure. Prior to the EU regulation the majority of firms were offering differentiated retail prices, depending on which network the consumers were connected to in the visited country. In July 2008, however, about a year after the EU regulation was implemented, the majority of firms within EU were offering uniform retail price structures. Each firm now offers a uniform retail price independent of which network consumers are connected to in the visiting country. Moreover, the retail price offered by a given retailer is uniform across countries within the EU region, and this will further increase upstream firms' incentives to raise unconstrained wholesale prices. This is in sharp contrast to the rather common differentiated pricing strategy before the regulation was implemented. Retail price variations have thus been significantly reduced after the implementation of the EU regulation, and we show that reduced price variations both at the retail and the wholesale level are consistent with the predictions of our model.

Why roaming charges have not been reduced in the same way as domestic

[2] The reason is that downstream firms may set upstream roaming providers up against each other, and consumers will have more accurate information about which network they are connected to. Wholesale and retail roaming prices will be driven downwards. This is shown by Salsas and Koboldt (2004), who discuss international roaming within a two-country duopoly setting.

call prices as more firms have entered the market, has been discussed informally by policy makers as well as by economists (European Commission, 2000, European Regulatory Group, 2005, Oftel, 2002, Sutherland, 2001, and Valletti, 2004, among others). Formal analyses on the topic are important, however, in order to evaluate the new regulatory obligations imposed in Europe.

Given the huge attention towards roaming prices there are, to our knowledge, surprisingly few formal analyses on the wholesale roaming markets. Valletti (2003) analyses the incentives for domestic roaming where an operator wants roaming rights on a domestic rival's network. Salsas and Koboldt (2004) analyze wholesale international roaming within a duopoly framework in two countries. Their main focus is on the effects of the ability to redirect roaming traffic and effects of cross-border mergers. Given their assumption of duopoly their model is not designed to analyze pricing in an oligopoly setting. Furthermore, they do not analyze whether possible effects of the recent EU regulation of international roaming. Lupi and Manenti (2008) too focus also on the role of traffic management and efficiency, also mainly in a two-country two-operator setting. In contrast to their paper we focus on the impact on retail and wholesale price structures from price-cap regulations and rent-seeking behavior.

Domestic mobile consumers may also base their demand on average prices. The reason is that consumers are often not able to identify which network they are calling, and the consumers are consequently often ignorant about the price they actually have to pay when prices differ between different networks. As a consequence, the providers may have incentives to raise their wholesale call termination charges (Gans and King, 2000 and Wright, 2002).[3] For domestic mobile telephony this negative price externality partly arises due to number portability (see Bühler and Haucap, 2004). This accentuates the fact that as long as the authorities do not solve the underlying problem there may be a permanent need for regulation analogous to what we have for domestic call termination.[4]

The paper is organized as follows. In Section 2 we present the model. In Section 3 we discuss the recent European price-cap regulation. Finally, in section 4 we conclude.

2 The model

We set up a simple model with two domestic downstream firms and n foreign upstream firms, and we consider the following three-stage game: At stage 1 each of the n upstream firms makes an investment in rent-seeking technology ΔI_j, where $j \in \{1, ..., n\}$. When upstream firms invest into rent-seeking technology the marginal investment cost is $c > 0$. At stage 2 each of the n upstream firms

[3] See Salop and Stiglitz (1977) for a more general framework where a fraction of consumers base their demand on average prices.

[4] Gans and King (2000) show that an increase in the number of mobile operators may increase domestic fixed-to-mobile charges. Gans, King and Wright (2006) provide a comprehensive overview of the literature on the economics of mobile communications.

sets its wholesale price w_j. We thus assume that both downstream firms are offered the same wholesale price from firm j.[5] Furthermore, we assume that both downstream firms buy the wholesale service from all n upstream firms. At stage 3 the two downstream firms simultaneously set retail prices p_{ij}, where $i \in \{1,2\}$ and $j \in \{1,..,n\}$. Note that firm i may charge end-user prices dependent on which upstream firm the consumer is connected to.

We make two assumptions that reflect some idiosyncratic features of the case at hand:

Assumption 1: Network selection independent of wholesale charges: The probability λ_j that a visitor is connected to upstream firm j's network is independent of w_j, where $\lambda_j > 0$, and $\Sigma_{j=1}^{n}\lambda_j = 1$.

Assumption 2: Customer ignorance: The consumers only take the average price, $\overline{p}_i = \Sigma_{j=1}^{n}\lambda_j p_{ij}$, into account.

The probability λ_j that a visitor is connected to upstream firm j is

$$\lambda_j = \frac{I_j^0 + \Delta I_j}{\Sigma_j \left(I_j^0 + \Delta I_j\right)} = \frac{I_j^0 + \Delta I_j}{I}, \quad \text{where } I = \Sigma_j \left(I_j^0 + \Delta I_j\right), \tag{1}$$

where I_j^0 is the level of quality enhancing investments, and is determined outside the model. One interpretation is that I_j^0 is the investment in general network quality and coverage (towards domestic end-users and foreign visitors), and that this decision is taken before the decision on rent-seeking technology. As described above, ΔI_j is a rent-seeking investment made by upstream firm j at stage 1. The probability of being selected is typically endogenous since operators may improve this probability through network investments beyond the capacity level needed to serve consumers. For instance, investments in capacity and coverage at e.g. airports enhances the probability of being selected when roaming end-users enter a country. Furthermore, improving indoor coverage, e.g. in hotels, to avoid that a visiting end-user switches to a competing network - due to loss of signal strength - may also be a way to increase a company's roaming market share.

The formulation in equation (1) is analogous to what has often been used in the contest literature, following the seminal work of Tullock (1980). In a Tullock (1980) contest the players compete for a prize by making a sunk investment of some kind.[6]

[5] Historically operators applied uniform wholesale pricing. In fact, non-discrimination was part of the standard roaming framework provided by the GSM Association (see e.g. Salsas and Koboldt, 2004, Sutherland, 2001, Valetti, 2004). More recently, operator specific discounts have become more common.

[6] Konrad (2007) provides a comprehensive survey of the contest literature and many contest type applications. A similar investment structure is also used in the literature on semicollusion, where firms typically collude on prices (stage 2) and compete in e.g. capacities (stage1); see e.g. Fershtman and Gandal (1994) and Steen and Sørgard (1999). An investment in e.g

As discussed in the Introduction, Assumption 2 may be seen as a consequence of Assumption 1; customer ignorance follows from the fact that network conncetion frequently switches between available upstream networks. From Assumption 1 it follows that both downstream firms face the following average wholesale price:

$$\overline{w} = \sum_{j=1}^{n} \lambda_j w_j \tag{2}$$

To rule out the possibility that collusion and/or unilateral strategic effects drive the results, we assume that there is perfect competition in the downstream market.[7] The assumption of perfect retail competition is not a realistic description of the market at hand. We make this assumption for the sake of the argument however and in order to focus on the effects from the features described in Assumptions 1 and 2.[8] The demand of downstream firm i is then given by

$$D_i\left(\overline{p}_i, \overline{p}_{-i}\right) = \begin{cases} A - \overline{p}_i \ \text{ if } \overline{p}_i < \overline{p}_{-i} \\ \left(A - \overline{p}_i\right)/2 \ \text{ if } \ \overline{p}_i = \overline{p}_{-i} \\ 0 \ \text{ if } \ \overline{p}_i > \overline{p}_{-i} \end{cases} \tag{3}$$

where $A = a + \Sigma_j I_j^0$. Hence, for the sake of the argument we have assumed that $\partial A / \partial \Delta I_j = 0$, such that ΔI_j is purely wasteful rent-seeking. The game may now be solved by standard backward induction. First, we analyze the outcome without price-cap regulation. Second, we we analyze the effects of wholesale price cap-regulation.

2.1 Without price-cap regulation

Stage 3. Since both downstream firms face the same average wholesale price (2), it follows that at stage 2 the average retail price is

$$\overline{p}_i = \overline{w} \tag{4}$$

Note that it is the average price that is important. Downstream firms have the flexibility to set some prices, p_{ij}, which deviate from $\overline{w}$ as long as the average price is competitive. At stage 3 the price vector offered by firm i is then given by:

$$p_i = (p_{i1}, ..., p_{in}) \text{ such that } \overline{p}_i = \Sigma_{j=1}^{n} \lambda_j p_{ij} = \overline{w} \tag{5}$$

Consequently, the downstream firms may implement a uniform retail price p_i, where $p_{i1} = ... = p_{in} = \bar{w}$, without losing competitive strength. However,

excessive capacity at stage 1 then increases the share of the "pie" (the cartel profit) at stage 2. The similarities with the contest literature are, to our knowledge, not emphasized in the literature on semicollusion.

[7] This is the reason why we assume that there are just two downstream firms. Increasing the number of downstream firms above two will not change the results.

[8] Alternatively we may have assumed a retail monopoly.

a price vector $p_i = (p_{i1} \lesseqgtr ... \lesseqgtr p_{in})$ will also be an equilibrium as long as (5) is fulfilled. We may for instance have that some retailers provide a price vector where p_{ij} is increasing in w_j. The model is thus consistent with the market observations that some retailers provide a uniform retail price, while other retailers provide a price structure where retail prices depend on which network the customer is connected to in the visiting country (see below).

Stage 2. The aggregate demand is given by

$$D(\overline{w}) = A - \overline{w} \tag{6}$$

At stage 2 upstream firm j faces the following demand (we assume that one unit of the upstream good is needed to produce the final service):

$$D_j(\overline{w}; \lambda_j) = \lambda_j (A - \overline{w}) \tag{7}$$

At stage 2 upstream firm j solves the following maximization problem:

$$\max_{w_j} \pi_j = w_j \lambda_j (A - \overline{w}) - c\Delta I_j \tag{8}$$

The first-order conditions of the upstream firm $j \in \{1, ..., n\}$ become[9]

$$(A - \overline{w}) - w_j \lambda_j = 0 \tag{9}$$

By adding up the n first order conditions we find the weighted average wholesale price

$$\overline{w} = \frac{nA}{n+1} \tag{10}$$

By inserting (10) into (9) the wholesale price charged by firm j becomes:

$$w_j = \frac{1}{\lambda_j} \frac{A}{n+1} \quad \text{for } j \in \{1, ..., n\} \tag{11}$$

Stage 1. By inserting (10) and (11) into (8) we find that upstream firm j's profit is given by

$$\pi_j = \frac{A}{(n+1)^2} - c_j \Delta I_j \tag{12}$$

.

From (12) the following result follows:

Proposition 1 *With customer ignorance and no wholesale price-cap regulation there will be no investments in rent-seeking technology.*

[9] Second-order condititions are fullfilled.

This reflects the fact that larger investments and higher probability of being selected fully are counteracted by lower wholesale prices (w_j decreases in λ_j). It is then straightforward to see that rent-seeking investments ΔI_j are not profitable. Roughly speaking, increasing the wholesale price is an alternative way for opportunistic ("rent-seeking") behavior. Note that this outcome may depend on the assumption that $\lambda_j > 0$ for all j, and that the downstream firms have a wholesale contract with all j. We do this to highlight the differences from the case with price-cap regulation analyzed below.

Furthermore, from (10) and (11) we have

Proposition 2 *With customer ignorance and no price-cap regulation:*

(i) The profit of upstream firm j is decreasing in the number of upstream firms n,

(ii) The weighted average wholesale price $\overline{w}$ is increasing in the number of upstream firms n and independent of the distribution of λ_j,

(iii) The wholesale price of firm j, w_j, is decreasing in the number of upstream firms n and decreasing in firm j's market share λ_j.

The results in Proposition 2 correspond to previous findings in the presence of customer ignorance and wholesale pricing (Gans and King, 2000, Ambjørnsen and Wasenden, 2005, and Lupi and Manenti, 2008). The reason why the weighted average wholesale price exceeds the monopoly wholesale price reflects the structure of the demand side. In particular, since a marginal increase in w_j by firm j increases the average wholesale price $\overline{w}$ only by a factor λ_j, the elasticity of demand, from firm j's perspective, may be very low. Given our assumption of perfect competition among the downstream firms, an increase in $\overline{w}$ is passed on to consumers in a 1:1 relationship. More generally, also under imperfect competition, and with more reasonable assumptions, we have that an increase in $\overline{w}$ will increase retail prices. A prediction that follows from Proposition 2 is that the average retail price is increasing in the number of upstream firms. In practice, the upstream firms are present in their domestic retail markets. When more firms enter the domestic retail market, this will at the same time increase the number of upstream firms in the wholesale roaming market. Fierce competition for domestic voice calls (a high n) will then increase roaming wholesale and retail prices. As mentioned in the Introduction, this is consistent with the findings by the European Commission (2000) in a sector inquiry into international roaming charges. The inquiry used data from 1997 to 2000, and one of the main findings was that during this period wholesale roaming prices (and consequently retail roaming prices) increased. In the same period, the number of mobile operators increased and domestic mobile charges were significantly reduced.

2.2 With wholesale price-cap regulation

A key feature of the new European regulation that came into force from June 2007 is a price cap both on retail and wholesale charges. Let us now assume that a wholesale price-cap regulation is imposed, but the retail prices are still unregulated. The wholesale price cap specifies a maximum average per-minute wholesale charge, and applies for all providers of wholesale roaming services. In the current model the European wholesale price cap may be interpreted as $w_j \leq \widehat{w}$ for all $j \in \{1,..,n\}$ where $\widehat{w}$ is the price cap. The price-cap regulation is imposed prior to the game analyzed above.

Stage 3 is then still given by equation (5).

Stage 2: Without loss of generality we assume that $1 > \lambda_1 \geq \lambda_2 \geq .... \geq \lambda_n > 0$, such that without regulation of wholesale prices it follows from (11) that $w_1 \leq w_2 \leq .... \leq w_n$. If $w_n \leq \widehat{w}$, we have a non-binding price cap for all upstream firms $j \in \{1,..,n\}$, while the price cap is binding for all $j \in \{1,..,n\}$ if $w_1 \geq \widehat{w}$. In an intermediate case where $w_m < \widehat{w} \leq w_{m+1}$, where $m \geq 1$, the price cap $\widehat{w}$ is binding for $j \in \{m+1,..,n\}$ but is not binding for $j \in \{1,..,m\}$. In the latter case, the firms $m+1$ through n are forced to reduce their wholesale charges when the price cap is enforced. The question is now: How will unconstrained firms 1 through m react?

From the first-order conditions given by (9) we find the reaction functions:

$$w_j = \frac{A - \sum\limits_{m \neq j} \lambda_m w_m}{2\lambda_j} \tag{13}$$

From the upstream firms' reaction functions (13) we have that:

Proposition 3 *The wholesale prices are strategic substitutes.*

A Corollary which follows from Proposition 3 is:

Corollary 1: *If the wholesale price cap $\widehat{w}$ is binding only for a fraction of the upstream firms $j \in \{m+1,..,n\}$, where $m \geq 1$ (i.e. the wholesale prices of firm $j \in \{m+1,..,n\}$ are regulated down), the unconstrained firms $j \in \{1,..,m\}$ will increase their wholesale prices when $\widehat{w}$ is enforced.*
Proof. See the Appendix ■

Put differently, the degree of wholesale price variations will be lower with than without a wholesale price-cap regulation as now implemented in the EU. Due to the feature of random network selection, the wholesale prices become strategic substitutes. The reduction in the average wholesale price from a wholesale price cap will partly be countered by the fact that unconstrained upstream providers will increase their wholesale prices (the weigthed average wholesale price will decrease, though).

Stage 1: For simplicity, we now assume $I_j^0 = I^0$ for all j, such that $\lambda_j = 1/n$ as long as the upstream firms do not invest in rent-seeking technology. We concentrate on the case where the price cap is binding. Then the profit for firm j may be written as

$$\pi_j = \hat{w}\left(A - \hat{w}\right) \frac{I^0 + \Delta I_j}{I} - c\Delta I_j. \tag{14}$$

Recall from (12) that in the unregulated case, the first part of the profit function is independent of ΔI_j, such that there will be no rent-seeking investments. In contrast to the unregulated case, the first part of the profit function (14) is dependent on ΔI_j. When the price cap is binding for all j, the regulation gives rise to a contest a la Tullock (1980).

In an interior equilibrium solution, ΔI_j is determined by[10]

$$\frac{\partial \pi_j}{\partial \Delta I_j} = \frac{I - \Delta I_j - I^0}{I^2} \hat{w}\left(A - \hat{w}\right) - c = 0, \;\; j \in \{1, .., n\}. \tag{15}$$

In a symmetric equilibrium, where $\Delta I_j = \Delta I$ for all j, the set of first-order condititions can be rewritten as

$$\frac{(n-1)}{n\left(I^0 + \Delta I\right)} \frac{\hat{w}\left(A - \hat{w}\right)}{n} - c = 0 \tag{16}$$

The equilibrium level of rent-seeking investment, ΔI_j, can now be found from (16)

$$\Delta I = \frac{\hat{w}\left(A - \hat{w}\right)}{n} \frac{n-1}{cn} - I^0, \text{ for all } j. \tag{17}$$

The condititon that ensures rent-seeking is

$$\Delta I > 0 \text{ if } \frac{\hat{w}\left(A - \hat{w}\right)}{n} \frac{n-1}{n} > cI^0$$

Proposition 4 *Assume that $I_j^0 = I^0$ for all j and that the wholesale price-cap regulation is binding($\hat{w} \leq \frac{nA}{n+1}$):*

(i) There will be investments in rent-seeking technolgy ($\Delta I > 0$ for all j) as long as $\frac{\hat{w}(A-\hat{w})}{n} \frac{n-1}{n} > cI^0$.

(ii) $\Delta I(\hat{w})$ is inverted U-shaped with a maximum at $\hat{w} = A/2$ (the monopoly price).

The price cap is binding when $\hat{w} = \frac{nA}{n+1}$. Then rent-seeking investment incentives make a positive shift. This reflects the fact that an increase in the probability of being the chosen network will not affect wholesale prices negatively. Network investment may now be used as a rent-seeking instrument.

[10] When $\hat{w}$ is sufficiently close to A or 0, an interior solution does not exist, i.e. $\Delta I_j = 0$.

As long as $\hat{w}$ binds, and $\Delta I \geq 0$, ΔI is a bell-shaped function of $\hat{w}$. The rent-seeking investment reaches its maximum level when the monopoly price is achieved ($\hat{w} = A/2$).

When $\hat{w} > A/2$, rent-seeking investments increase as $\hat{w}$ decreases towards $A/2$. To see why, note that $\hat{w}\,(A - \hat{w})$ reflects total roaming revenues in the market. When $\hat{w} > A/2$ total roaming revenues increase when $\hat{w}$ decreases. The larger "pie" stimulates rent-seeking activity. In contrast, when $\hat{w} < A/2$, rent-seeking investments decrease as $\hat{w}$ decreases. In this case total roaming revenues decrease as $\hat{w}$ is lowered.

This resembles a Tullock (1980) contest where the players compete for a price, and the rent-seeking investments increase the higher the prize is. The welfare implications of a price-cap regulation are therefore ambiguous. When $\hat{w}$ is lowered, prices are reduced. However, when $\hat{w} \in \left[\frac{A}{2}, \frac{nA}{(n+1)}\right]$, rent seeking investments are higher the lower $\hat{w}$. Below this level, both average retail prices and rent-seeking investments are reduced when $\hat{w}$ is lowered, and from (17) it follows that there will be no rent-seeking when $\hat{w}$ is close to zero (the marginal costs).

3 The European price-cap regulation on mobile roaming

As long as the national regulatory authorities care more about domestic consumer surplus and profits than about the negative impact of higher roaming prices, higher prices for international roaming may be seen as an externality from increased domestic retail competition. This may explain why a supranational regulatory approach is now initiated by the EU. The European Union (2007) states that "[The 2002 regulatory framework for electronic communications] has not provided national regulatory authorities with sufficient tools to take effective and decisive action with regard to the pricing of roaming services.....This Regulation is an appropriate means of correcting this situation." However, as shown in the previous section, while the European wholesale price-cap regulation by its very nature may reduce upstream firms' abilities to increase wholesale prices, the regulation may at the same time increase their incentives to raise wholesale prices. Furthermore, a binding wholesale price regulation may induce rent-seeking investments in order to capture a larger share of the total "pie".

We have limited our analysis to wholesale price-cap regulation. The next question is how a reduction in the wholesale price variation will transform into retail prices. From the above we know that the downstream firms may implement a uniform retail price, p_i, where $p_{i1} = ... = p_{in}$, or a price vector $p_i = (p_{i1} \lesseqgtr ... \lesseqgtr p_{in})$, as long as (5) is fulfilled. If downstream firm i provides a price vector where p_{ij} is increasing in w_j ($\partial p_{ij}/\partial w_j > 0$) and wholesale price changes partly or fully are passed on to end users, a binding wholesale price cap $\widehat{w}$ will also transform into lower retail price variations. If $w_m < \widehat{w} \leq w_{m+1}$, where $m \geq 1$, the downstream firm i will reduce p_{ij} for $j \in \{m+1, .., n\}$ (wholesale price reductions due to the binding cap are passed on to end users) and increase p_{ij} for $j \in \{1, .., m\}$ (reflect wholesale price increases of unconstrained upstream firms).

In addition to the wholesale price cap, the European regulation enforces a retail price cap on a call level such that $p_{ij} \leq \widehat{p}$ for all $i \in \{1, 2\}$ and $j \in \{1, ..., n\}$. Assume now that the retail price cap is binding; such that $\widehat{p} = \overline{w}$. We immediately see that the equilibrium average price $\overline{p}_i = \overline{w} = \widehat{p}$, can only be realized through uniform retail pricing. A price vector p_i where p_{ij} is increasing (or decreasing) in w_j, subject to the condition that $\overline{p}_i = \overline{w} = \widehat{p}$, would imply that some retail prices would violate the retail price -cap regulation.

Both wholesale and retail price-cap regulation may thus reduce retail price variations, and Corollary 2 follows from the above results:

Corollary 2: *The European wholesale and retail price-cap regulation may induce downstream firms to introduce uniform retail pricing; i.e.* $p_{ij} = p_i$ *for all* $j \in \{1, .., n\}$.

Therefore, when more downstream firms introduce uniform pricing as a response to the implementation of price caps, we expect to see that downstream firm i will increase retail prices which prior to the regulation were set below the retail price cap (i.e. where $p_{ij} < \widehat{p}$ prior to the regulation).

While wholesale prices are not publicly available, retail prices are. The European Commission (2008) compares retail prices in all EU retail markets before (March 2007) and after (July 2008) the price-cap regulation was enforced.[11] For each retail market (country) the European Commission (2008) has collected retail prices for consumers who are visiting six different EU countries (wholesale markets). There are a few exceptions, but, generally, the retail price cap was binding for most retail prices prior to the regulation. The possibility to test whether below-the-price-cap retail prices were in fact increased after the regulation was implemented is therefore limited. In the few cases where the retail price cap was non-binding, the majority of operators chose to increase retail prices.

In the table below we show evidence of a striking change towards uniform retail pricing as a response to the introduction of price cap regulation. In column 2 we have the number of retailers, and in column 3 the number of retailers using uniform retail pricing – where prices are independent of which network the consumers are connected to in the visited country – prior to the regulation. Generally, the picture is mixed. Some retailers use uniform pricing, while others use network dependent retail prices. France, Italy and Spain are the only retail markets where all retailers use uniform pricing prior to the regulation.

[11] Retail price information is also available for September 2007, soon after the regulation was implemented. We believe, however, that the July 2008 data are more representative for a more long term perspective. Data after July 2008 are currently not availbale.

In contrast, in July 2008 a majority of all providers in EU retail markets use uniform prices (column 4).

As illustrated in the table (column 5), the EU price-cap regulation seems to have induced many retail firms to switch to a practice with one uniform retail price for all countries in the EU-region; "EU zone tariff". We now investigate how such an "EU zone tariff" will affect upstream firms' pricing incentives. In order to do so we use the same model structure as above, except that we assume that there are M different upstream markets (i.e. countries). Within each upstream market there are n upstream firms.

Assumption 1 implies that the probability that upstream firm j in country k is used is λ_j^k, where $\lambda_j^k > 0$, and $\Sigma_{j=1}^n \lambda_j^k = 1$ for $k \in \{1, ..., M\}$. The probability that a consumer travels in country k, where $k \in \{1, ..., M\}$, is χ^k, where $\chi^k > 0$ and $\Sigma_{k=1}^c \chi^k = 1$.

We now add the restriction to the maximization problem that the retail price is uniform for all M. As we argued above, with random network selection it is reasonable to assume that the consumers only take the average retail price in the visited country into account. A uniform retail roaming price for a given foreign country is then an equilibrium. However, consumers obviously know which country they travel to, and consequently it is not reasonable to assume that they base their consumption on the average retail price for several countries if there are differences in the retail roaming prices between countries (markets). Hence, it may not be an equilibrium to offer a uniform price for several countries.

From the system of first-order conditions we find the wholesale price charged by firm j in market k

$$w_j^k = \frac{1}{\chi^k \lambda_j^k} \frac{A}{Mn+1},$$

and the weighted average wholesale price now becomes

$$\overline{w} = \frac{AMn}{Mn+1}.$$

We then have the result that uniform retail pricing used for several countries ("zone pricing") will, all other things equal, increase the weighted average wholesale price, $\overline{w}$.

The intuition is analogous to the basic model; the higher the number of upstream firms within a "zone" (Mn), the smaller the effect of a price increase will be on demand and the higher wholesale prices will be. Thus, all other things equal, the introduction of "zone pricing" tends to further increase the incentives to set high voice call charges abroad. Again we see that while the European price-cap regulation by its very nature may reduce firms' abilities to increase retail and wholesale prices, the regulation may at the same time increase firms' incentives to raise prices. This should be a cautionary tale to the authorities whose goal is that the regulatory remedies should be temporary.

	March 2007		July 2008	
Retail market	Number of retailers (which reported retail roaming charges March 2007)*	Number of retailers using uniform retail pricing March 2007**	Number of retailers using uniform retail pricing July 2008	Number of retailers using "zone pricing" for all destination countries July 2008***
Austria	2	1	1	1
Belgium	3	1	3	0
Bulgaria	2	0	2	2
Cyprus	2	0	2	1
Czech Republic	2	0	2	2
Denmark	5	3	2	2
Estonia	3	0	3	3
Finland	4	0	4	3
France	3	3	3	3
Germany	4	1	4	4
Greece	3	1	3	1
Hungary	3	2	3	3
Ireland	4	0	4	1
Italy	3	3	3	3
Latvia	3	0	2	2
Lithuania	3	0	2	2
Luxemburg	2	0	2	1
Malta	2	0	2	2
Netherlands	4	0	4	4
Poland	4	1	4	4
Portugal	3	1	3	3
Romania	3	2	3	3
Slovakia	2	0	2	2
Slovenia	2	0	2	2
Spain	3	2	3	3
Sweden	4	0	4	4
United Kingdom	5	3	5	5
Total	83	24	77	66

*In several countries more retail operators are present in the market in March 2007, but we only report the number of retailers which have reported prices both in March 2007 and July 2007.
**Uniform pricing implies that a retailer offers one price regardless of which network (wholesaler) the customer is connected to in the destination country when calling home.

***I.e. the retailer has the same uniform retail price in all six destination countries we have data from.

Figure 1: Retail price structure

4 Concluding remarks

Mobile phone usage when traveling abroad is expensive and the prices have not been reduced as more firms have entered the market. While collusive behavior and unilateral facilitating practices have been used as explanations for high prices, the core problem may be the technological structure for how network selection among available networks in the visited country has been designed. The network connection switches frequently between available networks, and the choice of network has largely been independent of wholesale prices. The recent European price-cap regulation (enforced in June 2007) does not solve this underlying problem, and there may be a permanent need for regulation. This is analogous to the case of domestic call termination, and should be a cautionary tale to the authorities whose goal is that the price cap regulation should be temporary. Furthermore, there is also a risk that wholesale price regulation stimualtes wasteful rent-seeking activity, where visited operators excessively increase their network capacity to capture a larger share of the increasing roaming traffic.

One crucial assumption in the present paper is that the downstream firms have wholesale agreements with all upstream firms. This may be seen as consistent with the observation that mobile operators generally have roaming agreements with all network operators with significant coverage in each country. One reason is that the downstream firms in so doing may improve coverage for their end-users when travelling abroad. In emerging markets this seems to be relevant. In mature markets, where several upstream firms have full coverage, this argument is less appealing. A downstream firm may reduce the number of wholesale agreements, and thereby undercut its rivals since the average wholesale price is lowered.

Another rationale for having several agreements in a particular country has been to increase wholesale demand at home. A high number of wholesale agreements implies more demand from foreign visitors. This is not incorporated in the basic model above, but may be seen as a justification for the assumption that the downstream firms have agreements with all the upstream firms even if this increases the average wholesale price.

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6 Appendix

Proof of Corollary 1. If $w_j \leq \hat{w}$ for all $j \epsilon \{1, ..., n\}$ (nonbinding or exactly binding), then unconstrained firms will not change their behaviour. Consider now the case where $w_j > \hat{w}$ for at least one firm $j \epsilon \{1, ..., n\}$. Suppose, by assumption, that the average wholesale price $\bar{w}$ (in equilibrium) increases. From the first-order condition (9) it follows that w_j must be reduced. A reduction in w_j, however, contradicts the assumption that $\bar{w}$ increases (recall that the wholesale prices of firms facing a binding cap are also reduced). The average wholesale price $\bar{w}$ must therefore decrease in equilbrium. It follows then from the first-order condition that w_j will increase ■

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