DISCUSSION PAPER SERIES

No. 9361

FIXED-MOBILE INTEGRATION

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INDUSTRIAL ORGANIZATION

Centre for Economic Policy Research

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Available online at: **www.cepr.org/pubs/dps/DP9361.asp**

ISSN 0265-8003

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Discussion Paper No. 9361
February 2013

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CEPR Discussion Paper No. 9361
February 2013

ABSTRACT

Fixed-Mobile Integration*

Often, fixed-line incumbents also own the largest mobile network. We consider the effect of this joint ownership on market outcomes. Our model predicts that while fixed-to-mobile call prices to the integrated mobile network are more efficient than under separation, those to rival mobile networks are distorted upwards, amplifying any incumbency advantage. As concerns potential remedies, a uniform off-net pricing constraint leads to higher welfare than functional separation and even allows to maintain some of the efficiency gains.

JEL Classification: L51 and L92
Keywords: call externality, integration, network competition and on/off-net pricing

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Submitted 13 February 2013

1 Introduction

The Issues at hand. Nine of the ten largest fixed-line carriers in the world own a controlling stake in a mobile operator (Dippon, 2005). Historically, these carriers entered the mobile markets in its early stage and have kept a strong presence ever since: Today, most incumbent operators own 100% of their mobile arms, which tend to be the largest operator in their market. For example, in Europe 11 out of 14 horizontally-integrated mobile operators were the leaders within their mobile market in 2012 (see the table in the Appendix). In emerging markets, such Brazil, China and Russia, fixed-mobile integration has also begun, with significant implications for their telecoms industry.[1] In a nutshell, today, integration between a mobile network and the fixed-line incumbent is a pervasive and key feature of most communications markets.[2]

What is the impact of integration between a fixed and a mobile operator on pricing incentives? Does integration provide a competitive disadvantage to non-integrated operators? Notwithstanding the clear relevance of the problem, these questions have received little attention in the economic literature. Most studies on network competition and interconnection (see the surveys by Armstrong, 2002; Vogelsang, 2003; Harbord and Pagnozzi, 2010) focus on the degree of market competition and the incentives to collude in setting (two-way) access charges in order to relax competition. The role of integration is still unexplored, and our paper aims to fill this gap.

In our model, we consider the effects of fixed-mobile integration in the presence of call externalities, that is, when customers obtain a positive utility not only from making

[1] For example, Telefonica de Espana is moving ahead with plans to merge its Brazilian mobile and fixed-line affiliates.

[2] The most notable exception is the UK, where BT sold its mobile arm O2 to Telefonica in 2005. Until the recent merger between Orange and T-Mobile, it remained the largest mobile operator in the UK.

but also from receiving calls. In our model, one fixed and two mobile operators are present. The mobile operators compete to attract one group of consumers who wish to subscribe to a mobile network and will make calls to all networks. The fixed operator provides access to its own group of customers, which is assumed to be separate from those of the mobile networks.[3] Since calls will be made between the different groups of customers, new call services emerge: Consumers can make fixed-to-mobile and mobile-to-fixed calls. Whenever a call is terminated on or originated by the fixed network, fixed and mobile networks provide essential inputs to each other. In this setting, we analyze the pricing incentives for mobile-to-mobile (MTM), fixed-to-mobile (FTM) and mobile-to-fixed (MTF) calls under both separate ownership, where all three networks are independent of each other, and integration, when a mobile network is integrated with the fixed network.

Our results show that in presence of integration, FTM calls to the rival mobile network are priced significantly above marginal cost, while those to the integrated mobile network are priced below cost. This pricing structure creates an additional disadvantage for the non-integrated mobile network, in terms of market shares and profits, and even magnifies any prior asymmetries. Furthermore, we also show that the integrated networks would prefer FTM termination rates to be set at zero, while the non-integrated network would prefer them to be high.

If remedies were to be imposed on retail prices, we find that imposing a uniform pricing constraint on FTM prices eliminates the strategic incentives for excessive FTM prices, while maintaining some of the efficiency gains from integration. The alternative remedy of imposing a functional separation obligation, in order to mimic price setting

[3] In two companion papers we assume that markets are not separate and consider issues such as fixed-to-mobile substitution and bundling strategies.

under separation, also eliminates the incentives for excessive pricing, but foregoes the efficiency gains that are obtained under integration.

Related literature. An important new feature in network competition models is the analysis of retail pricing in the presence of call externalities, i.e. when customers receive utility from receiving calls (Jeon et al., 2004; Berger, 2004 and 2005; Cambini and Valletti, 2008; Hermalin and Katz, 2011). Jeon et al. (2004) show that introducing call externalities strongly modifies pricing incentives for calls between mobile networks: On-net calls are priced below cost in an attempt to internalize the call externality, while off-net prices may be set significantly above cost for strategic reasons, i.e. in order to reduce the number of calls subscribers on rival networks receive, weakening their ability to compete. This increase in retail prices may even lead to "connectivity breakdowns": In order to discourage subscribers from connecting to the rival, a network has an incentive to charge extremely high off-net call prices or off-net receiver prices. Cambini and Valletti (2008) show that the risk of a connectivity breakdown is however much diluted when return calls are induced (i.e., calls made and received are complements), and that breakdown is completely eliminated if operators can set a jointly profit-maximizing reciprocal access charge. None of these papers however deal with the presence of both mobile and fixed networks, and integration and its impact on pricing incentives.

On the other hand, there exists an equally sizeable economic literature on the relationship between fixed and mobile telephony, see e.g. the survey by Vogelsang (2010). Wright (2002) considers FTM calls with a focus on mobile termination rates, while others (e.g. Valletti and Houpis, 2005) analyze how socially optimal FTM termination charges would depend on the magnitude of network externalities, the intensity of competition in the mobile sector, and the distribution of customer preferences. Armstrong and Wright

(2009) integrate the above two streams of literature into a unifying model and analyze the impact of introducing a uniform (FTM and MTM) termination charge. They show that imposing uniform access charges (set either unilaterally or cooperatively) leads mobile networks to set a termination charge below the monopoly level but above the level that they would set if MTM termination could be priced separately.

Still, there is no academic publication considering the issue of integration between fixed and mobile networks and the pricing incentives for on-net and off-net calls. The papers closest to ours are Cambini (2001), who considers vertical integration between local and long-distance communications providers and the resulting problems of one-way wholesale access (there is no corresponding retail pricing analysis, though), and Mu (2008), who analyzes symmetric competition between two pairs of integrated fixed and mobile networks and the necessity of regulating mobile termination rates. The latter paper does find that the integrated firm internalizes termination payments, i.e. does not take termination rates into account when setting its retail prices for calls between its parts, but neglects the decisive issues of asymmetric mobile market outcomes and call externalities.

The outline of the paper is as follows. In Section 2 we describe the model. Section 3 presents the retail pricing equilibrium in our benchmark case, i.e., the case in which networks are non-integrated, while in Section 4 we study equilibrium outcomes when the fixed and a mobile network are integrated. In Section 5 we propose potential regulatory remedies to limit the negative impact of integration on market outcomes. Section 6 concludes.

2 Model Setup

Networks, costs and tariffs. Consider a mobile telephony market with two potentially asymmetric networks. Mobile network 1 is owned by the monopoly fixed network, while mobile network 2 is independent. We assume that consumers in the mobile and fixed markets fall into different groups. Competition in the mobile market is modeled in Hotelling fashion as in Laffont et al. (1998), while networks are asymmetric as in Carter and Wright (1999) and Hoernig (2007). The fixed network's retail prices are unregulated. For simplicity, we only consider the fixed network's choice of FTM price and monthly subscription fee.[4] All networks are interconnected and terminate incoming calls charging termination rates which are set by the sectoral regulator. The central assumption that we make is that mobile network 1 and the fixed network choose their retail tariffs jointly.

There is a mass 1 of consumers in the mobile market, and a mass N of consumers in the fixed market. Mobile market shares are $\alpha_i \geq 0$, $i = 1, 2$, with $\alpha_i + \alpha_j = 1$, where network j generically denotes network i's rival. Mobile networks have symmetric costs and termination rates.[5] Each mobile network incurs a monthly fixed cost per customer f and has on-net call costs of $c = c_o + c_t$ per minute, where c_o and c_t are its origination and termination cost, respectively. The regulated mobile termination rate is denoted by a, and therefore, the per-minute cost of an off-net call to the other mobile network is $c_o + a$. The fixed network has a monthly fixed cost of f_x, and its per-minute costs of an FTM call to either mobile network are $c_{xo} + a$, where c_{xo} is its origination cost. Note that we assume, as in Armstrong and Wright (2009), that the termination charge both for MTM and FTM calls is uniform, that is, independent of the call's origin. Similarly,

[4] Free calls to other fixed network customers are often included in the monthly subscription. We therefore assume that FTF calls are free.

[5] A higher termination rate on network 2 would amplify the effects described below.

the per-minute cost of an MTF call is $c_o + a_x$, where a_x is the fixed network's regulated termination rate.

Mobile network i offers a multi-part tariff $(F_i, p_i, \hat{p}_i, \tilde{p}_i)$ which consists of a monthly fixed fee F_i, and of per-minute prices p_i for on-net calls, $\hat{p}_i$ for off-net calls to the other mobile network, and $\tilde{p}_i$ for calls to the fixed network. The fixed network offers a multi-part tariff (F_x, z_1, z_2) comprising a fixed fee F_x and per-minute call prices z_1 and z_2 to mobile networks 1 and 2, respectively.

Consumers and market shares. We assume that each mobile or fixed subscriber makes calls to all potential recipients with equal probability. Mobile subscribers receive a fixed utility A_i from being connected to network i, with $A_1 \geq A_2$. Fixed subscribers obtain a fixed utility A_x from subscription to the fixed network.[6] Subscribers also obtain utility $u(q)$ from making and $\gamma u(q)$ from receiving a call of length q, where $0 \leq \gamma \leq 1$ indicates the strength of the call externality. The corresponding caller net surplus at price p is $v(p) = \max_q\{u(q) - pq\}$, with call demand $q(p) = -v'(p)$. Let $q_i = q(p_i)$, $\hat{q}_i = q(\hat{p}_i)$, etc., and similarly for v and u. Finally, we define $q_i^x = q(z_i)$, $u_i^x = u(q_i^x)$ and $v_i^x = v(z_i)$.

For a given mobile consumer, the surplus of subscribing to mobile network $i = 1, 2$, apart from the fixed utility A_i, is given by

$$\begin{aligned} w_i &= \alpha_i (v_i + \gamma u_i) + \alpha_j (\hat{v}_i + \gamma \hat{u}_j) + N (\tilde{v}_i + \gamma u_i^x) - F_i \\ &= \alpha_i h_{ii} + \alpha_j h_{ij} + N h_{ix} - F_i. \end{aligned}$$

[6] Alternatively, one could assume that fixed subscribers are heterogenous, and then derive a downward-sloping demand curve. This would lead to the same conclusions about call prices as in the present setting.

The Hotelling market share of network i is then

$$\alpha_i = \frac{1}{2} + \sigma \left(w_i + A_i - w_j - A_j \right),$$

where $\sigma > 0$ measures the strength of horizontal differentiation. Solving this implicit condition for the market share α_i leads to

$$\alpha_i = \frac{1/2 + \sigma \left(h_{ij} - h_{jj} + N \left(h_{ix} - h_{jx} \right) + A_i - A_j - F_i + F_j \right)}{1 - \sigma H}, \tag{1}$$

where $H \equiv h_{ii} + h_{jj} - h_{ji} - h_{ij}$.[7]

A consumer in the fixed market with connection utility A_x subscribes if his net surplus is non-negative, that is, if

$$A_x + w_x = A_x + \alpha_1 \left(v_1^x + \gamma \tilde{u}_1 \right) + \alpha_2 \left(v_2^x + \gamma \tilde{u}_2 \right) - F_x \geq 0. \tag{2}$$

We assume that A_x is large enough so that in equilibrium the fixed network is active.

Profits and welfare. Mobile network i's profits are given by

$$\begin{aligned} \pi_i &= \alpha_i \left(F_i - f \right) + \alpha_i^2 \left(p_i - c \right) q_i + \alpha_i \alpha_j \left[\left(\hat{p}_i - c_o - a \right) \hat{q}_i + \left(a - c_t \right) \hat{q}_j \right] \\ & \quad + \alpha_i N \left[\left(\tilde{p}_i - c_o - a_x \right) \tilde{q}_i + \left(a - c_t \right) q_i^x \right]. \end{aligned} \tag{3}$$

The first two terms contain the profits from subscriptions and on-net calls, whereas the third and fourth terms represent the profits from off-net call origination and termination to the other mobile and fixed network, respectively.

[7] We assume that $H < 1/\sigma$, so that the equilibrium candidate is stable in customer expectations (see Laffont, Rey and Tirole 1998).

The fixed network's profits are

$$\pi_x = N(F_x - f_x) + \sum_{i=1,2} \alpha_i N\left[(z_i - c_{xo} - a) q_i^x + (a_x - c_{xt}) \tilde{q}_i\right]. \tag{4}$$

Finally, consumer surplus is given by

$$CS = \sum_{i=1,2} \left[\alpha_i (w_i + A_i) - \frac{\alpha_i^2}{4\sigma}\right] + N(w_x + A_x),$$

where the negative term represents the total Hotelling transportation costs, and total welfare is

$$W = CS + \pi_1 + \pi_2 + \pi_x.$$

In the following we will consider Nash equilibria where all three networks choose their tariffs simultaneously. To begin with, we provide a benchmark where network 1 and the fixed network are not jointly owned, i.e. set prices independently. Then, in a second step we consider the Nash equilibrium under integration, where the fixed network and mobile network 1 maximize their joint profits, $\pi_x + \pi_1$. In a last step, we revisit the equilibria when remedies have been imposed.

3 A Benchmark: Non-Integrated Networks

As a first step, we determine market outcomes with separately owned networks. In this benchmark, all three networks choose their tariffs simultaneously and independently to maximize their respective profits, taking the other networks' tariffs as given.

For the fixed market, the fixed network sets the subscription fee F_x such that condition

(2) holds with equality, hence,

$$F_x = A_x + \alpha_1 \left(v_1^x + \gamma \tilde{u}_1 \right) + \alpha_2 \left(v_2^x + \gamma \tilde{u}_2 \right). \tag{5}$$

Substituting F_x into the profits (4) and dropping the terms that do not depend on the FTM call prices, the fixed network chooses z_1 and z_2 to maximize

$$\sum_{i=1,2} \alpha_i \left[v_i^x + (z_i - c_{xo} - a)\, q_i^x \right].$$

Using the fact that $dv_i^x/dz_i = -q_i^x$, the maximum is obtained at

$$z_1^N = z_2^N = c_{xo} + a, \tag{6}$$

that is, without integration FTM calls are priced at marginal cost.[8] The intuition behind this result is that the fixed network only considers its own callers and profits. Otherwise stated, it does not take into account externalities on receivers and mobile networks.

Mobile networks, on the other hand, choose their optimal call prices while keeping surplus w_i (and therefore market shares) constant, by adjusting fixed fees F_i accordingly. Optimal call prices are therefore found by substituting F_i from the market share equation (1) into the profits (3), and by isolating the relevant terms. For the on-net call price, network i therefore maximizes

$$v_i + \gamma u_i + (p_i - c)\, q_i.$$

Using the fact that $du_i/dp_i = p_i q_i'$, we obtain the solution $p_i^N = c/(1+\gamma)$. As is well-

[8] In the following, superscripts N and I refer to non-integration and integration, respectively.

known, for on-net calls the call externality is fully internalized and the mobile networks optimally choose the efficient price level. The price for off-net calls to the other mobile network $\hat{p}_i$ is found by maximizing

$$\alpha_j \left[\hat{v}_i + \left(\hat{p}_i - c_o - a\right) \hat{q}_i\right] - \alpha_i \gamma \hat{u}_i.$$

As in Jeon *et al.* (2004), the resulting off-net price is

$$\hat{p}_i^N = \frac{c_o + a}{1 - \gamma\alpha_i/\alpha_j}. \tag{7}$$

This off-net MTM price is strategically distorted upwards due to the positive externality that subscribers of the rival network obtain when they receive a call.

Finally, the MTF call price is set in order to maximize

$$\tilde{v}_i + \left(\tilde{p}_i - c_o - a_x\right) \tilde{q}_i.$$

This expression again does not contain any externality term. Thus, the MTF price is also set at marginal cost,

$$\tilde{p}_i^N = c_o + a_x. \tag{8}$$

Finally, we determine the equilibrium fixed fees and the resulting market shares. First, note that from (1) we have

$$\frac{\partial \alpha_i}{\partial F_i} = -\frac{1}{1/\sigma - H}. \tag{9}$$

The first-order condition for maximizing mobile network i's profits π_i with respect to F_i

leads to fixed fees and profits

$$F_i^N = f + \frac{\alpha_i}{\sigma} - \alpha_i H - 2\alpha_i P_i^N - (1 - 2\alpha_i)\hat{P}_i^N - N\tilde{P}_i^N, \tag{10}$$

$$\pi_i^N = \alpha_i^2 \left[\frac{1}{\sigma} - H - P_i^N + \hat{P}_i^N\right], \tag{11}$$

with $P_i^N = \left(p_i^N - c\right) q_i$, $\hat{P}_i^N = \left(\hat{p}_i^N - c_o - a\right)\hat{q}_i + (a - c_t)\hat{q}_j$, and $\tilde{P}_i^N = \left(\tilde{p}_i^N - c_o - a_x\right)\tilde{q}_i + (a - c_t) q_i^x$ being profits from incoming and outgoing calls. The fixed fee decreases in the FTM profit $\tilde{P}_i$, which means that the "waterbed effect" is at play, i.e. the phenomenon that profits from fixed-to-mobile termination are handed on to consumers through a lower monthly fee.[9] Since this waterbed effect is full here, mobile networks' profits are not affected. Furthermore, the equilibrium prices computed above imply that $h_{ix} = h_{jx}$, and together with $\tilde{P}_i = \tilde{P}_j$, we obtain that market shares (1) do not depend on the presence of the fixed network under non-integration.

In the case where subscription surpluses A_1 and A_2 are identical, we obtain a symmetric equilibrium where $\alpha_i = 1/2$ and $\pi_i^N = \pi_j^N$. In the following we will compare these outcomes to those obtained under integration.

4 Integrated Networks

4.1 Equilibrium tariffs

Now we assume that mobile network 1 and the fixed network are integrated. The fixed network has no influence on the independent mobile network's pricing decisions, so net-

[9] The waterbed effect has some empirical relevance, as shown by Genakos and Valletti (2011). In particular, their results suggest that, although regulation in Europe reduced termination rates by about 10% to the benefit of callers to mobile phones from fixed lines, it also led to a 5% increase (varying between 2%-15% depending on the estimate) in mobile retail prices.

work 2 continues to set the on-net price $p_2^I = c/(1+\gamma)$, MTF price $\tilde{p}_2^I = c_o + a_x$ and MTM off-net price $\hat{p}_2^I$, given by (7) for new equilibrium market shares. On the other hand, network 1 and the fixed network maximize the sum of their fixed and mobile profits, $\pi_1 + \pi_x$. Holding market shares fixed and substituting F_1 and F_x as above, we find that mobile on-net and off-net prices are set as above, that is, $p_1^I = c/(1+\gamma)$ and $\hat{p}_1^I$ is as in (7). What does change, though, are the relevant terms for determining the prices of FTM calls to either mobile network and the MTF calls of network 1.

The optimal MTF call price $\tilde{p}_1$ is found by maximizing

$$\tilde{v}_1 + (\tilde{p}_1 - c_o - a_x)\,\tilde{q}_1 + \gamma\tilde{u}_1 + (a_x - c_{xt})\,\tilde{q}_1 = \tilde{v}_1 + (\tilde{p}_1 - c_o - c_{xt})\,\tilde{q}_1 + \gamma\tilde{u}_1.$$

Two externalities are internalized in this choice: first, the termination payment; and second, the receiver utility. Thus, the relevant marginal costs are the origination cost on the mobile network and the termination cost on the fixed network. Network 1's strategic marginal cost is even lower, since it also internalizes the call externality. The resulting MTF price is at the efficient level,

$$\tilde{p}_1^I = \frac{c_o + c_{xt}}{1+\gamma}. \tag{12}$$

This price is lower than the MTF price without integration for two reasons: First, marginal cost contains the termination cost c_{xt} and not the potentially higher termination rate a_x; second, the integrated network takes into account that receivers of these calls are also its clients; by lowering the MTF price it creates more surplus if $\gamma > 0$, which can then be extracted through higher fixed fees.

As concerns FTM calls, those to network 1 are priced in order to maximize

$$\begin{aligned} & \alpha_1 \left(\gamma u_1^x + (a - c_t)\, q_1^x + v_1^x + (z_1 - c_{xo} - a)\, q_1^x\right) \\ = \;& \alpha_1 \left(v_1^x + (z_1 - c_{xo} - c_t)\, q_1^x + \gamma u_1^x\right). \end{aligned} \tag{13}$$

Exactly the same two externalities are internalized in this case, so the optimal FTM price for calls to the partner mobile network becomes

$$z_1^I = \frac{c_{xo} + c_t}{1 + \gamma}. \tag{14}$$

Again, this FTM price is lower than without integration since $c_t \leq a$ and $\gamma > 0$.

On the other hand, the terms relevant for the FTM price of calls to network 2 are

$$\alpha_2 \left[v_2^x + (z_2 - c_{xo} - a)\, q_2^x\right] - \alpha_1 \gamma u_2^x, \tag{15}$$

which now contains the strategic marginal cost of network 2's clients receiving calls from the fixed network. Taking these into account leads to

$$z_2^I = \frac{c_{xo} + a}{1 - \gamma \alpha_1 / \alpha_2}, \tag{16}$$

which shows that the incentives for off-net FTM pricing are identical to those for off-net MTM pricing in (7). Compared to (6), the FTM price to the non-integrated network is distorted upwards. Furthermore, it continues to be based on the mobile termination rate instead of the lower mobile termination cost.

Finally, network 2's fixed fee F_2^I is formally identical to (10). The integrated network, on the other hand, solves $\max_{F_1, F_x} \{\pi_x + \pi_1\}$ subject to fixed users' surplus being non-negative. After substituting F_x from (5), we can compute the first-order condition for F_1 and solve it for

$$F_1^I = f + \frac{\alpha_1}{\sigma} - \alpha_1 H - 2\alpha_1 P_1 - (1 - 2\alpha_1)\hat{P}_1 - N\tilde{P}_1 \qquad (17)$$
$$-N\left\{(v_1^x + \gamma\tilde{u}_1 + Z_1) - (v_2^x + \gamma\tilde{u}_2 + Z_2)\right\},$$

where $Z_i \equiv (z_i - c_{xo} - a)\, q_i^x + (a_x - c_{xt})\, \tilde{q}_i$ are the fixed network's profits from calls to and from mobile network i. The first line of F_1^I is formally identical to the fixed fee (10). The second line describes how a change in mobile market shares affects the fixed network's profits: A higher fixed fee loses a marginal customer to the other mobile network, which implies the substitution of the corresponding FTM call profits. Put differently, the loss of FTM profits related to network 1 constitutes an opportunity cost, while the gain related to network 2 provides a corresponding benefit. The net effect on the fixed fee of the integrated network depends on which of the two is larger.

4.2 Market outcomes

We now determine the effect of the integrated networks' equilibrium tariff choices on market shares and profits. We first study whether the integrated mobile network gains an advantage over the non-integrated one due to integration, and second how this affects their respective profits. As an additional step, we analyze whether integration amplifies or dampens any initial asymmetry between networks.

Concerning market shares and profits, we obtain the following result:

Proposition 1 *Compared to the Nash equilibrium without integration, the integrated mobile network has a higher equilibrium market share. The difference increases in the size* *of the fixed market N and the strength of the call externality γ.*

Proof. Holding for now market shares and therefore off-net call prices and $H = h_{ii} + h_{jj} - h_{ji} - h_{ij}$ fixed at the non-integrated level $\bar{H}$, expression (1) results in a new estimate for the market share of firm 1, that is,

$$\alpha_1' = \frac{1/2 + \sigma\left(h_{12} - h_{22} + N\left(h_{1x} - h_{2x}\right) + A_1 - A_2 - F_1^I + F_2^I\right)}{1 - \sigma\bar{H}}.$$

After substituting the fixed fee in the equilibrium under integration, and denoting the total welfare from an exchange of calls between the fixed network and mobile network i by

$$\begin{aligned} W_i &= h_{ix} + v_i^x + \gamma\tilde{u}_i + \tilde{P}_i + Z_i \\ &= \left(\tilde{v}_i + \gamma\tilde{u}_i\right) + \left(v_i^x + \gamma u_i^x\right) + \left(\tilde{p}_i - c_o - c_{xt}\right)\tilde{q}_i + \left(z_i - c_{xo} - c_t\right)q_i^x, \end{aligned}$$

we obtain

$$\alpha_1' = \frac{N\left(W_1 - W_2\right)}{1/\sigma - \bar{H}} + const,$$

where the terms in *const* do not depend on MTF or FTM prices. Since $\tilde{p}_1$ and z_1 are lowered from marginal cost (including the termination rate) to the efficient level and $\tilde{p}_2$ and z_2 are raised from cost to an even higher level, $W_1 - W_2$ increases, and thus α_1' lies above the non-integrated market share. Since under stability there is a unique equilibrium market share, this implies that in the integrated equilibrium network 1's (network 2's) market share rises (decreases). This effect increases in N. Furthermore, $W_1 - W_2$ increases in γ since in W_1 prices are efficiently set and in W_2 they become increasingly distorted. ■

The difference in market shares increases in the strength of the call externality γ and the size of the fixed customer base N. Integration has an effect even for $\gamma = 0$, because the integrated network charges a lower FTM price due to the internalization of the mobile termination rate.

An additional issue of interest is whether pricing under integration amplifies or reduces ex-ante asymmetries, and how it affects profits.

Proposition 2 *If the strength of call externality γ is small, then in the Nash equilibrium under integration:*

1. *Any ex-ante market share asymmetry in favour of the integrated firm is magnified.*

2. *The non-integrated rival's profits decrease.*

Proof. 1. First we establish that for small γ the term H has a local minimum at $\alpha_1 = 1/2$ and is quasiconvex. The Taylor expansion of $dH/d\alpha_1$ around $\gamma = 0$ is

$$\frac{dH}{d\alpha_1} = \gamma\,(c_o + a)\,q(c_o + a)\left(\frac{1}{(1-\alpha_1)^2} - \frac{1}{\alpha_1^2}\right) + O(\gamma^2)$$

The first term cuts the horizontal axis from below and equals zero at $\hat{\alpha}_1 = 1/2$. This implies that if γ is small then H has a unique stationary point, which is a local minimum at $\hat{\alpha}_1$. Therefore H is quasiconvex.

Second, since $A_1 > A_2$, the market share α_1 is above $1/2$ before integration, and increases further after integration. We conclude that H increases with α_1, and therefore also $(1 - \sigma H)^{-1}$ in (1), which is the multiplier of the surplus difference $A_1 - A_2$.

2. Network 2's profits are given by $\pi_2^N = \alpha_2^2 \left[1/\sigma - H - P_2^N + \hat{P}_2^N\right]$. Both the factor α_2^2 and $\hat{P}_2^N$ decrease (the latter due to lower call and termination profits) and H increases, thus π_2^N falls. ■

It is now possible to determine the equilibrium profit of the integrated firm, $\pi_1 + \pi_x$. Using (5) and (17), we obtain

$$\pi^I = \pi_1 + \pi_x = \alpha_1^2 \left[\frac{1}{\sigma} - H - P_1 + \hat{P}_1 \right] + N \left[A_x - f_x + v_2^x + \gamma \tilde{u}_2 + Z_2 \right].$$

Given that termination payments are internalized, the equilibrium profit is equal to the MTM profit (first component) plus the value (utility plus profit) generated from FTM calls to the non-integrated mobile operator 2.

From this expression for the integrated profits, we can easily conclude what level for FTM termination charges (as opposed to MTM ones) the integrated network will prefer. This question needs to be seen on the background that non-integrated fixed networks prefer very low termination rates because they constitute a cost, while mobile networks prefer very high FTM termination rates. How will this conflict of interest be resolved under integration?

Corollary 1 *The integrated networks prefer a zero FTM termination rate over a positive one.*

Proof. Since $d\left(v_2^x + \gamma \tilde{u}_2 + Z_2\right)/da = -q_2^x$ if z_2 is chosen optimally, the integrated network's profits are decreasing in a. ■

The intuition for this result is that the integrated equilibrium profits do not depend on profits related to traffic between the two integrated networks because termination payments cancel out. On the other hand, for the same reason, the effect of traffic to the other mobile network is reinforced, through the adjusted fixed fee (17). To be precise, what the integrated network actually prefers is a low FTM termination rate on its rival network, while it is indifferent about this rate on its mobile arm.

5 Potential Remedies

In this section we consider two potential remedies, in case the effects of integration outlined above are considered market failures: i) an obligation to set uniform FTM prices, i.e., the integrated fixed network must charge the same FTM price for calls to either mobile network; ii) functional separation, at the retail pricing level, between the integrated fixed and mobile businesses, i.e., FTM and MTF prices would have to be set as if networks were not integrated.

It is immediately clear that functional separation reproduces the retail pricing outcome without integration, that is, $z_1 = z_2 = c_{xo} + a$ as in (6) and $\tilde{p}_i = c_o + a_x$ as in (8). While this obligation establishes the call pricing structure without integration, it foregoes the benefits from the internalization of the termination rates that arises under integration.

Let us now consider uniform FTM pricing. We obtain the following result:

Proposition 3 *If a uniform FTM price is imposed, in equilibrium it will be set equal to the average network cost, internalizing the integrated mobile network's termination rate:*

$$z^U = c_{xo} + \alpha_1 c_t + \alpha_2 a. \tag{18}$$

Proof. Under the obligation to set $z_2 = z_1 \equiv z^U$, the fixed network maximizes the sum of the terms depending on z_1 and z_2 in (13) and (15), that is,

$$\begin{aligned} & \alpha_1 \left(v_1^x + (z_1 - c_{xo} - c_t)\, q_1^x + \gamma u_1^x\right) + \alpha_2 \left[v_2^x + (z_2 - c_{xo} - a)\, q_2^x\right] - \alpha_1 \gamma u_2^x \\ = \; & v^U + \left(z^U - c_{xo} - \alpha_1 c_t - \alpha_2 a\right) q^U, \end{aligned}$$

from which the above result follows directly. ■

Two observations are in order. First, just as with pricing of calls between mobile networks, under a uniform price the call externalities do not matter and therefore do not influence equilibrium pricing. Second, the resulting FTM price is below the non-integration one, due to a lower average network cost. As a result of this remedy, the FTM price towards the integrated mobile network increases by relatively little from z_1^I to z^U, while the FTM price to the other mobile network decrease more strongly from z_2^I to z^U. Thus, total welfare should be expected to increase when this remedy is imposed.

6 Conclusions

Integration between fixed and mobile operators is typical of many national communications markets. In this paper we analyze the impact of fixed-mobile integration on retail pricing incentives, which is a rather unexplored issue in the literature.

We show that FTM calls to rival mobile networks will be priced significantly above marginal cost, while those to the integrated mobile network will be priced below cost. Our results show that this pricing structure creates an additional disadvantage for non-integrated mobile networks, in terms of market shares and profits, and even magnifies existing asymmetries. On the policy side, we find that the potential remedy of imposing a uniform pricing constraint on FTM prices leads to a significantly more efficient pricing structure, which is also better than the alternative remedy of function separation.

Our framework is suitable to be extended in different directions. First, it is possible to extend the analysis considering fixed-to-mobile substitution. The latter can occur at the level of calls if consumers subscribe to both a fixed and a mobile network (Armstrong and Wright, 2009), or at the level of access, i.e. consumers decide about which and how many networks to subscribe to. Fixed-mobile integration may also imply that consumers are offered bundles involving both fixed and mobile services, which should be analyzed by introducing bundling strategies into a network competition framework. Both extensions are dealt with in our companion papers.

References

Armstrong, M., (2002). "The Theory of Access Pricing and Interconnection." In Cave, M., Majumdar, S. and Vogelsang, I. (eds.), *Handbook of Telecommunications Economics* (North-Holland, Amsterdam).

Armstrong, M., and J. Wright (2009). "Mobile Call Termination." *The Economic Journal,* 119, F270-F307.

Berger, U. (2004). "Access charges in the presence of call externalities." *Contributions to Economic Analysis & Policy*, 3 (1), Article 21.

Berger, U. (2005). "Bill-and-keep vs. cost-based access pricing." *Economics Letters*, 86, 107-112.

Cambini, C. (2001). "Competition between vertically integrated networks." *Information Economics and Policy*, 13, 137-165.

Cambini, C., and T. Valletti (2008). "Information Exchange and Competition in Communication Networks." *Journal of Industrial Economics,* 56(4), 707-728.

Carter, M., and J. Wright (1999). "Interconnection in Network Industries." *Review of Industrial Organization*, 14(1), 1-25.

de Fontenay, C., and J.S. Gans (2005). "Vertical Integration and Competition between Networks." *Review of Network Economics*, 4(1), 4-18.

Dippon, C.M. (2005). "Fixed-Mobile Convergence. Economic Motivations and Market Implications." NERA Economic Consulting, San Francisco (USA), June.

Genakos, C., and T. Valletti (2011). "Testing the 'Waterbed Effect' in Mobile Telephony." *Journal of European Economic Association*, 9(6), 1114-1142.

Harbord, D., and M. Pagnozzi (2010). "On-Net/Off-Net Price Discrimination and 'Bill&Keep' vs. 'Cost Based' Regulation of Mobile Termination Rates." *Review of Network Economics*, 9(1).

Hermalin, B., and Katz, M. (2011). "Customer or Complementor: Intercarrier Compensation with Two-sided Benefits." *Journal of Economics & Management Strategy,* 20(2), 379-408.

Hoernig, S. (2007). "On-Net and Off-Net Pricing on Asymmetric Telecommunications Networks." *Information Economics & Policy*, 19:171–188.

Jeon. D.-S., Laffont J.-J., and J. Tirole (2004). "On the Receiver-Pays Principle." *RAND Journal of Economics*, 35(1), 85-110.

Laffont, J.-J., Rey, P., and J. Tirole (1998). "Network Competition: I. Overview and Nondiscriminatory Pricing; II. Discriminatory Pricing." *RAND Journal of Economics*, 29(1), 1-56.

Mu, H. (2008). "Fixed-Mobile Interconnection under Competition." Unpublished manuscript.

Vogelsang, I. (2003). "Price Regulation of Access to Telecommunications Networks." *Journal of Economic Literature* 41(3), 830-62.

Vogelsang, I. (2010). "The relationship between mobile and fixed line communications: a survey." *Information Economics and Policy*, 22 (1), 4-17.

Valletti, T., and G. Houpis (2005). "Mobile Termination: What is the 'Right' Charge?" *Journal of Regulatory Economics*, 28(3), 235-258.

Wright, J. (2002). "Access pricing under competition: an application to cellular networks." *Journal of Industrial Economics*, 50, 289-315.

Appendix: Integrated Incumbents in the EU15

In the following table we report the historical fixed-line incumbent operators in each country of the EU15, as well as their mobile subsidiary and its respective market share. In the last column we also report the number of mobile network operators (MNOs) which are active in each country. The data are drawn from the Telecom Market Matrix, Merrill Lynch/Bank of America (April 2012).

State	Fixed Incumbent	Controlled Mobile Operator	Market Shares (Subscribers, 2012)	Number of MNOs (2012)
Austria	Telekom Austria	A1 - Mobilkom	40.7% (L)	4
Belgium	Belgacom	Proximus	41.1% (L)	3
Denmark	Tele Danmark	TDC Mobil	46.5% (L)	4
Finland	Sonera	Sonera	34% (S)	3
France	Orange	Orange	41.4% (L)	3
Germany	Deutsche Telekom	T-Mobile	30.5% (S)	4
Greece	OTE	Cosmote	48.5% (L)	3
Ireland	EIRCOM	Meteor	20% (S)*	4
Italy	Telecom Italia	TIM	35.4% (L)	4
Luxemburg	P&T Luxemburg	LuxGSM	60% (L)*	4
Netherlands	KPN	KPN Mobile	41.3% (L)	3
Portugal	Portugal Telecom	TMN	42.8% (L)	3
Spain	Telefonica de Espana	Movistar	40.5% (L)	4
Sweden	Telia	Telia	46.6% (L)	4
UK	British Telecom	O2 (up to 2005)	26.5% (2005,L)**[10]	4

* Source: Company web site

** Source: Ofcom (2005), "The Communications Market - Telecommunications"

L = Market Leader

S = Second-biggest operator

[10] In 2012, O2 had a market share of 28.8% and became the second-largest operator only after the 2010 merger of Orange and T-Mobile.