Mobile Number Portability*

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Abstract

This paper examines the competitive effects of introducing mobile number portability (MNP). As MNP allows consumers to keep their telephone number when switching providers, it reduces consumers' switching costs. However, MNP also causes consumer ignorance, since telephone numbers no longer identify networks, and consumers may thus be unaware of exact charges for calls to numbers on mobile networks. As a result, MNP is likely to both foster competition for mobile customers and increase the termination charges for calls to mobile networks. The total welfare effect of introducing MNP is found to be ambiguous.

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1 Introduction

In many countries, telecommunications regulators are about to require cellular telecommunications operators to offer so-called *mobile number portability* (MNP).[1] MNP implies that customers can keep their telephone number—including the prefix—when switching from one provider of mobile telecommunications services to another. In the absence of MNP, customers have to give up their number and must adopt a new one when they switch operators. In the latter case, customers have to bear the switching costs associated with informing people about changing their number, printing new business cards, missing valuable calls from people that do not have the new number, etc. Based on these considerations, regulatory authorities typically impose mandatory MNP so as to reduce customers' switching costs, attempting to make mobile telecommunications more competitive (see, e.g., Reinke, 1998).

The intuitive notion that number portability enhances competition due to reduced switching costs has formally been analyzed by Aoki and Small (1999), who examine whether there is a positive welfare effect if implementing MNP is costly. They find that, if the investment costs of implementing a MNP system are weighed against the benefits of more intense competition between mobile operators, the overall welfare effect is ambiguous. In related papers, Gans, King and Woodbridge (2001) and Haucap (2003) have focused on the question of how to allocate the property rights in telephone numbers and the costs of implementing number portability.

An important aspect that has largely been ignored in this debate is the fact that MNP makes it more difficult for consumers to distinguish between different networks when placing a call. In the absence of MNP, consumers can usually distinguish between different mobile networks through the number prefix.[2] When MNP is introduced, however, the number prefix does not automatically indicate the network assignment of a given number. As a result, if calling prices differ between different networks, consumers may be unaware of exact charges for placing calls to mobile networks. The effects of consumer ignorance with respect to relevant prices have recently been explored by Gans and King (2000) and Wright (2002). They show that mobile operators may have incentives to increase their termination charges if consumers only take notice of average retail prices. Furthermore, they suggest that MNP may deteriorate the customers' price information. However, they do not formally work out the argument or analyze the trade offs associated with the introduction of MNP.

[1] For instance, most countries in the European Union require operators to introduce MNP in the foreseeable future (see European Commission, 2002, p. 35).

[2] For example, in New Zealand all *Vodafone* numbers start with the prefix 021 while *Telecom New Zealand* uses the 025 numbering range.

The present paper aims to fill this gap by analyzing the following basic trade off associated with the introduction of MNP: On the one hand, MNP reduces switching costs, thereby making mobile markets more competitive. On the other hand, MNP deteriorates the customers' information about the relevant prices. The welfare effects of introducing mandatory MNP should therefore be expected to be ambiguous in general. We find that the introduction of mandatory MNP is less likely to generate welfare gains (i) the closer substitutes mobile networks are, and (ii) the larger the market for fixed line telephony.

The intuition of these results is straightforward: If mobile networks are close substitutes and competition is thus intense, introducing MNP does not strongly affect the consumers' subscription decisions. That is, the benefits of introducing MNP are small. However, the costs of introducing MNP persist, since consumers base their calling decisions on average prices. This induces mobile operators to increase their termination charges, thereby adversely affecting the fixed line telephony customers. The latter effect is more pronounced if the market for fixed line telephony is large.

The remainder of the paper is organized as follows. In Section 2 we introduce the model and present the key results of our analysis. Section 3 discusses policy implications and concludes.

2 The Model

There are two mobile networks $i = A, B$ and a fixed line telephony market of size k. We assume that fixed and mobile telephony constitute two different markets, so that there is no intermodal competition between fixed and mobile operators. The mobile networks are assumed to be differentiated along a Hotelling line of length 1 with network A being located at 0 and network B at 1. Suppose that A is the incumbent mobile operator while firm B is a new entrant. Consumers face a switching cost S when changing from A to B, where $S > 0$ in the absence of MNP and $S = 0$ with MNP. Hence, S reflects the consumers' valuation for keeping their telephone number. In addition, suppose that consumers are uniformly distributed between 0 and 1. Finally, assume that for given income y, a consumer located at x receives utility U_A and U_B when joining network A or B, respectively, with

$$\begin{aligned} U_A &= y + v_0 - \tau x + u(q), \\ U_B &= y + v_0 - S - \tau(1 - x) + u(q). \end{aligned}$$

Here, v_0 denotes a consumer's intrinsic value of being connected to a mobile telephone network, and τ reflects the degree of network differentiation. The term $u(q)$ measures

consumers' utility from making calls so that for a given call price p consumers' indirect utility is given by $v(p) \equiv \max_q(u(q) - pq)$, i.e. we assume that consumers are indifferent to incoming calls.[3]

We consider the case where mobile operators $i = A, B$ compete in non-linear prices, i.e. they choose two-part tariffs consisting of a fixed subscription fee F_i and variable service charges p_{ij} for mobile services (such as calls, SMS, etc.) indexed by $j = 1, ..., n$. Hence, mobile operator i offers a tariff function

$$W_i(q_{i1}, ..., q_{in}) = F_i + \sum_{j=1}^{n} p_{ij}q_{ij}, \quad i = A, B.$$

It is well known that firms set service charges at marginal cost when they can set multi-part tariffs, i.e. $p_{ij} = c_{ij}$.[4] For simplicity, we follow Wright (2002) and Gans and King (2000) in focusing our analysis on fixed-to-mobile calls, ignoring the more complex issue of mobile-to-mobile interconnection.[5] We also assume that firms' marginal costs are constant and symmetric. Given these assumptions, the market share of mobile operator A is given by

$$s_A = \frac{1}{2} + \sigma S + \sigma(F_B - F_A),$$

where $\sigma \equiv 1/(2\tau)$ is a measure of the substitutability of mobile networks, and $s_B = 1 - s_A$. As is well known from the literature, an interior equilibrium exists only if σ is not too high.[6]

Regarding the fixed network, let us assume that consumers' indirect utility from calling people on their mobile network is given by the quadratic function $\varphi(p) = (a - bp_F)^2/2$ where p_F is the price for a fixed-to-mobile call. Hence, we obtain a linear demand function $q(p_F) = a - bp_F$ for fixed-to-mobile calls.

Finally, we assume that mobile networks set their termination charges t_i for fixed-to-mobile calls simultaneously. If the fixed network is able to set multi-part tariffs, the prices for fixed-to-mobile calls will be given by $p_{Fi} = t_i$ for $i = A, B$. The marginal cost for terminating fixed-to-mobile calls is denoted by c_T and assumed to be symmetric for the two mobile networks.

[3] Apart from the incorporation of switching costs, this is the basic set-up of virtually all network competition models as introduced by Laffont, Rey and Tirole (1998) and Armstrong (1998). It is also used in the literature referenced above, i.e. Aoki and Small (1999), Gans and King (2000) and Wright (2002).

[4] Intuitively, by setting service charges equal to marginal cost firms maximize the consumers' surplus that they can extract using the fixed fee (see, e.g., Laffont, Rey and Tirole, 1998).

[5] The analysis of mobile-to-mobile calls is more complex since changes in the relevant termination charges also affect the market shares of mobile networks.

[6] More specifically, we constrain our analysis to cases where $\sigma \leq 3/(2S)$. Otherwise A would capture the entire market so that B would not have entered the mobile market in the first place.

2.1 Competition without MNP

In the absence of MNP, the incumbent mobile network A has a competitive advantage, as consumers face switching costs $S > 0$ when switching to operator B. Furthermore, the customers of the fixed network can perfectly distinguish the mobile networks $i = A, B$ through their numbering prefixes. Hence, assuming a balanced calling pattern, network i's profit is given by

$$\pi_i = s_i F_i + k s_i (t_i - c_T)(a - b t_i), \quad i = A, B.$$

The first term reflects the profit generated by the subscription fee charged to i's customer base. The second term represents the profit from fixed-to-mobile calls terminated on network i.[7] Maximizing over F_i and t_i yields

$$t_A = t_B = \frac{1}{2}\left(\frac{a}{b} + c_T\right), \tag{1}$$

$$F_A = \frac{1}{2\sigma} - \frac{k}{4b}(a - b c_T)^2 + \frac{1}{3}S, \tag{2}$$

$$F_B = F_A - \frac{2}{3}S. \tag{3}$$

Since both mobile operators have monopoly power over the calls that are being made to their customers, it is not surprising that both termination charges are set at the monopoly level (see (1)). However, as (2) and (3) indicate, the associated monopoly profit of $(k/4b)\,(a - b c_T)^2$ is entirely used to "subsidize" consumers' subscription fees. Nevertheless, the incumbent operator A is able to charge a higher fixed fee than operator B, since A can exploit its customer base facing switching costs. Put differently, operator B has to offer a lower fixed fee to attract consumers. For later reference, note that equilibrium market shares are given by $s_A = (1/2) + (1/3)\sigma S$ and $s_B = (1/2) - (1/3)\sigma S$, and firms' profits are $\pi_i = s_i^2/\sigma$ for $i = A, B$.

2.2 Competition with MNP

As explained above, we model MNP as having two effects: First, MNP removes the asymmetry between incumbent A and entrant B, so that $S = 0$. Second, with MNP in place, fixed network customers cannot determine ex ante which mobile network they are calling when placing a call to a particular number.[8] To incorporate the latter effect, we follow Gans and King (2000) and assume that consumers base their calling decisions

[7] Recall that all other service charges are set so as to equal marginal cost, i.e. the corresponding terms are equal to zero.

[8] Equivalently, customers do not know ex ante the price of the service they wish to purchase.

on the average price for a fixed-to-mobile call, i.e. $\overline{p}_F = s_A t_A + s_B t_B$. Hence, operator i maximizes

$$\pi_i = s_i F_i + k s_i (t_i - c_T)(a - b(s_i t_i + (1 - s_i) t_j)), \quad \text{for } i, j = A, B \text{ and } j \neq i.$$

Maximizing over F_i and t_i now yields

$$t_A^{MNP} = t_B^{MNP} = \frac{1}{3}(2\frac{a}{b} + c_T), \tag{4}$$

$$F_A^{MNP} = F_B^{MNP} = \frac{1}{2\sigma} - \frac{2}{9}\frac{k}{b}(a - bc_T)^2. \tag{5}$$

Thus, the introduction of MNP removes the networks' asymmetry so that mobile operators charge both the same termination and subscription fees and, accordingly, have the same market shares $s_A^{MNP} = s_B^{MNP} = 1/2$.

It is important to note that both network operators increase their termination charges for fixed-to-mobile calls ($t_i^{MNP} > t_i$, for $i = A, B$). This follows from the fact that operator i does not bear the full consequences of increasing its termination charge t_i, since consumers base their calling decisions on the average price $\overline{p}_F$ rather than individual prices t_i. That is, operators exert a *negative externality* on each other when increasing their termination charges. Since this externality leads to termination charges above the monopoly level, the operators' profits from fixed-to-mobile termination decrease, and hence the "cross-subsidies" towards the fixed fee must also decrease.

Condition (5) further indicates that F_B unambiguously increases with the introduction of MNP. With the asymmetry between networks removed, B no longer has an incentive to offer a discount (relative to A) so as to induce switching. In addition, the funds available for "cross-subsidization" are reduced, which reinforces the increase of F_B. The effect on the incumbent's subscription fee F_A is less clear-cut. Both the "cross-subsidization" and the incumbency advantage are reduced, with ambiguous net effect on F_A.[9] Finally, note that firms' profits are still given by $\pi_i = s_i^2/\sigma$.

2.3 Distributional and Welfare Effects of MNP

In order to analyze the overall effects of MNP, we consider each of the groups affected: The mobile operators, A and B, their respective customers, and the customers of the fixed network placing fixed-to-mobile calls. First, consider the effects of MNP on the profits of *mobile operators*. As indicated above, profit functions are given by $\pi_i = s_i^2/\sigma$ for $i = A, B$ both with and without MNP, i.e. mobile operators' profits are convex in own

[9] More specifically, the introduction of MNP will strictly reduce A's fixed fee ($F_A^{MNP} < F_A$) if the switching cost without MNP is sufficiently high, i.e. $S > \frac{1}{12}\frac{k}{b}(a - bc_T)^2$.

market shares. Since MNP aligns the mobile operators' market shares, it follows immediately that aggregate mobile profits must decrease. That is, the extra profits awarded to B are smaller than the profit reduction of A. In general, we should thus expect the incumbent A [the competitor B, respectively] to oppose [support] the introduction of MNP.

Next, consider the effect of MNP on *mobile customers*. One might expect that mobile customers always benefit from MNP. After all, mobile customers on network B directly gain from the removal of switching costs, as their utility is no longer reduced by S. In addition, MNP implies that consumers' subscription decisions are no longer distorted by switching costs,[10] i.e. consumers' average "transport" costs decrease. However, the fixed fee for customers of network B will generally increase, while F_A may fall or raise, depending on parameter values.[11] Hence, the overall effect of MNP on the consumers' surplus is ambiguous in general. More formally, in the absence of MNP, the mobile customers' surplus is given by

$$\begin{aligned} CSM &= y + v_0 + u(q) - s_A F_A - (1 - s_A)(F_B + S) - \tau \left(\int_0^{s_A} x dx + \int_{s_A}^1 (1 - x)\, dx \right) \\ &= y + v_0 + u(q) - s_A F_A - (1 - s_A)(F_B + S) - \frac{\tau}{2} \left(s_A^2 + (1 - s_A)^2 \right). \end{aligned}$$

With MNP (where $F_A = F_B$ and $S = 0$) mobile consumers obtain the surplus

$$CSM^{MNP} = y + v_0 + u(q) - F_A - \frac{\tau}{4}.$$

In equilibrium, mobile customers are thus strictly better off with MNP if

$$\Delta CSM \equiv CSM^{MNP} - CSM = \frac{1}{2} S - \frac{1}{18} \sigma S^2 - \frac{1}{36} \frac{k}{b} (a - bc_T)^2 > 0.$$

That is, the customers of mobile networks are less likely to benefit from MNP when mobile networks are close substitutes (σ is high) and the market for fixed line telephony is large (k is high), so that mobile operators dispose of sizeable funds from the fixed-to-mobile monopolies to "cross-subsidize" subscription fees.

The *customers of the fixed network*, in turn, are always adversely affected by the introduction of MNP. To see this, recall that mobile operators raise their fixed-to-mobile termination charges above the monopoly level ($t_i^{MNP} > t_i$ for $i = A, B$) when MNP is introduced. Since the fixed network sets non-linear prices, the variable prices for fixed-to-mobile calls are set equal to marginal costs (i.e. the termination charges). The customers' indirect utility therefore decreases by $k (a - bc_T)^2 / 8 - k (a - bc_T)^2 / 18 > 0$.

[10] Customers with a preference for network B will no longer choose A simply because of the existence of switching costs.

[11] The average subscription fee will strictly fall with the introduction of MNP iff $k < 8b\sigma S^2 / (a - bc_T)^2$.

Finally, let us examine the total *welfare effect* of MNP. Suppose that there is an exogenous investment cost I associated with the introduction and implementation of MNP. Let W^{MNP} and W denote total welfare with and without MNP, respectively. Then, introducing MNP increases welfare if $\Delta W \equiv W^{MNP} - W \geq 0$. Alternatively, let I^* denote the critical level of investment costs below which the introduction of MNP is desirable from a welfare point of view, i.e. $\Delta W \geq 0$ for $I \leq I^*$. In equilibrium, I^* is given by

$$I^* = \frac{1}{2}S - \frac{2}{9}\sigma^2 S^2 - \frac{1}{18}\sigma S^2 - \frac{k}{72}(5 + \frac{2}{b})\left(a - bc_T\right)^2 .$$

Straightforward calculations show that $\partial I^*/\partial\sigma < 0$ and $\partial I^*/\partial k < 0$. That is, the introduction of MNP is less likely to bring about welfare gains if the mobile networks are close substitutes and the market for fixed line telephony is large.

Intuitively, if mobile networks are close substitutes (σ is high) and competition is thus intense, introducing MNP does not strongly affect the consumers' subscription decisions. That is, the benefits of introducing MNP are relatively small. The costs of introducing MNP, however, persist even if mobile networks are close substitutes, since consumers still base their calling decisions on average prices; mobile operators therefore have an incentive to increase their termination charges. Because mobile operators also directly determine the prices that the fixed network customers pay for fixed-to-mobile calls, the main effect of MNP is to increase the prices of the fixed network. Clearly, this adverse effect is more pronounced if the market for fixed line telephony is large (k is high).

3 Conclusion

We have argued that the introduction of MNP generates various competitive effects that are of potential interest to regulatory authorities. In particular, we have analyzed the basic trade off associated with the introduction of MNP: (i) the reduction of switching costs, and (ii) the introduction of consumer ignorance, since the prefix of a mobile telephone number no longer indicates its network assignment. Furthermore, one has to be aware of the set-up costs associated with introducing MNP. As a result, the total welfare effect of introducing MNP is generally ambiguous.

The introduction of MNP has interesting distributional effects: the new mobile operator benefits and the incumbent loses. Also, the customers of the fixed network are unambiguously adversely affected due to higher termination charges for fixed-to-mobile calls. Finally, the effects on the customers of mobile networks are ambiguous.

We believe that these findings might be helpful for regulatory authorities debating the introduction of mandatory MNP. One should keep in mind, however, that in the present paper, we have adopted the simplest version of the standard network competition model

to explore the competitive effects of introducing MNP. In particular, we have abstracted from the challenging issue of mobile-to-mobile calls and ignored the possibility of further entry into mobile telecommunications. Future research into these directions might prove to be instructive for antitrust theorists and practitioners alike.

References

Aoki, R. and J. Small (1999), The economics of number portability: Switching costs and two-part tariffs, working paper, University of Auckland, November 1999.

Armstrong, M. (1998), Network interconnection in telecommunications, *Economic Journal* 108, 545-564.

European Commission (2002), *Eighth Report from the Commission on the Implementation of the Telecommunications Regulatory Package*, COM(2002) 695, Brussels: December 2002.

Gans, J.S. and S.P. King (2000), Mobile network competition, customer ignorance and fixed-to-mobile call prices, *Information Economics and Policy* 12, 301-327.

Gans, J.S., King, S.P. and G. Woodbridge (2001), Numbers to the people: Regulation, ownership, and local number portability, *Information Economics and Policy* 13, 167-180.

Haucap, J. (2003), Telephone number allocation: A property rights approach, *European Journal of Law and Economics* 15, 91-109.

Laffont, J.J., Rey, P. and J. Tirole (1998), Network competition I: Overview and nondiscriminatory pricing, *RAND Journal of Econmics* 29, 1-37.

Laffont, J.J. and J. Tirole (2000), *Competition in Telecommunications*, MIT Press: Cambridge, MA.

Reinke, T.H. (1998), Local number portability and local loop competition, *Telecommunications Policy* 22 (1), 73-87.

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