INCENTIVES TO LICENCE VIRTUAL MOBILE NETWORK OPERATORS (MVNOs) *

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1 Introduction

A vivid debate about the intensity of competition in mobile telecommunications markets has recently emerged in many jurisdictions. Given that radio spectrum is a scarce ressource which limits the number of mobile network operators (MNOs) that can use their own radio spectrum to provide services, one idea has been to require MNOs to sell or lease spare spectrum capacities to so-called mobile virtual network operators (MVNOs), i.e. operators that provide mobile communications services without their own radio spectrum. One aspect of this policy debate is on the appropriate regulatory framework: Should MNOs be required by regulation to open up their networks for MVNOs and if so, under which terms and conditions? Or, are the MNOs' incentives to rent out their spare capacities sufficient to facilitate entry by MVNOs? In January 2006, for example, the European Commission has answered the latter question with a "no" and endorsed a measure proposed by the Spanish national regulator, CMT, to regulate access to the networks of the three Spanish MNOs (Telefónica, Vodafone, and Armena) by MVNOs (see European Commission, 2006). Both the European Commission and the Spanish regulator CMT consider the current state of competition in the Spanish mobile telecommunications market to be unsatisfactory, and both authorities expect MVNOs to intensify competition in that market.

A related question has recently emerged in Austria when one of the then four incumbent MNOs (called *one*) opened up its network for the first Austrian MVNO, *Tele2*. The three other incumbent MNOs complained to the regulatory authority that the introduction of further competitors would be a violation of license conditions and had to be regarded as a hold-up on their specific investment into network infrastructure. Hence, *one* (as well as all other MNOs) should be prevented from entering into access agreements with potential MVNOs to safeguard the MNOs' specific investments. Put differently, when enabling MVNOs to enter into a mobile communications market there is a trade-off between facilitating competition in services on the one hand and providing incentives to invest into network infrastructure on the other hand. In fact, this trade-off has been explored with respect to MVNOs in the academic literature by Foros, Hansen and Sand (2002) who analyze the interdependence between voluntary and mandatory roaming agreements on the one hand and cooperative and non-cooperative investment in network coverage on the other hand. They find that investment levels decrease when the quality of access provided to the virtual operator by the investing firms (i.e., the facilities-based competitors) increases. Nevertheless, they show that welfare increases if an MVNO is allowed to enter, but investment decisions should be allowed to be taken cooperatively between firms.

Complementary to the work on investment incentives by Foros, Hansen and Sand

(2002) is the paper by Kim and Park (2004) who analyze the optimal (linear) access charge between MNOs and MVNOs when the products offered are either complements or substitutes. As they show, the linear access charge should exceed marginal cost if MVNOs offer substitutes while the access charge should be below marginal cost if the MVNO offers complements.

While both Foros, Hansen and Sand (2002) and Kim and Park (2004) focus on different aspects of market entry by MVNOs, they also both take the MVNOs' entry as exogenous. Most of the policy debate, however, circles around the question of whether incumbent MNOs should be required at all to mandatorily open their networks for MVNOs. Hence, the focus of our chapter will be on the question whether or not MNOs may voluntarily grant network access to MVNOs. To our knowledge, this question has not been thoroughly analyzed in the academic literature, even though there have been some economic policy papers (see, e.g., Kiesewetter, 2002; Ergas, Waters and Dodd, 2005) and some case studies (see, e.g., Dorabialski and Morawski, 2004) on this matter. In order to fill this gap, this chapter will provide a microeconomic analysis of incumbent MNOs' incentives to provide network access to MVNOs under various modes of market competition.

As we will show in this chapter, the MNOs' incentives to voluntarily provide network access and invite MVNOs onto their network critically depend on two issues: Firstly, the mode of competition and, secondly, the degree of product differentiation. Generally, MNOs will voluntarily provide network access if the services offered by the candidate MVNOs are sufficiently differentiated, as with a high degree of product differentiation the revenue effects outweigh the competition (or cannibalization) effects. Furthermore, we can show that MNOs will always invite MVNOs onto their network under Cournot competition if the market is sufficiently large, even if MVNOs offer homogeneous products. In contrast, the incentives to voluntarily grant MVNOs access are lower under Bertrand competition and decline even further under Stackelberg competition. Under Bertrand and Stackelberg competition voluntary MVNO access is only granted if the services offered by MVNOs are sufficiently differentiated.

The remainder of this chapter is organized as follows: In section 2 we will provide an overview over various MVNO definitions and business models before section 3 discusses the rationales underlying the regulation of MVNO access. In addition, section 3 provides an overview over the emergence of MVNOs in various countries. Our model is presented and analyzed in section 4, before section 5 summarizes our findings and draws conclusions.

2 What are MVNOs?

While the literature on the economic effects of MVNOs is relatively thin, there is a wide range of definitions offered in the literature. In fact, the questions of what constitutes an MVNO and how to define MVNOs appear to be a major issue of debate, at least in the business literature (see, e.g., Maitland, Bauer and Westerveld, 2002; Anderson and Williams, 2004). The discussions about the appropriate definition of an MVNO are also a result of the lack of any such definition in most jurisdictions' legislation (see, e.g., Kiesewetter, 2002, p. 1; detecon, 2005, p. 13). Among the various MVNO definitions offered in the literature, the International Telecommunications Union (ITU) has defined an MVNO as an operator who provides mobile communications services to users without its own airtime and government-issued licenses (ITU, 2001). In the UK, Oftel (now: Ofcom) has defined it as "an organization providing customers with mobile phone services without owning any airtime" (see Oftel, 1999) and Hong Kong's OFTA has defined a Mobile Virtual Network Operator (MVNO) as an entity that "provides mobile telecommunications services to customers through interconnection with and access to the radiocommunications infrastructure of a Mobile Network Operator (MNO)" (see OFTA, 2002). According to the Finnish Ministry of Transport and Communications (2005, p. 11) the difference between mobile network operators (MNOs) and mobile virtual network operators (MVNOs) is that the latter lease the right of use of radio spectrum from the licensed mobile network operators. However, MVNOs have their own SIM-card that is independent from the MNO's SIM-card, they can have their own numbering resources and also some infrastructure, their own brand and pricing schemes, and their own mobile services. MVNOs can also establish their own interconnection agreements with other network operators. Similarly, detecon (2005, p. 3) notes that "a straightforward formulation defines an MVNO as a company that does not own a mobile spectrum license but sells mobile services under its own brand name, network code and SIM cards using a licensed mobile operator's radio network" (detecon, 2005, p. 3).

The call routing of an MVNO that uses a maximum of own mobile communications infrastructure is depicted in Figure 1:

Figure 1 goes here

However, as is also pointed out in the literature, this broad definition of an MVNO is not always applicable to all MVNO business models deployed in diverse countries with different regulatory systems. While some MVNOs operate their own core network infrastructure including switching, home location register, billing, customer care, value added services platforms and intelligent network systems, other MVNOs simply repackage network operators' services and issue their own SIM cards by relying almost

completely on the host network's facilities with a little product differentiation. These operators are sometimes also referred to as (enhanced) service providers. Accordingly, Ergas, Waters and Dodd (2005) differentiate between three types of MVNO models:

- Full MVNOs, which provide their own network core including a mobile switching center (MSC);
- Intermediate MVNOs, which acquire a switched service, but either provide their own home location register (HLR) or share a jointly owned HLR with an MNO; and
- Thin MVNOs, which only provide additional applications and content and which are little different from pure resellers or service providers. These thin MVNOs are often also labelled enhanced service providers (see, e.g., Kiesewetter, 2002).

The borders between these three different types of MVNO are illustrated in Figure 2:

Figure 2 goes here

While it is important to keep the different meanings of the expression "MVNO" in mind when discussing both business opportunities on the one hand and regulatory approaches and economic efficiency implications on the other hand, we will simplify matters for the purpose of your analysis in this chapter. In the following, we will not distinguish between thin, intermediate and thick MVNOs, service providers and resellers. Instead, we rather treat all these models as being dependent on access to an MNO's network infrastructure, as the focus of our analysis is on the question of whether MNOs will voluntarily open their network for MVNOs. Our analysis is quite general and also applies to service providers and other business models that have to rely at least to some degree on an MNO's network infrastructure. For simplicity, we will refer to all of these business models as MVNOs. In fact, this treatment is in line with much of the literature and reflects the fact that, from the user point of view, all other than licensed mobile operators are virtual operators because they do not have their own network (also see Ministry of Transport and Communications Finland, 2005, p.10).

3 Regulatory Approaches and Emergence of MVNOs

Regulatory approaches towards MVNOs differ quite substantially between jurisdictions. This concerns both the requirements that MVNOs themselves face as well as the access

obligations put onto MNOs (see Ergas, Waters and Dodd, 2005; Kiesewetter, 2002). While, for example, Ireland, Denmark and Hong Kong have made specific regulatory provisions for MVNOs, several Nordic countries require MNOs to provide network access in quite general terms. Other countries such as the USA, the UK, Australia and New Zealand have no access obligations. In Germany, MNOs are required by regulation to enter into wholesale agreements with so-called service providers (who basically act as resellers).

Differences in regulation also exist with respect to the MVNOs' treatment. For example, some jurisdictions that mandate MVNO access require MVNOs to undertake some minimum investment into their own mobile infrastructure while others have very little infrastructure requirements.[1]

The underlying rationale of mandating MVNO access is twofold (see Ergas, Waters and Dodd, 2005): Firstly, MVNOs may increase retail competition as a consequence of which prices may decrease and mobile penetration and the quantity of services supplied increase. For example, the European Commission (2006) argues that "MVNOs can boost competition with tangible benefits for consumers in terms of lower prices." Furthermore, there is usually a presumption among the advocates of regulated MVNO access that MVNOs may offer innovative service bundles and also facilitate downstream innovations by incumbent MNOs in response to an MVNO's market entry. And secondly, the so-called ladder of investment theory states that new entrants slowly climb up a ladder of investment if they can enter a market without burdensome investment requirements. Put differently, the idea is that an entrant first enters an industry without much specific investment, offering services only. Once the entrant has acquired a certain threshold number of customers he may invest into its own infrastructure in order to be less dependent on the incumbent and to offer a wider range of services (see, e.g, Cave and Vogelsang, 2003). Following this line of reasoning, regulated MVNO access may spur investment by new entrants. On the other hand, incumbents' investment incentives are likely to decrease if they have to share their facilities with competitors. Since forced access reduces the rents that an incumbent can appropriate from its investment, the incentives to invest will decrease so that mandated MVNO access may reduce investment by incumbent operators. Hence, the overall effect of regulating MVNO access on investment is not clear.

When MVNO access is provided for by regulation it is not surprising that MVNOs have emerged as competitors in markets for mobile communications services. However, even in the absence of mandatory access provisions MVNOs have successfully entered

[1] For example, OFTA and the ODTR require that MVNOs establish their own home location register (HLR) and their own mobile switching center (MSC), see Ergas, Waters and Dodd (2005, fn. 15).

the industry in many jurisdictions. By now, MVNOs or similar business models exist in almost all jurisdictions with liberalized mobile telecommunications markets. The following tables provide an overview of market entry by MVNOs in various countries:

Table 1 and Table 2 go here

Given that MVNOs have emerged in many jurisdictions even though regulatory approaches differ widely, let us now analyze the conditions for market entry by MVNOs (or similar business models) in more detail. For that purpose the following section will develop and analyze a microeconomic model of MVNO entry.

4 The Model

4.1 Cournot Competition

Let us start by considering a homogeneous duopoly situation where we initially have two symmetric MNOs (labelled firm 1 and firm 2), which compete in quantities. We assume that the inverse demand for mobile telecommunications services is linear and given by $p = A - bQ$ where p is the price and Q the total quantity provided by all firms in the market. Both MNOs can enter into access agreements with MVNOs, i.e. they can license MVNOs to provide mobile telecommunications services using the respective MNO's network. The MVNOs are free in their pricing decisions and also compete with their host networks in Cournot fashion. Let us also assume that the two MNOs can extract the entire surplus from their MVNOs by setting two-part tariffs. This means that we assume that there are many potential MVNOs competing for access to the MNOs' networks so that the MNOs have the entire bargaining power and submit take-it-or-leave-it offers to potential MVNOs. Finally, let n denote the number of symmetric MVNOs roaming on network 1 and m denote the according number of MVNOs roaming on network 2. Hence, the total quantity is given by $Q = q_1 + q_2 + \sum_{i=1}^{n} q_i + \sum_{j=1}^{m} q_j$.

Also assume that there is a fixed cost f of establishing an MVNO agreement and providing network access to the MVNO. However, let us assume for reasons of simplicity that the marginal cost of providing mobile telecommunications services are zero. Given the linear inverse demand function and assuming that the two MNOs can extract the entire surplus from their MVNOs firm 1's equilibrium profit under Cournot competition is given by its own profit plus the profits extracted from its n MVNOs, the total of which is given by

$$\pi_1 = \frac{(1+n)A^2}{b(n+m+3)^2} - nf. \tag{1}$$

Accordingly we can write down firm 2's profit by substituting n by m.

Maximizing π_1 with respect to the number of MVNOs, n, and solving for the symmetric equilibrium values with $m = n$, we find that the profit maximizing number of MVNOs is given by

$$m = n = \frac{1}{2}(A^{\frac{2}{3}}(bf)^{-\frac{1}{3}} - 3). \tag{2}$$

Now it is straightforward to calculate that for all $A > A^*$ with $A^* \equiv 3\sqrt{3bf}$ there will be a positive number of MVNOs. That means, the profit maximizing number of MVNOs, $n^* = m^*$, is strictly larger than zero if the market is not "too small". If the mobile communications market is sufficiently large (as measured by A) the two MNOs will voluntarily provide MVNOs with access to their network. Similarly, we can calculate a critical $f^* \equiv A^2/(27b)$. For all $f < f^*$ the two MNOs will voluntarily provide access to their network. That is, the fixed cost of establishing MVNO arrangements must not be too high for MVNOs to emerge without regulatory intervention. If the fixed cost is sufficiently low MNOs will voluntarily enter into roaming agreements with MVNOs, even without any regulatory intervention. It is also straightforward to observe that the two MNOs will enter into the more MVNO roaming agreements the larger the mobile telecommunications market's size (as measured by A) and the lower the fixed cost of establishing MVNO arrangements, f.

The situation described resembles a Prisoners' Dilemma. Both MNOs would be better off if they jointly denied MVNOs access to their networks. In this case, the two MNO's profit would be given by expression (1), which is strictly smaller than the firm's duopoly profit in the absence of any MVNOs, $\pi^D(m = n = 0) = A^2/(9b)$, for all m, $n > 0$. However, for each operator it is a dominant strategy to open up its network for MVNOs if $A > A^*$ and $f < f^*$. If MNOs cannot collude about access provisions (which has been the suspicion in Spain, see European Commission, 2006), both will license MVNOs, thereby increasing competition, lowering prices and both the firms' individual as well as joint industry profits. In fact, this result resembles the finding of the literature on divisionalization under Cournot competition as developed by Corchón (1991), Polaski (1992) and Baye, Crocker and Ju (1996).

As we know from this literature and the literature on horizontal mergers under Cournot competition (see Salant, Switzer and Reynolds, 1983), the incentives to divest or to divisionalize are even stronger the less concentrated the industry is. Hence, MNOs' incentives to offer MVNOs access to their networks are even stronger if there are more than two incumbent MNOs. Similarly, the incentives to offer MVNOs access increase if products are not homogenous but differentiated. With product differentiation competition between MVNOs and MNOs is softer so that MNOs are even more inclined to provide access to their networks, as the cannibalization effect is smaller. The MNOs'

incentives to offer MVNO agreements decrease, however, if the MNOs cannot extract their MVNOs' full profit. If, for example, MNOs can only extract some fraction $\alpha \in [0, 1]$ of an MVNO's profit the MNO's incentive to grant network access are reduced. Put differently, for $\alpha < 1$ the critical level of market demand (A) which makes an MVNO agreement profitable for an MNO is strictly larger than A^* while the critical fixed cost level (f) associated with establishing an MVNO agreement is strictly smaller than f^*. Nevertheless, it is straightforward to show that there are critical levels $A^{**}(\alpha)$ and/or $f^{**}(\alpha)$, which make MVNO agreements profitable for the MNOs where A^{**} is decreasing in α and f^{**} is increasing in α. The higher the percentage of an MVNO's profit that the MNO can extract, the lower is the critical size of market demand, A, and the higher is the critical fixed cost level, which would just make an MVNO arrangement unprofitable for the MNO.

4.2 Bertrand Competition

Having demonstrated that MVNO access is unlikely to be denied under Cournot competition (unless there is collusion), let us turn to the question how the results change if mobile telecommunications service providers compete in prices instead of quantities. As we know from the literature on horizontal mergers, mergers are always profitable under Bertrand competition if products are differentiated and the number of firms is fixed (see Deneckere and Davidson, 1985). This result would suggest that divisionalization, and accordingly access provision to MVNOs, is not profitable under Bertrand competition. However, this result is based on the assumption that divisionalization does not lead to further product differentiation or, viewed from the opposite perspective, that market concentration does not lead to less product differentiation. One of the main arguments put forward in favor of MVNO business models, however, is that MVNOs may increase product differentiation. Hence, we will assume that MVNOs introduce new varieties into the market which would otherwise not exist.

Let us now denote the number of incumbent MNOs as M and the total number of licensed MVNOs as V and assume that the inverse demand function faced by firm 1 is given by

$$p_1 = A - bq_1 - b\theta(\sum_{i=1}^{M} q_i + \sum_{j=1}^{V} q_j), \tag{3}$$

so that firm 1's residual demand can be written as

$$q_1 = \frac{A(1-\theta) - p_1(1 + (N-2)\theta) + \theta \sum_{i=2}^{N} p_i}{b\,(1-\theta)\,(1+\theta(N-1))}, \tag{4}$$

where $N \equiv M + V$. Keeping in mind that MVNOs are assumed to be independent from their host networks in their pricing decisions, an MNO will set its price to maximize its profit which, after rearranging the first-order conditions, yields the following equilibrium price

$$p_i = \frac{(1-\theta)A}{2+\theta(N-3)} \ \forall i. \tag{5}$$

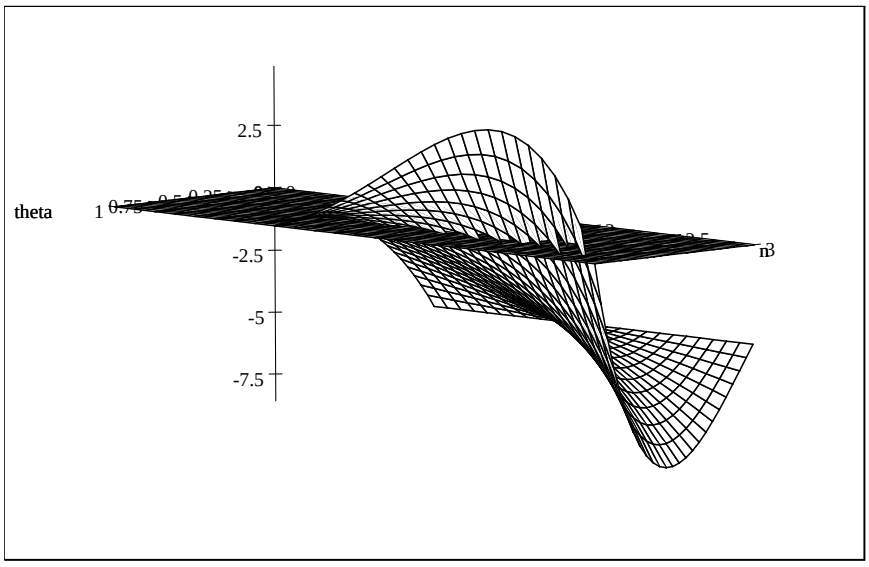
Now let us first assume that there are initially no MVNOs (i.e., $N = M$) and consider the incentives of an MNO to "invite" an MVNO onto its network. In the initial situation without MVNOs the MNOs' profits are given by

$$\pi_i = \frac{A^2}{b} \frac{(1-\theta)\left(1+\theta(M-2)\right)}{\left(1+\theta(M-1)\right)\left(2+\theta(M-3)\right)^2} \ \ \forall i. \tag{6}$$

To analyze whether an MNO finds it profitable to invite an MVNO onto its network let us compare firm i's profit for $N = M$ and for $N = M + 1$. Assuming again that firm i can extract the entire profit from an MVNO the MNO firm i strictly profits from inviting an MVNO if $\pi_i(M) > 2\pi_i(M+1)$ or

$$\frac{A^2}{b} \frac{(1-\theta)\left(1+\theta(M-2)\right)}{\left(1+\theta(M-1)\right)\left(2+\theta(M-3)\right)^2} > 2\frac{A^2}{b} \frac{(1-\theta)\left(1+\theta((M+1)-2)\right)}{\left(1+\theta((M+1)-1)\right)\left(2+\theta((M+1)-3)\right)^2}.$$

Simplifying this expression one can rewrite the above inequality so that $\pi_i(M) > 2\pi_i(M+1)$ if $\Delta > 0$ where $\Delta \equiv \left(2+\theta(M-2)\right)^2\left(1+\theta M\right)\left(1+\theta(M-2)\right) - 2(1+\theta(M-1))\left(2+\theta(M-3)\right)^2\left(1+\theta(M-1)\right)$. As it is not possible to find a numeric solution for $\Delta = 0$, it is helpful to plot Δ as presented in figure 3, where we have plotted Δ for $\theta \in [0,\, 1]$ and $n \in [1,\, 3]$



Whenever $\Delta > 0$ MNOs do not have any incentive to open their network for MVNOs. This is the case when products are close substitutes (θ is large) so that the competitive effect of MVNOs is strong. If, however, θ is small so that competition is soft as products are not close substitutes, MNOs profit from additional MVNOs so that we would expect them to voluntarily open their network for MVNO access.

For example, suppose there is a monopoly MNO which could invite a differentiated MVNO onto its network. Comparing the monopolist's profit with a duopoly profit when products are differentiated (i.e., $\pi_i(M)$ and $2\pi_i(M+1)$ for $M = 1$), we find that the monopolist strictly benefits from inviting an MVNO if $\theta < 0.61171$. Hence, the MVNO has to offer sufficiently differentiated services in order to provide sufficient benefits for a monopoly MNO. Similarly, we can compare $\pi_i(M)$ and $2\pi_i(M+1)$ for $M = 2$. Again, an MNO profits from inviting an MVNO if products are sufficiently differentiated, in this case $\theta < 0.71443$. Hence, a smaller degree of product differentiation is necessary under a duopoly situation to make MVNO arrangements profitable for an incumbent MNO.

Finally, as soon as at least three incumbents MVNOs offer their services, the MNOs will always have strictly positive incentives to provide network access to MVNOs for $\theta < 1$. Increasing the number of firms from 3 to 4 (i.e., 3 MNOs and 1 MVNO) will strictly increase the host network's profit if it can extract the MVNO's entire surplus. Of course, if the host MNO cannot extract the MVNO's entire surplus, the same arguments hold as put forward in the case of Cournot competition. The smaller the share of the MVNO's profit that the host network can extract the lower the incentive to offer MVNO arrangements. Similarly, the incentives to contract with MVNOs decrease as the fixed cost of contracting with and arranging for MVNOs increase. Unfortunately, calculating the optimum number of MVNOs proves to be too difficult, as the complexity of the problem prevents us from finding even numerical solutions.

Nevertheless, even though we cannot determine the optimum number of MVNOs that duopoly MNOs would invite onto their networks, we have shown that even under Bertrand competition MNOs can have sufficient incentives to offer network access for MVNOs. This is especially so once there are at least three MNOs. While MNOs in monopoly or duopoly markets will only grant MVNOs access if these are sufficiently differentiated, MVNOs will always be granted access once there are three competing MNOs and the fixed costs of arranging for MVNOs are not prohibitive. While the role for regulation appears to be rather limited once there are three or more MNOs, there may be a role for regulation in duopoly or monopoly markets.

4.3 Stackelberg Competition

So far we have assumed that all firms make their decisions simultaneously. This assumption, however, may not be an appropriate reflection of reality in mobile communications markets where some firms were licensed earlier than others. In order to account for this sequentiality of moves, let us in the following consider a modified Stackelberg model.

Suppose that in the first stage M MNOs simultaneously choose quantities before they can decide to open their network for V MVNOs which act as Stackelberg followers relative to the M MNOs. Also let us start the analysis by assuming that products are homogeneous and that the inverse demand function is linear again with $p = A - bQ$. Given that the M MNOs, who act as Stackelberg leaders vis-a-vis the V MVNOs, compete in Cournot fashion within the group of MNOs, an MNO's quantity will be given by

$$q_L = \frac{A}{(M+1)b}. \tag{7}$$

Assuming that the V MVNOs also compete in Cournot fashion within their group even though they act as Stackelberg followers vis-a-vis the group of MNOs, an MVNO's quantity will be given by

$$q_F = \frac{A}{(M+1)(V+1)b}.$$

Without any MVNO ($V = 0$) the M MNOs compete in Cournot fashion so that their profit is given by

$$\pi_L = \frac{A^2}{(M+1)^2 b}. \tag{8}$$

If now one of the MNOs "invites" V MVNOs to use its network the retail price drops to

$$p = \frac{A}{(M+1)(V+1)}$$

and, assuming again that the host MNO can extract the MVNOs' entire profits, the host MNO obtains a total profit of

$$\pi_{HOST} = \left(\frac{A}{(M+1)b} + V\frac{A}{(M+1)(V+1)b}\right)\frac{A}{(M+1)(V+1)} = \frac{(2V+1)A^2}{(M+1)^2(V+1)^2 b}. \tag{9}$$

Comparing (8) and (9) it is clear that the host MNO's profit decreases when granting network access. The MVNOs' competitive effect on the retail market outweighs the additional revenue generated from any number of MVNOs. As MVNOs act as followers their market share and their profit are too small to compensate the host network for the

decrease in price that the MVNOs induce. Hence, in contrast to Cournot competition the incumbent MNOs' incentives to grant MVNOs network access completely vanish under Stackelberg competition. As this result shows, voluntary MVNO agreements may be completely eliminated if MNOs have a first-mover advantage and if MVNOs have a significant impact on price, but only small profits to compensate the host MNO.

Of course, this result is relaxed once we consider the case of product differentiation. For example, if we consider the case with two incumbent MNOs and one potential MVNO one can show that the host network benefits from entry by a MVNO (assuming that the host network can appropriate the MVNO's entire surplus) if $\theta < 0.7153$. Hence, as in the case of Bertrand competition, products have to be sufficiently differentiated so that an MVNO's market entry does not lead to such an intensive degree of competition that the competitive effect on the MNO's price level outweighs the additional revenues obtained from the MVNO.

Finally, if we consider price leadership instead of a Stackelberg game with quantity competition, it is straightforward to show that there is, again, a critical θ^* such that MNOs voluntarily open up their networks for MVNOs for all $\theta < \theta^*$. Moreover, another Nash equilibrium can result even for $\theta > \theta^*$: If we assume that there are at least two MNOs and only one potential MVNO, then each MNO will rather give the MVNO access to its own network than letting the rival sell access to the MVNO. Put differently, given that the rival MNO is willing to grant access the other MNO's best response is to also grant access. However, if the rival MNO is not willing to grant access the other MNO's best response is not to grant access either so that there are two Nash equilibria in pure strategies. This implies that even for $\theta > \theta^*$ MNOs may grant access to MVNOs.

5 Summary and Policy Conclusions

As we have shown in this chapter, MNOs' incentives to voluntarily provide network access and invite MVNOs onto their network critically depend on two things: Firstly, the mode of competition and, secondly, the degree of product differentiation. Generally, MNOs will voluntarily provide network access if the services offered by the candidate MVNOs are sufficiently differentiated, as with a high degree of product differentiation the revenue effects outweigh the competition (or cannibalization) effects. Furthermore, MNOs will always invite MVNOs onto their network under Cournot competition if the market is sufficiently large, even if MVNOs offer homogeneous products. In contrast, the incentives to voluntarily grant MVNO access are lower under Bertrand competition and decline even further under Stackelberg competition. Under Bertrand and Stackelberg competition voluntary MVNO access is only granted if the services offered by MVNOs

are sufficiently differentiated.

>From a policy perspective our findings imply that firms may not always voluntarily grant MVNO access as the simple Cournot model would predict. If firms compete in prices or if firms move sequentially (which may not be too bad a reflection of reality, given that licenses to operate mobile telecommunications networks have been granted sequentially in almost all jurisdictions), MNOs may not face proper incentives to host MVNOs. This means that even in the absence of any collusive behavior firms may find it individually rational (i.e, profit maximizing) not to grant MVNOs access, as the simple Stackelberg model has demonstrated. In this case, there may be a role for regulatory intervention in order to boost competition.

When calling for regulatory intervention, however, one should keep in mind that our model is a static one which does not consider investment, but assumes that the necessary infrastructure is given. If, however, investment incentives need to be considered as well (which is, of course, necessary from a dynamic efficiency perspective), the model presented here needs to be augmented. Therefore, we think that the integration of investment decisions into our model provides an interesting topic for further research.

Similarly, we have assumed that the established MNOs are symmetric in costs, capacities, and so on. However, MNOs incentives to provide MVNOs access may change if MNOs differ in their level of capacity utilization. While we have to leave this question open at this point, we think that it also provides an interesting question for further research.

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Table 1: MVNOs in Selected Countries

Country	Wholesale Relationships	MVNOs	ESPs
Australia	29	1	28
Austria	3	1	2
Belgium	29	3	26
Canada	6	6	0
Denmark	14	4	10
Estonia	3	2	1
Finland	10	5	5
France	13	9	4
Germany	32	13	19
Hong Kong	6	0	6
Ireland	4	3	1
Latvia	1	0	1
Liechtenstein	1	1	0
Lithuania	2	2	0
Luxembourg	1	1	0
Malaysia	2	2	0
The Netherlands	36	6	30
New Zealand	1	1	0
Norway	13	12	1
Philippines	1	1	0
Poland	5	3	2
Portugal	3	3	0
Russia	2	2	0
Singapore	1	1	0
Slovenia	2	1	1
South Africa	1	1	0
Spain	4-5	3-4	1
Sweden	23	20	3
Switzerland	5	3	2
Taiwan	2	2	0
Ukraine	2	2	0
United Kingdom	27	24	3
United States	60	50	10

MVNO - Mobile Virtual Network Operator
ESP - Enhanced Service Provider
Source: www.takashimobile.com/mvno.html, 7 January 2006

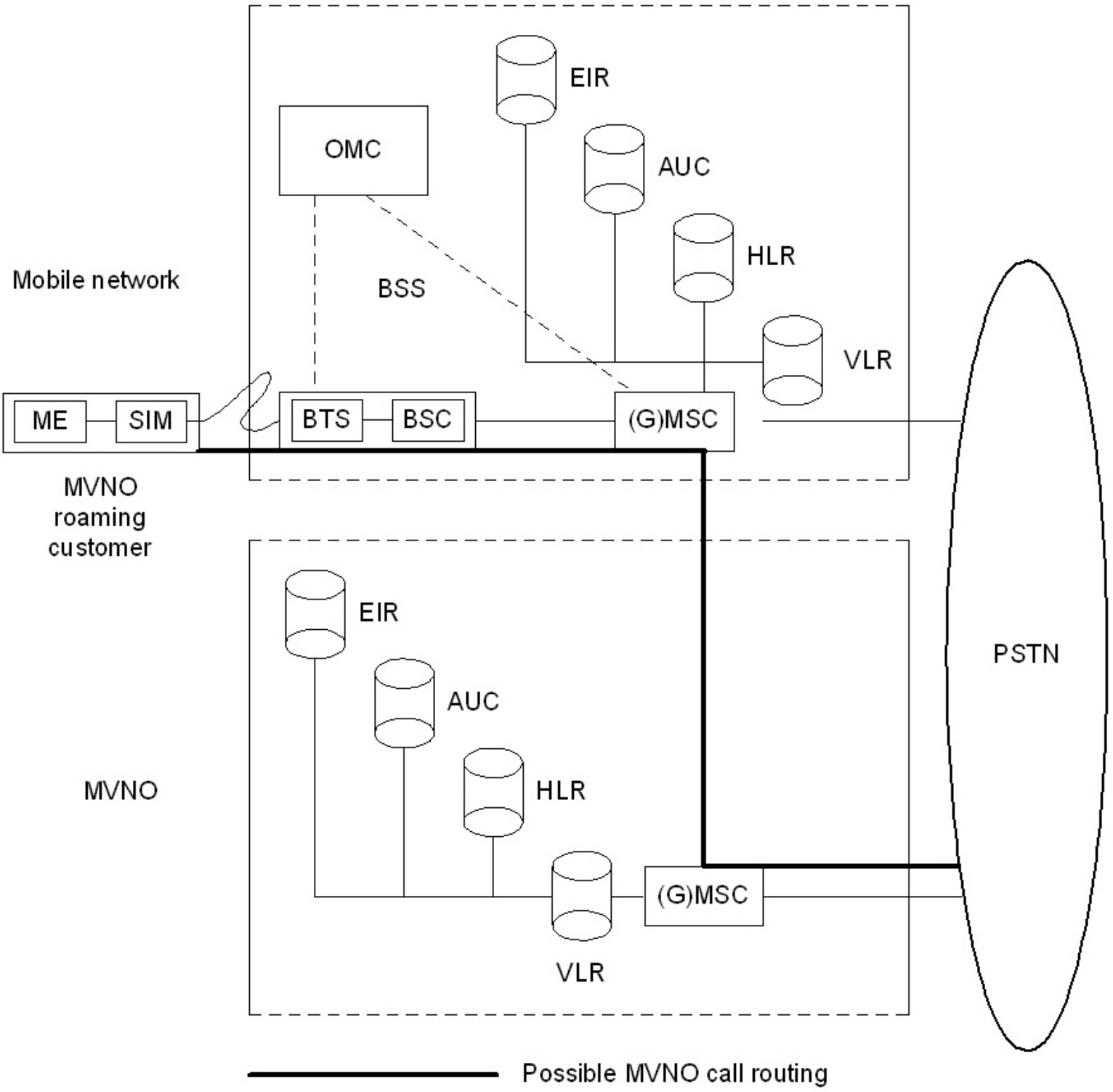
Table 2: MVNOs and Host Networks in Selected Countries

Country	Operator	Market Share (4Q/2003)	Relationships
Austria	one	20	2
	tele.ring	9	1
	mobilkom	44	0
	T-Mobile Austria	28	0
Belgium	Base	16	25
	Mobistar	32	1
	Proximus	52	1
Denmark	H3G	0	0
	Sonofon	24	3
	TDC Mobil	53	11
	Telia Mobile*	23	0
Finland	Elisa	30	1
	Finnet	17	3
	TeliaSonera	53	3
France	Bouygues	16	3
	Orange	48	4
	SFR	36	5
The Netherlands	KPN Mobile	39	11
	Orange	10	3
	Telfort	12	19
	T-Mobile	15	0
	Vodafone	24	3
Portugal	Optimus	23	1
	TMN	48	1
	Vodafone	29	1
Switzerland	Swisscom	62	2
	Sunrise	20	1
	Orange	18	2
UK	Orange	26	2
	T-Mobile	26	7
	Vodafone	24	4
	O2	25	4

* Telia Mobile's market shares include those of Orange Denmark, which was acquired by Telia Mobile in 2004.

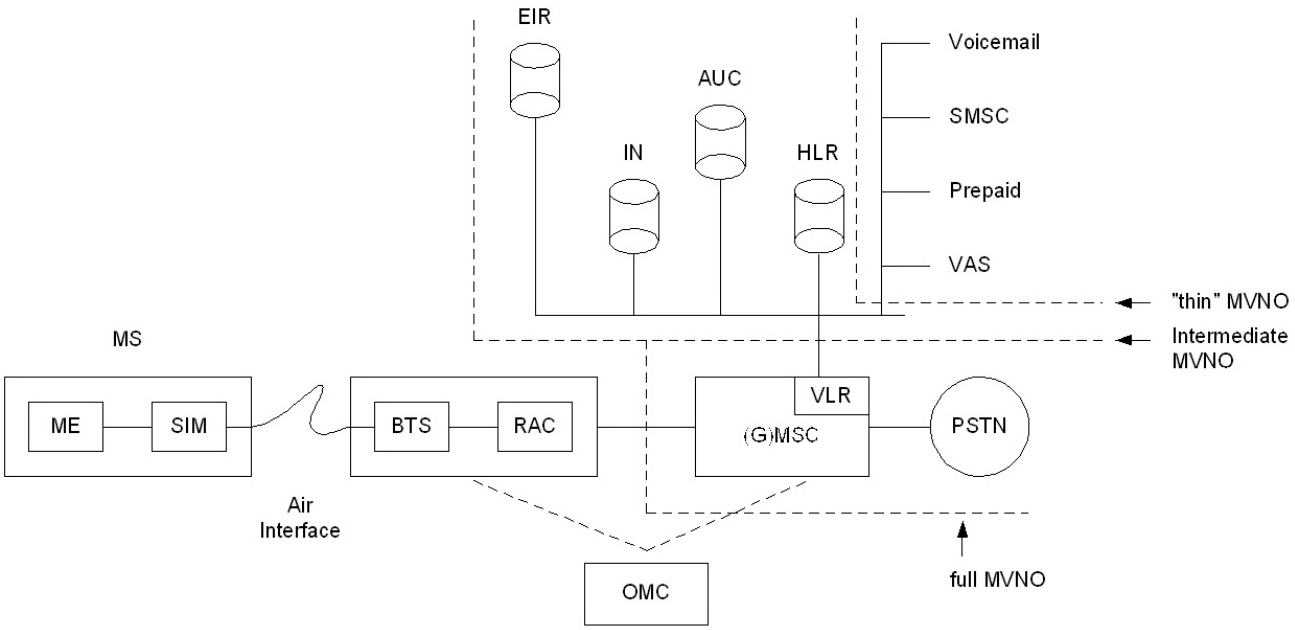
Source: http://www.mobileisgood.com/

Figure 1: MVNO Call Routing



Source: Kim and Park (2004)

Figure 2: Full, Intermediate, and Thin MVNOs



MS:	Mobile Station	OMC:	Operations and Maintenance Centre
ME:	Mobile Equipment	(G)MSC:	(Gateway) Mobile services Swiches Centre
SIM:	Subscriber Identity Module	HLR:	Home Location Register
BSS:	Base Station subSystem	VLR:	Visitor Location Register
BTS:	Base Transceiver Station	EIR:	Equipment Identity Register
RAC:	Radio Access Controller	PSTN:	Public Switched Telephone Network
AUC:	Authorisation Centre		

Source: Ergas, Waters and Dodd (2005)