Voluntary Relationships Among Mobile Network Operators and Mobile Virtual Network Operators: An Economic Explanation

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Aniruddha Banerjee[1]
Telecommunications Consultant
10 Chestnut Street, Acton, MA 01720
axbaner@comcast.net

Christian M. Dippon
NERA Economic Consulting
One Front Street, Suite 2600, San Francisco, CA 94111
christian.dippon@nera.com

Abstract

Mobile virtual network operators (MVNOs) do not hold spectrum licenses and own little or no network infrastructure. Rather, they resell mobile services by purchasing airtime at wholesale rates from mobile network operators (MNOs). Unlike ordinary resellers, MVNOs rely on brand appeal and reputation acquired in other businesses to sell mobile services (often bundled with other products). Significant worldwide growth in voluntary MNO-MVNO partnerships, without intervention from public policies that mandate MVNO access to MNO networks, raises many interesting issues. Since MNOs that sell wholesale services to MVNOs potentially forfeit sales in downstream retail markets, voluntary relationships are plausible only if MVNOs add value by widening and/or deepening MNO-served markets. This paper provides sufficient conditions for profit-maximizing MNOs and MVNOs to form voluntary strategic partnerships based on resale, product differentiation, and rebranding. The two key factors are (1) value of the MVNO's brand reputation and (2) wholesale discount at which the MNO offers service to the MVNO.

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1   Corresponding author. Tel: +1-978-263-9031; fax: +1-978-263-1325. We gratefully acknowledge the comments and suggestions of the editor and three anonymous referees for helping to improve the paper in a number of directions. All remaining errors are our responsibility.

Introduction

Mobile virtual network operators (MVNOs) are an important development in wireless telecommunications. Like standard wireless carriers or mobile network operators (MNOs), MVNOs sell wireless (or mobile) communications services, sometimes along with other products and services. Unlike MNOs, however, they do not hold licenses to the radio spectrum and may not even own network infrastructure.[2] Instead, they must purchase network capacity from MNOs that have spectrum licenses and own the network infrastructure needed to offer mobile services. Yet, from a customer's perspective, an MVNO's services may sometimes be virtually indistinguishable from those provided by MNOs.

MVNOs are much more than mere resellers of mobile services. Although MVNOs resell airtime purchased at wholesale rates from MNOs (Federal Communications Commission, 1996), they also distinguish themselves from other wireless resellers by leveraging their brand appeal and reputation in non-wireless or non-telecommunications lines of business to sell mobile services. Besides bundling mobile services with their other products, MVNOs sometimes add distribution channels and other bonus items when reselling their services. In that respect, MVNOs are a cross between resellers and affiliated subsidiaries of host MNOs. Like resellers, they maintain separate structural identities from their host MNOs. However, unlike resellers, even while appearing to compete with their host MNOs, MVNOs actually use their resources to benefit both themselves and their hosts.[3] We postulate that brand reputation and cross-selling ability—traits associated with MVNOs but not ordinary wireless resellers—play a significant economic role in enabling voluntary MNO-MVNO relationships and prompting MNOs to behave differently than when competing against ordinary resellers in downstream markets.

The emergence of MVNOs around the world, and in significant numbers in the United States (US) and the European Union (EU), is interesting because it differs in some important ways from the way more conventional market structures have evolved in countries that allow competition in their telecommunications sectors.[4] For example, vertically integrated incumbent fixed-line operators (whether regulated private monopolies or *de facto* government-run monopolies) have lost market share to new unregulated competitors that entered as either resellers or partially facilities-based operators.[5] Also, in many countries, those incumbent fixed-line operators face asymmetric regulation designed to constrain the profits they can earn (whether from retail sales in competitive downstream markets or wholesale sales in upstream markets). The market structure emerging from these developments has prompted detailed explorations into the vertically-integrated incumbent's incentive and ability to discriminate against its downstream competitors that depend on it for access to the wholesale service. Specifically, questions arise about whether the incumbent can (and does) discriminate either by charging wholesale rates that place its dependent downstream competitors in a price squeeze or by degrading the quality of the wholesale service it provides to competitors relative to what it provides its own downstream operations.[6] Accordingly, policies and regulations have been adopted to deter or remediate abuses of dependent fixed-line competitors by such methods.

In contrast, mobile communications markets have developed very differently. In the absence of a single incumbent providing universal coverage, mobile carriers (especially MNOs) have grown by developing duplicative network facilities and overlapping coverage areas. In most countries, mobile carriers remain unregulated or regulated less than incumbent fixed-line operators.[7] MNOs have to

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2   Some MVNOs possess only parts of the network infrastructure, such as mobile switching centers or home location registers.

3   We argue later that, employing product differentiation as a strategic tool, MVNOs often refrain from offering near-substitutes for their host MNOs' services. This is a very different *modus operandi* than that of resellers. However, by creating an alternative outlet for mobile services from a customer's perspective, MVNOs still appear to expand competition in the retail market.

4   MVNOs first appeared in the US in May 1996 when TracFone Wireless commenced operations. By early 2005, 22 MVNOs were operating in the US—a number that has fluctuated of late with the launches of Helio and XE Mobile and the failures of Amp'd, ESPN Mobile, and Disney Mobile. In addition, major retailers, such as Wal-Mart, Apple, and Nike, have long been expected to launch MVNO offerings of their own that tie their established brands to wireless services (Takashi Mobile 2006). In 1999, Virgin Mobile UK became the first MVNO to launch service in Europe. Virgin Mobile UK (and, later, Tele2) are examples of fixed-line operators that lacked wireless network facilities and access to the radio spectrum but were able to diversify into offering mobile services by becoming MVNOs. By 2005, over 50 MVNOs were in operation in the EU, serving a diverse set of customers and offering a range of mobile voice and data services. This diversity in their backgrounds, customers, and product offerings is, in fact, the hallmark property of MVNOs.

5   In many countries, the prohibitive economic cost of duplicating incumbents' network facilities—a significant entry deterrent—has been overcome by mandatory unbundling and interconnection policies that enable entrants to acquire essential network facilities from incumbents at cost-based prices and combine them with their own resources.

6   See, e.g., Weisman (1995) and Reiffen (1998).

7   We do not mean to suggest that effective antitrust policies or monitoring are not needed for the wireless segment just because it has evolved very differently from the fixed-line segment in most countries. The European Commission (and the national regulatory authorities of the EU member states) keep a close watch on competitive conditions in their wireless markets and frequently subject them to regulatory scrutiny and remedial actions.

acquire licenses to use scarce radio spectrum resources, a process that governments typically manage through multi-stage auctions that neither favor nor disfavor individual MNOs.[8] With access to the spectrum, MNOs may build and operate their network facilities to offer mobile services.[9]

The mobile communications sectors of many countries (such as the US and those in the EU) display several common characteristics: (1) multiple competitors, (2) little or no advantage of incumbency, (3) little or no (asymmetric) regulation, (4) allocation of a critical resource (radio spectrum) through competitive bidding and auctions, (5) provision of broadband and converged services, (6) high or rapidly rising market penetration rates, (7) emerging mode of choice for pursuing the goal of universal access, (8) termination access monopoly in countries with calling-party-pays regimes, and (9) ubiquitous fixed-to-mobile and mobile-to-mobile interconnection and domestic and international roaming agreements. Worldwide, mobile handsets in use have long surpassed the number of fixed-line connections, and market shares of mobile carriers for overall telecommunications calling exceed those of fixed-line carriers in many countries.[10] These features raise several interesting questions: (1) Why have MVNOs emerged in the first place? (2) What explains the widespread emergence (especially in the US and the EU) of *voluntary* relationships among MNOs and MVNOs?[11] and (3) How are MVNOs different from resellers? We address these questions from a theoretical perspective in this paper.

Although policy implications are not the primary focus of the paper, no discussion of the rise of MVNOs worldwide can be complete without addressing the following question: are regulatory policies needed to *mandate* that MNOs provide wholesale access *upon demand* to MVNOs?[12] This question is controversial for at least two reasons. First, it raises the prospect that, despite strong *retail*

competition (for which reason MNOs are not, or only lightly, regulated in many countries), competition at the *wholesale* level has not yet emerged or matured. Absent such competition, it is sometimes argued, entry by MVNOs and resellers of mobile services is likely to be impeded and, therefore, require help from regulation. Second, while sparse or uneven wholesale competition may be a concern in particular instances, the large-scale emergence of voluntary MNO-MVNO partnerships in the US, the EU, and other places casts doubt on any proposition that entry-facilitating regulatory intervention should be either automatic or universal. Rather, a sensible reading of the empirical evidence would be that (1) where voluntary MNO-MVNO partnerships have taken hold, the minimum conditions for mutually beneficial relationships already exist and, more importantly, have been discovered by the partnering entities themselves, and (2) where such relationships have not yet emerged, market failure—typically the reason given for regulatory intervention—may not always be the cause. If proven, market failure (e.g., due to monopoly control or denial of wholesale access) can justify entry-facilitating regulation. However, the mere absence of a voluntary MNO-MVNO relationship does not automatically prove either MNO malfeasance or market failure. Therefore, a blanket regulatory policy that compels MNOs to partner with aspiring MVNOs, regardless of actual market circumstances, cannot guarantee improvements in economic welfare.

The paper is organized as follows. Section 2 summarizes various theoretical economic models that explain the incentive of profit-maximizing MNOs and MVNOs in effectively competitive retail and wholesale markets to enter into voluntary strategic partnerships based on resale, product differentiation, and rebranding. Section 3 presents our conclusions, including a brief exploration of the policy implications of the MNO-MVNO relationship.[13]

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8   Sometimes, governments reserve parts of the spectrum for carriers designated to provide specialized services, such as those serving specific national security or public service needs. The radio spectrum is non-homogeneous in nature, and different frequencies are best suited to different forms of radio transmission.

9   Some exceptions to this rule have emerged, for example, in the form of wireless carriers that offer "limited mobility" services within a fixed radius by using technologies based on the IEEE 802.11 standard (popularly known as *WiFi* that use only the unlicensed portions of the radio spectrum).

10   International Telecommunication Union (2006).

11   By a "voluntary" relationship, we mean one that is formed between an aspiring MVNO and a host MNO on mutually acceptable terms and not as a result of regulatory mandates or any form of coercion in the market.

12   While this paper was being revised, the editor very kindly informed us of a recently published article by Dewenter and Haucap (2007) that addresses the very same question. Despite different analytical approaches, the article and our paper appear independently to reach comparable conclusions on several essential issues. For instance, starting with a homogeneous duopoly with two symmetric MNOs, Dewenter and Haucap investigate the economic incentives of the MNOs to voluntarily partner with MVNOs under Cournot, Bertrand, or Stackelberg competition and with different degrees of product differentiation. Below, at appropriate junctures, we compare our respective approaches. More significantly, Dewenter and Haucap find that voluntary MNO-MVNO relationships can emerge even under near-monopoly or limited competition conditions if there is "sufficient" product differentiation between the retail offerings of the MNO and the MVNO. With a different analytical approach, we establish a similar result.

13   A more elaborate discussion of policy implications may be found in Dippon and Banerjee (2006).

Economic Model Of The
MNO-MVNO Relationship

What is the economic premise for the existence of a *voluntary* MNO-MVNO relationship? Given the many advantages and disadvantages associated with MVNOs, it is not immediately obvious why they exist and why they seek strategic partnerships with MNOs. Nevertheless, those questions are important because the relationship being examined is spontaneous and voluntary rather than one mandated by public policy. Since an MNO that sells wholesale services to an MVNO potentially forfeits some of its own sales in a downstream retail market,[14] a voluntary relationship can plausibly exist only if the MVNO adds value to that relationship in ways that mere resellers cannot, such as by widening and/or deepening the MNO-served market. This can help to boost the combined profits of MNOs from retail and wholesale services beyond the likely profits from retail operations alone. Also, the MNO must be left with no particular incentive to discriminate against an aspiring MVNO, even if it has the ability to do so.

We present theoretical economic models to explain the incentive of (i.e., sufficient conditions for) profit-maximizing MNOs and MVNOs to enter into voluntary, strategic partnerships based on resale, product differentiation, and rebranding from outside the telecommunications industry. We demonstrate that, under the right circumstances, an MNO's strategy to voluntarily provide wholesale access to an MVNO is justified by the net economic benefits produced. This is intuitively obvious and borne out by empirical evidence.[15] In particular, the two key factors in that relationship are (1) the value of the MVNO's brand reputation and (2) the level of the wholesale discount in the resale transaction between the MNO and the MVNO.

Incentives for Discrimination and Sabotage: Review of Related Literature

At first glance, a voluntary MNO-MVNO partnership may seem incompatible with the incentives of firms in markets in which regulatory intervention is needed to establish (at least resale-based) competition. However, to understand whether such a relationship represents something new, it is useful to first review the existing literature on the incentives of a vertically-integrated firm with monopoly control in an upstream market to discriminate against, or sabotage, its competitors in a downstream market.[16] Typically, the vertically-integrated incumbent is assumed to control an essential wholesale service in an upstream market (such as exchange access in telecommunications) and is the sole supplier of that service to firms against which it competes in a downstream market.

Several researchers have examined the circumstances under which the vertically-integrated incumbent has an incentive to increase profits from its upstream and downstream operations by *exploiting* its dependent downstream competitors in some way.[17] Factors affecting that incentive include: (1) degree of product differentiation in the downstream market, (2) incumbent's cost to sabotage its downstream competitors, (3) incumbent's incremental production cost, (4) relative efficiency of downstream competitors, (5) extent of coordination between incumbent's upstream and downstream operations, (6) degree of competition in both upstream and downstream markets, and (7) incumbent's profit margin in the upstream market.[18] Specifically, the incentive to discriminate against dependent downstream competitors is *greater* with less product differentiation, lower cost to sabotage, lower production costs, relatively less efficient downstream competitors, more coordinated wholesale and retail operations, less competition in upstream and downstream markets, and smaller profit margins in the upstream market.

We propose in this paper that some, but not all, of these considerations apply in a market in which MNOs and MVNOs form voluntary strategic partnerships. First, unlike the vertically-integrated incumbent, the MNO is *not* a monopolist in sole control of an essential facility (the upstream wholesale service). In most countries, multiple MNOs compete and few, if any, among them are dominant in terms of market share. As a result, aspiring MVNOs frequently have a choice of MNOs when seeking the wholesale access service or, more generally, a strategic partnership. Second, as we argue in this paper, MVNOs do not aspire to be merely

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14 This is precisely the outcome that creates opportunities for (and concerns about) discrimination in the fixed-line sector where vertically-integrated incumbents control wholesale access in upstream markets while competing with dependent retail competitors in downstream markets. We review briefly the literature on this issue later in the paper.

15 It is a fact that MVNOs have emerged in large numbers in both the US and other countries where regulators have refrained from regulating wireless telecommunications. This fact clearly implies that both MVNOs and MNOs can benefit from voluntary strategic relationships.

16 Sabotage here refers to any act by the vertically-integrated monopolist to unduly disadvantage its downstream competitors through non-price discrimination or other acts that raise those competitors' costs asymmetrically. See, e.g., Mandy and Sappington (2001) and Mandy (2000a).

17 See, among others, Economides (1998), Bernheim and Willig (1996), Beard *et al*. (1999), Weisman (1995, 1998), Reiffen (1998), Mandy (2000a, 2000b, 2001), Mandy and Sappington (2000), Lewis and Sappington (1999), Sibley and Weisman (1998a, 1998b), Weisman and Kang (2001), and Sand (2003).

18 Mandy (2000a). The first two factors were discussed at length in the exchange between Weisman (1995, 1998) and Reiffen (1998). Also, Sand (2003) argues that the upstream service should be priced above marginal cost (i.e., seemingly inefficiently) so that a regulated incumbent with monopoly control over that service will have a reduced incentive to discriminate.

(resale-based) competitors of MNOs; rather, they expect to form partnerships that are mutually beneficial. MNOs, too, see a financial interest in partnering with MVNOs instead of discriminating against (or sabotaging) them, even if they have the ability to do the latter. Finally, even the literature on regulated vertically-integrated monopolists is mixed on the incentive to discriminate. That incentive is unambiguous only under very restrictive assumptions (such as those in Economides, 1998).[19]

Relaxing even some of these assumptions, however, is enough to produce a more ambiguous, and even an opposite, result. The incentive to discriminate or sabotage is non-existent or questionable at best in a number of circumstances: the retail offerings of the incumbent and its competitors are not perfect substitutes, the direct and indirect (opportunity) costs[20] of discrimination are non-trivial, the incumbent does not have sole control of the upstream market, or the incumbent's share of the downstream retail market is relatively "small."[21] Some of these conditions are very likely to exist in the market for mobile services. For example, far from charging premium prices or imposing onerous terms and conditions on the supply of wholesale access, MNOs frequently use their wholesale discount rate strategically to attract MVNOs. As we discuss later, the services that MNO and MVNOs offer are not perfect substitutes—indeed, most MVNOs try to develop retail services and market segments that MNOs largely ignore. Finally, it is no accident that the MNOs most likely to partner voluntarily with MVNOs are those that rank third or fourth in terms of retail market share.[22] We conclude that voluntary MNO-MVNO relationships cannot be explained by the literature on regulated, vertically-integrated monopolists. Indeed, the incentives of MNOs and MVNOs need a different explanation.

Theoretical Model of the MNO-MVNO Relationship

We explore first the circumstances in which a voluntary MNO-MVNO relationship may exist. Intuitively, when the services offered are differentiated, a relationship can form when the MVNO is able to widen or deepen the market for the MNO's services.[23] The MNO's incentive to pursue such a relationship can arise from being able to earn combined retail and wholesale profits that exceed profits in alternative circumstances, such as (1) in the absence of an MNO-MVNO relationship and/or (2) when the MNO and the MVNO operate independently (i.e., the MVNO is a pure reseller). To establish the minimum conditions under which a voluntary partnership may form, we assume that MNOs and MVNOs maximize their respective profits and consider, in particular, the implications of product (service) differentiation by the MNO.

Before proceeding to the formal analysis, we make the following observations. First, in this paper, we make no attempt to determine whether or not an MNO-MVNO relationship is *always* mutually beneficial or welfare-enhancing. Common sense suggests that it may not always be so.[24] Rather, we focus only on the circumstances in an effectively competitive market in which such a relationship *may* be mutually beneficial. Second, although the formal analysis concentrates on the incentives and actions of MNOs and the MVNOs, the consumer side of the equation is represented by the price elasticity of demand and the importance of an MVNO's brand reputation to the process by which consumers make purchase decisions.[25] The importance of these demand-related factors can be explained as follows.

While some MVNOs emerge from within the telecommunications industry itself (see fn. 4), many others actually have no prior connection with that industry. For example, the latter type of

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19 These assumptions include (1) homogeneous retail product, (2) zero cost to discriminate, (3) identically efficient retail firms (including both the incumbent and its competitors), (4) constant incremental cost of producing the retail product, (5) full integration of the monopolist's wholesale and retail operations, (6) Cournot oligopoly in the downstream market and monopoly control in the upstream market, and (7) fixed positive profit margin on the wholesale product. See Mandy (2000a).

20 Direct costs to discriminate include those related to contracts, delays, quality degradation, and countering regulatory oversight that are all designed to raise competitors' costs. Indirect costs consist of the upstream market profits that are lost when successful discrimination reduces competitors' demand for the wholesale service.

21 Various counterpoints to the results of Economides (1998) or Beard *et al*. (1999) may be found in Mandy (2000a), Weisman (1995, 1998), and Sibley and Weisman (1998a, 1999b). Reiffen (1998) contends that if the incumbent practices quality (or some form of non-price) discrimination, its cost to discriminate may actually be lower and, hence, the incentive to discriminate greater. Weisman (1998) argues persuasively that, at best, the ultimate outcome is an empirical matter and depends on various structural conditions that vary by market.

22 In the US, the earliest MVNO entrants mostly selected Sprint as the host MNO. Similarly, T-Mobile was the host for Virgin Mobile UK, the first MVNO in Europe. In the late 1990s, neither Sprint nor T-Mobile was among the MNOs with the highest shares in their respective mobile services markets.

23 By "market widening" and "market deepening," we refer to market expansions in horizontal and vertical directions, respectively. An MVNO widens the market by attracting additional customer segments for its host MNO's existing services, and it deepens the market by introducing additional services to the MNO's existing customers.

24 Indeed, Dewenter and Haucap (2007) show that, under Cournot (or quantity-based) competition, the size of the overall market and the fixed cost of establishing an MNO-MVNO relationship are determinants of the MNO's incentive to provide access to an MVNO. Furthermore, that incentive diminishes under Bertrand (price-based) or Stackelberg competition unless there is a corresponding increase in product differentiation so that the MVNO, in generating new revenues of its own, cannibalizes less of the MNO's revenues.

25 These mark the fundamental difference between our analytical approach and that of Dewenter and Haucap (2007). There is no discussion of the significance of rebranding (and what sets an MVNO apart from an ordinary reseller) in the Dewenter and Haucap article.

MVNO may be an airline, a major retailer, a sporting goods company, a broadcasting or entertainment company, or a seller of popular beverages. The main idea is that such an entity attempts to leverage its popularity and brand appeal with certain segments of the population to cross-sell mobile telecommunications services. Although it may not own network facilities or have any special expertise in providing telecommunications services, an MVNO helps to take the MNO's mobile services beyond a purely telecommunications context. It is this use of crossover brand appeal (which we label the "brand reputation effect") that sets an MVNO apart from an ordinary reseller and helps to keep customers loyal to it and, in the process, firms up support for the MNO-MVNO partnership itself, even when retail mobile service prices rise.[26] Furthermore, because the MVNO can imaginatively bundle mobile services with other products, it can create an important degree of product differentiation (to serve narrower customer niches) that an ordinary reseller cannot. That ability to differentiate can also help the MNO-MVNO partnership pursue price discrimination (among customer segments with different demand characteristics) to a degree that would be outside the reach of an ordinary reseller.

MVNOs rely precisely on this special asset to sell specialized mobile services to niche customer segments that MNOs (which serve broader market segments) cannot or will not address. In this scheme of things, the customer segments that MVNOs reach may produce either lower or higher average revenue per user (ARPU) than the traditional MNO, but it is always the possibility of *additional* profits (not just revenue) that motivates the MNO-MVNO relationship.[27] Viewed another way, in this scenario with both product differentiation and price discrimination, overall social welfare is improved not merely by some narrowly defined concept of competition but also by market deepening and widening.

Our analysis focuses on a series of increasingly complex model scenarios.[28] This progression is a useful device for understanding the circumstances in which voluntary MNO-MVNO partnerships are likely to form. We first examine the "base case" scenario in which a profit-maximizing MNO is assumed to offer only a homogeneous retail mobile service, and then extend this scenario to a profit-maximizing MNO that sells both the retail service and a wholesale service (at a discount) but experiences a trade-off of sales between the two services.[29] Next, we examine a more realistic base case scenario in which the profit-maximizing MNO offers differentiated retail mobile services. As before, we extend this scenario to factor in the offering of a discounted wholesale service alongside retail services. In both sets of scenarios, the MVNO only becomes a factor when the MNO offers the wholesale access service as well. For both, we explore the comparative profit performance of the MNO, operating first without any involvement with an MVNO and then in partnership with it.

Profit maximization with homogeneous retail service only
The initial base case scenario assumes that the MNO is a price-setting, profit-maximizing monopolist in the market for a homogeneous retail service. The MNO does not sell a wholesale (access) service, and no MVNO seeks to enter the downstream retail market. In this market, the MNO's sales (q_R) are solely a function of the retail price (P_R) it charges. The MNO sets that retail price to maximize its profit π^M, given the incremental cost of service (C_R)

$$\underset{\{P_R\}}{\text{Max}}\ \pi^M = (P_R - C_R)\ q_R(P_R) \tag{1}$$

It can be shown that the profit-maximizing price is[30]

$$P_R^* = C_R\ \frac{\varepsilon_R^M}{1 + \varepsilon_R^M} \tag{2}$$

where ε_R^M is the own-price elasticity of demand for the retail service. The profit-maximizing price is positive only if $C_R > 0$ and $|\varepsilon_R^M| > 1$; that is, the MNO operates on the price-elastic segment of its downward-sloping demand curve. Also, from (2), it follows that

$$\frac{P_R^* - C_R}{P_R^*} = -\ \frac{1}{\varepsilon_R^M}$$

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26   It is hard to be too precise about the brand reputation effect. We believe it goes beyond mere brand recognition or the reputation acquired in other lines of business by providing reliable and high-quality products. The brand reputation effect also encompasses other, sometimes intangible, attributes that make a firm stand out in the perception of consumers, such as exclusivity or snob value, customer service, attractive pricing, or corporate citizenship.

27   This aspect of the relationship is worth emphasizing. MNOs may choose not to address certain customer segments or develop certain service variants because it is unprofitable for *them* to do so. However, an MVNO that leverages its brand reputation to create "sticky" customers and also provides more economical sales/distribution channels may be in a position to profitably serve customers or provide services that the host MNO cannot.

28   To keep the formal analysis tractable, we consider only a one-period profit-maximization model with interior solutions (all second-order conditions are assumed to hold). Obvious extensions would be to assume: (1) the MNO is risk-averse and maximizes the expected utility of profits, (2) the MNO maximizes a discounted stream of profits, or (3) the MNO's objective is constrained profit maximization subject to a minimum level of profits for the MVNO.

29   In the US, this resembles the case of a Regional Bell Operating Company (a vertically-integrated incumbent fixed-line operator) that became eligible to offer retail long distance services in competition with other long distance carriers but was also obliged to provide those carriers with carrier interconnection (or access) to retail customers. For every minute of such access it provided a competing long distance company, the incumbent operator sacrificed a minute of long distance service that it could have provided itself. Conversely, for each minute of long distance service it sold directly to the retail customer, it forfeited the sale of a minute of the wholesale access service.

30   Mathematical derivations underlying the results in this paper are available from the authors upon request.

which is the standard inverse elasticity rule, namely, the percentage markup in the profit-maximizing price varies inversely with the own-price elasticity of demand for the retail service. This percentage markup tends to zero (i.e., the profit-maximizing price tends to equal the unit, or constant incremental, cost) as $|\varepsilon_R^M| \to \infty$, i.e., when the MNO becomes a price-taker. Thus, the bounds imposed by $|\varepsilon_R^M| \in (1,\infty)$ imply that the percentage markup of the profit-maximizing price is also bounded between 100 percent and zero.

Profit maximization with wholesale discount and trade-off in sale of homogeneous retail and wholesale services

Next suppose that the MNO offers both a retail and a wholesale service and maximizes its joint profits from selling both. The MNO remains a price-setter in both downstream retail and upstream wholesale markets. Resellers (and, specifically, MVNOs) can now participate in the retail market by acquiring the wholesale access service from the MNO at a discounted price. The MNO sets a discount off its retail price using the rule $P_W = (1 - \phi) P_R$, where P_W is the price of the wholesale service and ϕ is the wholesale discount *rate*.[31]

The MNO's wholesale sales are a function of both the retail price it sets (because that affects the MVNO's retail sales and, indirectly, the MVNO's demand for wholesale service) and the price it sets for the wholesale service, which, in turn, depends on the wholesale discount. Demand for the MVNO's retail service is also a function of the MVNO's brand reputation, denoted by the index $\tau \geq 0$. This index acts as a "shift variable," i.e., it moves the demand curve up (higher demand at any given price) for higher values of τ (signifying greater brand reputation). In sum, demand for the wholesale service is $q_W = q_W (P_W (\phi), P_R ; \tau)$. Being a price taker, the MVNO's price for retail service rises and falls with the MNO's retail price P_R. While a higher P_R suppresses demand for the retail services of both, the MVNO's brand reputation can act as a mitigating factor. That is, the greater is the MVNO's brand reputation, the smaller is the suppression of demand for its retail service (hence, the demand for

the MNO's wholesale service) from an increase in P_R. Thus, if ε_{WR}^M is the MNO's cross-price elasticity of demand for the wholesale service with respect to the retail service price, this implies $|\varepsilon_{WR}^M|_{\tau = \tau_1} \leq |\varepsilon_{WR}^M|_{\tau = \tau_2}$ for $\tau_1 \geq \tau_2$.[32] Under these circumstances, the MNO sets P_R and ϕ to maximize its joint profits

$$\underset{\{P_R, \phi\}}{\text{Max}} \; \pi^M = (P_R - C_R)q_R(P_R) + [(1-\phi)P_R - C_W]q_W(P_W(\phi), P_R ; \tau)$$
$$- (P_R - C_R]q_W(P_W(\phi), P_R ; \tau)$$

$$=(P_R - C_R)q_R(P_R) + [C_R - C_W - \phi P_R]q_W(P_W(\phi), P_R ; \tau) \qquad (3)$$

The MNO's profit-maximizing levels for and can be shown to be

$$\phi^* = \left(\frac{C_R - C_W}{P_R}\right)\left(\frac{\varepsilon_W^M}{1 + \varepsilon_W^M}\right) + \frac{1}{1 + \varepsilon_W^M} \qquad (4)$$

and

$$P_R^* = \frac{(C_R - C_W)q_W\left(\dfrac{\varepsilon_W^M}{1+\varepsilon_W^M}\right) - C_R \varepsilon_R^M q_R}{\left(\dfrac{1+\varepsilon_{WR}^M}{1+\varepsilon_W^M}\right)q_W - (1+\varepsilon_R^M)\,q_R} \qquad (5)$$

respectively.

From (4), the bounds of the profit-maximizing wholesale discount rate ϕ^* can be found as follows. First, note that as

$$|\varepsilon_R^M| \to \infty, \; \phi^* \to \frac{C_R - C_W}{P_R}.$$

Since the difference $C_R - C_W$ is the retailing or marketing cost incurred to bring the wholesale service to the retail market, it follows that the wholesale discount rate reaches its peak (as, simply, the pure retailing/marketing cost as a percentage of the retail price) when the demand facing the MNO for its wholesale service is

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31   Strictly speaking, the assumption of the MNO as a retail monopolist can be relaxed. As in one of the scenarios examined by Dewenter and Haucap (2007)—an oligopoly setting with no capacity constraints—the MNO can remain a price-setter but in a Bertrand sense, i.e., compete against other MNOs (assumed to offer close, but not perfect, substitutes) by first choosing the retail price. From the perspective of the *MVNO*, however, the retail price that *it* can charge is determined primarily by what it pays for the underlying wholesale service. That, in turn, is a function (through the wholesale discount rule) of the retail price set by its host MNO, not of the retail prices chosen by other MNOs in the market. The central role of the wholesale market (its structure and price properties) is an important point of distinction between our analytical approach and that of Dewenter and Haucap. The latter also assume that MNOs can set the wholesale access price to always extract the MVNO's surplus. We do not make the same assumption and are still able to explore the impact of the wholesale price on the incentives for voluntary MNO-MVNO relationships.

32   In this paper, we use this cross-price elasticity as a measure of the impact of the MVNO's brand reputation. Indeed, even with homogeneous retail services, the brand reputation effect acts as a product differentiator. Other things being equal, an MVNO with a "greater" brand reputation is hypothesized to have more "sticky" customers, i.e., customers that are less likely to reduce demand, or reduce demand less, when the mobile service sold by that MVNO experiences a price increase (such as when the host MNO itself increases the price of the retail service that the MVNO buys at wholesale from that MNO). Under these conditions, the MVNO reduces its own wholesale demand less than it would with less sticky customers, i.e., with a smaller brand reputation effect.

perfectly elastic. In general, that would be the case when there is unbounded competition for the provision of the wholesale service (perhaps because excess network capacity is available from other MNOs and no binding radio spectrum constraint applies).[33] At that limit, the wholesale price is at its minimum, and the MNO can pass on to the MVNO *no* portion of the cost that is unrelated to the wholesale access service itself (i.e., the MVNO pays the lowest possible wholesale price). At the opposite end, as ε_W^M declines (in absolute value), the wholesale discount rate falls and the wholesale price rises.[34] This implies that competitive availability of the wholesale service, *ceteris paribus*, ensures the greatest MVNO participation. In addition, the MNOs facing the highest price elasticities of demand for the wholesale access service are more likely to offer the greatest wholesale discounts to attract MNOs.

Even then, the extent to which the wholesale discount can fall (and the wholesale price can rise) is limited by how much the price elasticity ε_W^M itself can decline. Even if the MNO is a monopoly provider of the wholesale service, it will only operate profitably where its price elasticity of demand remains above one in absolute value (i.e., in the elastic range). However, under some circumstances, the wholesale discount rate can fall to zero *well before* ε_W^M declines to around –1 in value.[35]

From (5), the MNO's profit-maximizing retail price is a function of the quantities sold at both retail and wholesale, the incremental (or average) costs to provide the retail and wholesale services, the own-price elasticities faced by the MNO for both sets of services, and the cross-price elasticity faced by the MNO between the two sets of services. Various special cases can be derived from this general solution for the retail price.[36]

The more general result when the MNO engages in both retail and wholesale operations is as follows. Any attempt by the MNO to raise its retail price can (through the wholesale discount) cause the price of the MVNO's retail service to rise as well. This can have both a direct and an indirect effect on the demand for the MNO's services. First, the demand for the MNO's retail service is likely to fall in response to a higher retail price. Additionally, because that price increase is passed on to the MVNO's retail price causing some contraction in demand for the MVNO's retail service, the demand for the MNO's wholesale service is likely to fall as well. This linkage of sales and earnings between the MNO's retail and wholesale services is familiar. In the context of fixed-line telecommunications, Weisman (1995, 1998) found that just such a linkage accounts for the vertically-integrated incumbent's incentive to *lower* the retail price in order to stimulate demand for its wholesale service, particularly if it has a relatively low retail market share but a relatively high share (or absolute control) of the upstream wholesale market.

In the present context, however, another factor comes into play: while a higher retail price can dampen retail demand to some degree (and lower demand for the wholesale service in the process), the MVNO's brand reputation and cross-selling ability can also act as a mitigating factor. If this happens, then the original attempt by the MNO to charge a higher retail price may, with the help of the MVNO's brand reputation effect, actually be "sustainable" by producing a smaller suppression of MVNO demand for the wholesale service than without that effect. This brand reputation effect, which (as explained earlier) manifests itself in a lower absolute value of the cross-price elasticity ε_W^M, mitigates the loss of demand for the wholesale service, and that mitigation is stronger as the brand reputation effect is itself greater.[37]

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33 This finding is important because it suggests that the strength of *retail* competition alone among MNOs is not a sufficient indicator of likely MVNO participation. As Dewenter and Haucap (2007) report, the Spanish regulatory authority (CMT) has adopted a policy—endorsed by the European Commission—to mandate that MNOs grant access to MVNOs. Our results suggest that the emphasis in such a policy may be in the wrong place—strong *wholesale* competition among MNOs (which requires incentives for the MNOs to invest in their networks) can create conditions for MVNO entry *even when* retail competition among MNOs is not particularly strong.

34 This result may be compared to the findings of Sand (2003) and Mandy (2001) who recommend that the optimal price of wholesale access (provided by a vertically-integrated monopolist) must be set above incremental cost if non-price discrimination in the downstream retail market is possible, but that markup can be lower as discrimination becomes impossible (such as when competitive conditions prevail for both wholesale and retail services).

35 Simulations show that the wholesale discount rate can fall to zero at ε_W^M values that exceed (in absolute value) the lower bound of -1 for realistic operation of a profit-maximizing monopoly. For example, when the retailing/marketing cost markup over the retail price is 30 percent, the wholesale discount rate goes to zero at $\varepsilon_W^M = -3.4$. In general, the higher (lower) is that percentage markup, the lower (higher) is the value of ε_W^M at which the wholesale discount rate reaches zero.

36 First, when the MNO is a price-taker in the wholesale market (i.e., $|\varepsilon_W^M| \to \infty$), the profit-maximizing markup in its retail price remains positive but at its lowest level. That markup grows as the strength of wholesale competition diminishes, i.e., the MNO's price elasticity of demand for the wholesale service falls in absolute value. Second, when the MNO reverts back to pure retail operation, i.e., withdraws from providing a wholesale service to a reseller or MVNO, its profit-maximizing retail price also reduces to the level determined by the familiar inverse elasticity rule.

37 The MVNO's extraneous asset—its brand reputation—separates it from an ordinary reseller as follows. When the MNO raises the retail price (forcing the MVNO or reseller to follow suit), the suppression of demand that results affects both the MNO and the MVNO or reseller. However, unlike an ordinary reseller in the same circumstances, the MVNO can weather the suppression of retail demand better and is likely to reduce its demand for the MNO's wholesale service *less* than would the reseller. This implies a lower value for the cross-price elasticity ε_{WR}^M in an MNO-MVNO partnership than in an MNO-ordinary reseller relationship. Note that a similar effect is likely to be induced when the MVNO relies not on (or only on) its brand reputation but rather on its offering of innovative services that customers value highly, i.e., of services strongly differentiated from those of the host MNO. Under resale, achieving such differentiation is difficult, if not impossible. An ordinary reseller that can succeed at it, however, is likely to benefit from sticky customers in the same way that MVNOs can by relying on their brand reputation.

The comparative retail price and profit performance of the MNO with and without the MVNO

Is the MNO's profit-maximizing retail price likely to be higher or lower under combined retail and wholesale operations (specifically, in a relationship with an MVNO) as opposed to pure retail operation? In which scenario is it likely to make the greater profit? Intuitively, it would seem that because of the demand mitigation provided by the MVNO's brand reputation effect, the MNO does not need to raise its retail price as much to maximize its profits when it sells a wholesale service as when it does not. However, as discussed next, this result is not generally true—such as when the elasticity of demand for the MNO's wholesale service is "low" (i.e., when the MNO provides wholesale access in less-than-competitive conditions).

In general, whether the MNO charges a higher retail price when it partners with an MVNO than when it supplies only the retail service depends on several demand and supply parameters. For example, outside of the special cases discussed above, the difference between the MNO's profit-maximizing retail prices with and without an MVNO partnership depends on the magnitudes of the price elasticities of demand for both retail and wholesale services and the cross-price elasticity between the two (reflecting, in part, the brand reputation effect). Denoting the profit-maximizing retail price under pure retail operation by P^*_{R1} and that under combined retail-wholesale operations (the MNO-MVNO relationship) by P^*_{R2}, it can be shown that

$$P^*_{R2} - P^*_{R1} = \frac{(C_R - C_W)\varepsilon^M_W(1+\varepsilon^M_R) - C_R\varepsilon^M_R(1+\varepsilon^M_{WR})}{(1+\varepsilon^M_{WR}) - \frac{q_R}{q_W}(1+\varepsilon^M_R)(1+\varepsilon^M_W)} \quad (6)$$

For plausible values of the three elasticities, that difference of prices can be either negative or positive. That is, in general, there is no clear indication of whether the profit-maximizing price will *inevitably* be higher with an MNO-MVNO partnership or without one.[38]

Figure 1 shows this property under different configurations of the price elasticities and the ratio of the wholesale quantity sold to the retail quantity sold. Specifically, three curves are shown

corresponding to three different values of the cross-price elasticity ε^M_{WR} ("high," "medium," and "low"). Those curves are steepest (have the greatest slope) when ε^M_{WR} is "high," but become flatter for lower values of that elasticity. In the region *above* any curve (corresponding to a given value of ε^M_{WR}), the MNO's profit-maximizing retail price is higher when it forms a partnership with an MVNO than when it does not. The opposite is true in the region *below* any curve.[39] The former region (in which the retail price is higher under an MNO-MVNO partnership) is larger compared to the latter region (in which the retail price is lower under an MNO-MVNO partnership) as gets progressively smaller in absolute value, i.e., the brand reputation effect is stronger.

Figure 1. **MNO's profit-maximizing retail price outcomes with and without MNO-MVNO partnership**
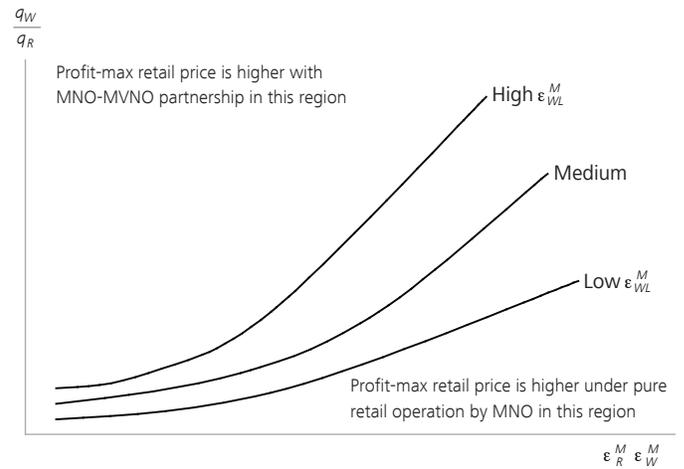
The effect of the MVNO's brand reputation is of special interest. If greater brand reputation produces a lower absolute value for the cross-price elasticity ε^M_{WR}, and the two own-price elasticities (ε^M_R and ε^M_W) do not exceed one in absolute value by very much, the denominator in (6) can conceivably be positive. In those circumstances, the MNO can charge a higher profit-maximizing price than under pure retail operation. Intuitively, although a higher retail price may suppress the MNO's *own* demand, the MVNO's "high" brand reputation can help to substantially offset whatever

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38   The MVNO's profit-maximizing retail price need not *necessarily* move in lockstep with the MNO's profit-maximizing retail price. Even if it does, and rises with any increase in the MNO's retail price, the usual negative *consumer* welfare effects associated with a higher price and curtailed output may not be inevitable. Rather, the product-differentiating (and value-enhancing) effects of the MVNO's brand reputation and innovative service may boost welfare in ways that offset welfare losses from a higher price and curtailed output. Therefore, the *net* consumer welfare effects of higher and co-trending MNO and MVNO retail prices under an MNO-MVNO partnership are ambiguous at best.

39   Each curve is thus a locus of points representing a zero difference between the profit-maximizing prices in the two situations (with and without an MNO-MVNO partnership), for a given value of ε^M_{WR} and strictly positive q_W (note that the price difference is trivially zero when $q_W = 0$, i.e. when the MNO reverts to pure retail operation). As expected, for a fixed value of the wholesale-retail quantity ratio, higher magnitudes of the two own-price elasticities tend *after a point* to produce a higher profit-maximizing price in the scenario with no MNO-MVNO partnership (i.e., under pure MNO retail operation). Conversely, for fixed elasticities, higher ratios of wholesale to retail sales by the MNO tend *after a point* to be associated with a higher profit-maximizing price under an MNO-MVNO partnership.

loss of demand the MVNO faces because of its higher retail price. As a result, the minimal suppression of demand for its own wholesale service enables the MNO to maximize its profits while charging a higher retail price. Without the MVNO's brand reputation effect, however, the MNO may well be better off charging a lower profit-maximizing price (perhaps even lower than under pure retail operation) while partnering with the MVNO.[40]

The MNO's profit performance with and without an MVNO relationship is ambiguous as well. Denoting the maximized profit under pure retail operation by π_1^{M*} and that under combined retail-wholesale operations (the MNO-MVNO relationship) by π_2^{M*}, it can be shown (after some tedious algebra) that the difference between the two profit levels is a complicated function of the quantities sold of wholesale and retail services, the incremental costs to provide both services, and the three price elasticities.[41] In other words, the exact outcome can only be determined empirically. Assuming plausible values for the elasticities and quantities, it can be shown that the MNO's profit when partnering with an MVNO can actually be greater when the MVNO's brand reputation effect is strong and cross-price elasticity ε_{WR}^M is "low." In other words, whenever engaging *voluntarily* in an MNO-MVNO relationship helps to expand the MNO's profits, such a relationship is likely be in the MNO's best interest. Without the brand reputation effect working in that fashion, however, voluntary engagement of this sort is unlikely, explaining why an MNO may not partner with an ordinary resale-based downstream competitor.

This finding has an interesting policy implication: a *mandatory* MNO-MVNO relationship arising from a policy that *requires* the MNO to provide the MVNO access to its network can actually backfire in some circumstances. For plausible configurations of the price elasticities, an MNO's profits can actually be lower under combined retail-wholesale operations. Accordingly, an MNO may strongly resist any policy that compels it to provide access to an aspiring MVNO if it expects to be worse off as a result of that relationship. Moreover, unless the MVNO can gain at least as much in profits as the MNO stands to lose in those circumstances, other things being constant, aggregate social welfare can also suffer from any mandatory open access policy.[42]

Profit maximization with differentiated retail services

We now examine a more refined base case scenario in which the MNO offers two levels (or varieties) of retail service (i.e., it offers differentiated, rather than homogeneous, services). We continue to assume that the MNO has no upstream market operations and provides no wholesale service to a reseller or an aspiring MVNO in the downstream retail market. In this scenario, the differentiation may take the form of an "upper range" retail service (*U*, such as a high-ARPU postpaid service) and a "lower range" retail service (*L*, such as a low-ARPU prepaid service).[43] The MNO is a price-setter for both services and sets prices (P_U and P_L, respectively) to maximize its joint profits from those services. The services are not perfect substitutes and the cross-price elasticities between them are not necessarily symmetric. Thus, the MNO's objective is

$$\text{Max}_{\{P_U, P_L\}} \pi^M = (P_U - C_U)q_U(P_U, P_L) + (P_L - C_L)q_L(P_L, P_U) \qquad (7)$$

Solving the usual first-order conditions for this maximization problem yields the MNO's two profit-maximizing prices:

$$P_L^* = \frac{1}{\Phi}\left[C_L\left\{\varepsilon_L^M(1+\varepsilon_U^M) - \varepsilon_{LU}^M\varepsilon_{UL}^M\right\} + C_U\left\{\varepsilon_{UL}^M(1+\varepsilon_U^M) - \varepsilon_U^M\varepsilon_{UL}^M\right\}\frac{q_U}{q_L}\right] \quad (8)$$

and

$$P_U^* = \frac{1}{\Phi}\left[C_U\left\{\varepsilon_U^M(1+\varepsilon_L^M) - \varepsilon_{LU}^M\varepsilon_{UL}^M\right\} + C_L\left\{\varepsilon_{LU}^M(1+\varepsilon_L^M) - \varepsilon_L^M\varepsilon_{LU}^M\right\}\frac{q_L}{q_U}\right] \quad (9)$$

where $\Phi = (1+\varepsilon_U^M)(1+\varepsilon_L^M) - \varepsilon_{LU}^M\varepsilon_{UL}^M$.

These solutions show that the two profit-maximizing prices depend on the quantities sold of the two services (q_U and q_L), their respective incremental costs (C_U and C_L), own-price elasticities (ε_U^M and ε_L^M), and cross-price elasticities (ε_{UL}^M and ε_{LU}^M) that need not be equal.

Profit maximization with wholesale discount and trade-off in sale of differentiated retail and wholesale services

The more interesting insights come from extending this base case scenario to include, as before, wholesale operations by the MNO that are likely to attract MVNO entry. Specifically, we assume that

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40   Since an MVNO without a brand reputation is, in effect, no different from an ordinary reseller, this result of seeking a *lower* profit-maximizing retail price under combined retail-wholesale operations is exactly that posited by Weisman (1995, 1998) in the context of vertically-integrated fixed line operators. A deviation from this finding (in the direction of a *higher* and sustainable profit-maximizing retail price) thus depends critically on a strong brand reputation effect—uniquely a property of MVNOs.

41   See Banerjee and Dippon (2007), equation (7).

42   Dewenter and Haucap (2007) identify insufficient market size, "high" fixed cost to establish an MNO-MVNO relationship, and insufficient product differentiation as factors that limit MNO interest in voluntary partnerships.

43   Another example would be of a voice-only service as distinct from a bundle of voice and data services.

only the lower-range (or *L*) service is available from the upstream wholesale market at a price set by the MNO by applying a wholesale discount to *L*'s retail price. The MNO remains the sole provider of the upper-range (or *U*) service, i.e., it does not offer *U* on a wholesale basis.[44] As before, the MNO's sales of the wholesale service are influenced, at least in part, by the brand reputation effect of MVNO operations.

With combined retail-wholesale operations, the MNO's objective now is

$$\underset{\{P_U, P_L, \phi\}}{\text{Max }} \pi^M = (P_U - C_U)q_U(P_U, P_L) + (P_L - C_L)q_L(P_L, P_U)$$
$$+ [(1 - \phi)P_L - C_W]q_W(P_W(\phi), P_L; \tau) \qquad (10)$$
$$- (P_R - C_R)q_W(P_W(\phi), P_L; \tau) - (P_L - C_L)q_W(P_W(\phi), P_L; \tau)$$

Solving the first-order conditions for the maximization problem yields the profit-maximizing levels of the wholesale discount rate and the two retail prices. Again, the MNO's profit-maximizing prices for the *L* and *U* services are complicated functions of the incremental costs of the two retail services and the wholesale service, the quantities sold of the three services, and six price elasticities (three own-price and three cross-price, including that of the wholesale service with respect to the retail price of *L*).[45] Despite the apparent complexity, however, the solutions for the profit-maximizing prices reduce to simple and standard results under certain restrictions.

For example, if the *U* and *L* services are not substitutes in either direction (i.e., $\varepsilon_{UL}^M = 0$ or $\varepsilon_{LU}^M = 0$, or both), then the markets for the two services are, in effect, separable from the standpoint of the MNO's operations. Then, the MNO's profit-maximizing price for the *U* service is simply $P_U^* = C_U \dfrac{\varepsilon_U^M}{1 + \varepsilon_U^M}$, which leads to the familiar

inverse-elasticity rule for U, irrespective of the supply and demand conditions prevailing for *L* at both retail and wholesale levels. Also, it follows that $P_U^* \to C_U$ as $|\varepsilon_U^M| \to \infty$ (i.e., as competition for the *U* service increases indefinitely and the MNO goes from being a price-setter for it to being a price-taker).

In contrast, when there is no substitutability between *L* and *U* in either direction, the profit-maximizing price for *L* reduces to

$$P_L^* = C_L \, \frac{(\varepsilon_{WL}^M - \varepsilon_W^M)q_W - (1 + \varepsilon_W^M)\varepsilon_L^M q_L}{(1 + \varepsilon_{WL}^M)q_W - (1 + \varepsilon_W^M)(1 + \varepsilon_L^M)q_L},$$

which is a function of the quantities sold of both retail and wholesale versions of the service, the incremental cost to provide L, and three price elasticities (own-price for retail L, own-price for the wholesale version of L, and cross-price between the wholesale version of *L* and the retail price of L). Even this result reduces, however, to the standard inverse-elasticity rule for *L* if the MNO stops wholesale operations altogether.

Finally, it follows from the general solution for the wholesale discount rate[46] that its profit-maximizing $\phi^* \to = \dfrac{C_L - C_W}{P_L}$

as $|\varepsilon_W^M| \to \infty$. This is the analogous result in the wholesale market where, as competition increases indefinitely and the MNO becomes a price-taker, the profit-maximizing wholesale discount rate settles at its peak level, i.e., the pure retailing/marketing cost as a percentage of the retail price for the *L* service (a result also seen for the simplest MNO model).

Comparative profit performance of MNO with and without MVNO

As before, in examining why a voluntary MNO-MVNO relationship may exist with differentiated retail services, it is important to examine whether—and under what conditions— the MNO stands to gain from such a relationship. Evaluation of the MNO's profits in this scenario, with and without a relationship with an MVNO, is a complicated and, ultimately, an empirical matter. As before, it can be shown (after some tedious algebra) that the difference in profits between combined retail-wholesale operations and pure retail operations is a complicated function of retail and wholesale quantities, incremental costs, and own- and cross-price elasticities.[47]

The bottom line is that many of the insights gained from the scenarios with homogeneous services continue to apply with differentiated services. The most important of these is that the MNO's profits from the MNO-MVNO relationship is actually likely to be greater than that under pure retail operation when, along with other factors, the cross-price elasticity of the wholesale service with respect to *L*'s retail price, i.e., ε_{WL}^M, is low (or, at least, in the inelastic

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44   This only rules out retail competition based on resale of the MNO's *U* service. It does not, however, necessarily preclude competition from substitute services offered by other facilities-based MNOs.

45   See Banerjee and Dippon (2007), equations (13)-(14).

46   See Banerjee and Dippon (2007), equation (12).

47   *Id.*, equation (15).

range).[48] This cross-price elasticity reflects, in part, the brand reputation effect. To the extent that the cross-price elasticity can actually be estimated in a given market from empirical data, a testable proposition would be that the elasticity is lower with MVNO entry than it is with ordinary resellers alone.

Practical implications

Although the implications of our theoretical analysis can only be verified empirically, in reality, any such empirical analysis is likely to be arduous, if not impossible. For example, while retail and wholesale sales information for various mobile services may be available from the MNOs, it can be more difficult to identify the incremental costs of specific services, particularly when they are offered by multiproduct firms with substantial joint or shared costs. Reliably estimating market price elasticities (both retail and wholesale) can be even more difficult because of onerous data requirements. The concept of the "unit price" itself is problematic when mobile carriers employ a variety of pricing formulas, including price per minute, flat-rated pricing, multi-part or nonlinear tariffs, etc. If there is inadequate price variation, or prices move in unison (such as when carriers make parallel price adjustments), price elasticities—especially cross-price elasticities—are difficult to estimate reliably. We believe that the cross-price elasticity of demand for the MNO's wholesale service with respect to its retail price is a critical parameter because of the hypothesized brand reputation effect. We expect such an effect to be manifested in low values for that cross-price elasticity but cannot be sure of being able to test that belief empirically.

If what we conclude about the MVNO's brand reputation effect and its consequences for the cross-price wholesale-retail elasticity is true, then does it follow that voluntary MNO-MVNO partnerships may not emerge when that cross-price elasticity is high? Again, although an empirical test is hard to implement, a high cross-price elasticity can conceivably be an impediment to a voluntary MNO-MVNO partnership. That is, the probability of observing a high cross-price elasticity and a voluntary MNO-MVNO partnership at the same time is likely to be low, although it can be hard to test for

that possibility.[49] Regardless, it is possible to speculate on the circumstances in which the cross-price elasticity is high or, equivalently, a significant hurdle exists to the formation of a voluntary MNO-MVNO relationship.

The cross-price elasticity is likely to be high in the absence of a proven brand reputation effect. An aspiring MVNO may attempt to leverage its brand appeal in non-telecommunications markets to cross-sell mobile services, but that appeal alone may not be sufficient tp succeed as an MVNO. The brand reputation effect is not observable *ex ante*, just as the cross-price elasticity cannot be measured before wholesale transactions between the MNO and MVNOs actually occur. The failure of Mobile ESPN only eight months after launch as an MVNO is a reminder that even MNOs, privy to private data on themselves and the MVNOs with whom they wish to partner, cannot be entirely sure about the MVNOs' ability to successfully convert their brand appeal from other lines of business into mutually beneficial partnerships.[50]

The cross-price elasticity is also likely to be high when the services that the MVNO plans to offer are not sufficiently differentiated from those that the MNO already offers. It is theoretically possible for a brand reputation effect to occur when the services are homogeneous or near-perfect substitutes, but the prospects for market widening and deepening are better with product (or service) differentiation.

Finally, a high cross-price elasticity is likely when the upstream market for the wholesale access service is not competitive or, equivalently, wholesale discounts available from the MNO are too small to make resale-based operation more attractive than facilities-based competition. In those circumstances, any attempt by the MNO to raise the retail price in the downstream market will necessarily raise the MVNO's retail price as well and cause a general suppression of retail demand. Any mitigation of that suppression from a brand reputation effect will be weak at best if high wholesale prices make the MVNO commercially unviable as a resale-based operation.[51]

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48   The accompanying requirements are: (1) the MNO's ratio of wholesale to retail sales of the *L* service must be "sufficiently small" and (2) the two own-price elasticities associated with the *L* service, i.e., ε_L^M and ε_W^M, must be "sufficiently large" in absolute value. Collectively, these create a set of sufficient conditions for the MNO's profits with differentiated services to be higher in an MNO-MVNO relationship than under pure retail operation.

49   In our analytical approach, a high cross-price elasticity connotes a low brand reputation effect and is, therefore, a weak agent for product differentiation even when the underlying retail service is homogeneous. The finding that an MNO has little economic incentive to grant access to an MVNO in that circumstance parallels that in Dewenter and Haucap (2007) who show that any such incentive is weak when competition occurs with little product differentiation.

50   Mobile ESPN was launched in February 2006 by the Walt Disney Company with the aim to capitalize on both the Disney brand and, more specifically, the appeal of ESPN (a Disney property) to sports fans. However, in late September 2006, Disney decided to shut Mobile ESPN down and license its content instead to MNOs. It appears that a combination of unattractively priced handsets, limited choice of handsets, lack of experience with mobile services, etc. resulted in the number of customers that signed up falling far short of that expected. See, e.g., Hau (2006).

51   As mentioned earlier, MVNOs with no facilities of their own may bear a surface resemblance to ordinary resellers but are distinguished from them by the all-important asset of brand appeal and cross-selling ability. Like all resale-based operators, an MVNO must still first determine whether paying a wholesale price that includes some markup or premium can place it at a disadvantage when competing in the downstream retail market. Unless it has compensating retailing-related efficiencies of its own, resale-based entry is likely to be deterred as a result. A competitive or near-competitive market for wholesale access in which the MNO is content with earning positive, but small, profit margins is actually likely to encourage MVNO participation and benefit both the MNO and the MVNO.

Conclusions

This paper explored why and how MNOs voluntarily provide wholesale access to MVNOs and engage in strategic partnerships that are evidently mutually beneficial. In the real world, the very fact that such voluntary relationships have developed signifies that profit-pursuing MNOs have an economic interest in partnering with MVNOs, particularly those that have high brand reputations or can develop highly-valued innovative services. The spontaneous emergence of these voluntary relationships is puzzling at first glance because, after all, MVNOs siphon off some sales from their host MNOs. However, our analysis explains such behavior by the fact that MVNOs add value (principally through their brand reputations) in ways that mere resellers cannot and, therefore, help to boost the profitability of MNOs under certain demand and sales conditions.

A caveat is, however, in order. Because the formal analysis relies solely on sufficient conditions to determine the range of values for the elasticities and the sales quantities that can lead to greater profit from a voluntary MNO-MVNO relationship, such an outcome need not be universally true. That is, under certain configurations of elasticities and sales quantities, the MNO-MVNO relationship may actually prove to be inferior from a profitability perspective. In those circumstances, a voluntary MNO-MVNO relationship may not emerge in the market and any policy imperative that *mandates* one will only produce an inferior outcome from the standpoint of economic welfare. This conclusion is crucial and needs to be explored further in the context of overall telecommunications regulatory policy.

If the emergence of voluntary MNO-MVNO relationships signifies that market conditions favoring such a development (given by our sufficient conditions) exist and have been discovered, then what explains the fact that such relationships have not yet formed in many markets or countries? More importantly, should public policy (such as an open access obligation for MNOs) then aim at creating mandated MNO-MVNO relationships in those markets and countries?

Answering these questions is not easy, given that the conditions identified for voluntary MNO-MVNO relationships (based on mutual profitability) are both complicated and merely sufficient (but not necessary). A simple explanation may be that the sufficient conditions (competitive wholesale markets, strong brand reputation effects, certain configurations of price elasticities and MNO shares of the wholesale market, etc.) do not yet exist or that potential MVNOs and host MNOs have not yet discovered them. An alternative explanation may be that MNOs deliberately manipulate the market or exercise market power. If that explanation is true, then public policy can have a legitimate role for facilitating MVNO entry. However, even then, it may not be apparent why MNOs would choose to abuse their market power (if they possess any) when the option to partner voluntarily and profitably with MVNOs is also available. Anti-competitive and discriminatory behavior is not costless to incumbent MNOs, and several pre-conditions must exist for such behavior to prove profitable. The high probability of detecting some of those pre-conditions (which can be monitored independently) has to be factored in as well.

Regulators generally agree that the market itself (through commercial negotiations and legal enforcement) should be able to regulate the provision and growth of MVNO services. In most countries with MVNOs, regulators have refrained from mandating that MNOs grant MVNOs open access to their networks. However, some governments (mainly in countries with no MVNOs) have either imposed or considered imposing an open access obligation on MNOs. In support of both types of decisions, regulators frequently cite welfare-enhancing objectives, such as increased competition, consumer choice, lower retail prices, innovation, service diversity, and more efficient use of scarce spectrum resources. The benefits cited may or may not themselves be in dispute; however, whether mandatory policies should be used to secure them is far from certain. When voluntary MNO-MVNO relationships do not form because favorable sufficient conditions do not exist, no economic welfare gain can accrue from forcing such relationships to exist. On the other hand, if proven discriminatory behavior or abuse of market power is the real cause behind a lack of MVNO entry, then entry-facilitating policies (even those that place mandates on previously unregulated MNOs) may be justified. From a public policy perspective, the primary difficulty lies with determining which of these two alternative circumstances prevails. As we noted earlier, tests to detect whether or not all of the conditions exist for voluntary MNO-MVNO relationships to form may be hard to conduct. The best that policymakers can do is monitor and analyze market conditions as assiduously as possible and systematically rule out acts of discrimination as proximate causes for the lack of MVNO entry.

Based on the theoretical explorations in this paper, our general recommendations are twofold. First, the default regulatory policy should be to encourage the *voluntary* formation of MNO-MVNO relationships. If the prerequisites exist in the market for such relationships (such as the availability of wholesale mobile access or an effectively competitive mobile retail market), then no regulatory

intervention may be called for, even if some or all aspiring MVNOs are unable to privately reach agreement with existing MNOs.[52]

Second, if neither the upstream wholesale access market nor the downstream retail market for mobile services functions competitively, then the appropriate regulatory response should be to address the root cause of the problem. If, for example, the problem is one of market power—whether exercised individually by a single dominant MNO or collectively by a number of MNOs[53]—then antitrust or competition enforcement policies should tackle the market power problem directly, but stop short of a blanket *ex ante* mandatory rule that requires MNOs to grant open access to their networks. Regulatory policy would be better directed instead at creating and helping to maintain reasonably competitive wholesale access markets by (1) ensuring efficient *retail* competition, (2) preventing the exercise of individual or collective market power, (3) permitting spectrum trading to enable more efficient access to, and use of, spectrum resources,[54] and (4) using spectrum caps to prevent anti-competitive MNO concentrations.[55]

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52 In July 2004, Finland's regulatory authority, Ficora, found the "market" for wholesale mobile access in Finland to be imperfectly competitive—primarily because the MNO TeliaSonera had a dominant market position (60% market share)—and proposed imposing an open access obligation on TeliaSonera and other MNOs. Subsequently, in rejecting Ficora's findings and proposed remedies, the European Commission concluded that there were no demonstrable capacity constraints on Finland's mobile networks and MVNOs and independent service providers had been able to privately reach commercial agreements with MNOs. In the Commission's view, a dominant market share for TeliaSonera notwithstanding, Ficora had failed to prove the existence of significant market power and had overlooked the success with which MVNOs had found host MNOs on their own. See European Commission (2004).

53 Some observers of wireless telecommunications believe that MNOs routinely engaged in tacit coordination (or collusion) during the formative years of that segment of the industry. In recent years, with entry by more MNOs and a change from "beauty contests" to competitive auctions for allocating spectrum, there have been fewer serious allegations of such anti-competitive behavior. Others contend that seemingly high and stable prices for mobile services have been directly caused by regulation itself. See a review by Gans *et al*. (2005).

54 Noam (1997), Valetti (2001).

55 Cramton (2002).

References

Banerjee, A., and Dippon, C.M. (2007). "Voluntary Relationships Among Mobile Network Operators and Mobile Virtual Network Operators: An Economic Explanation," mimeo (available from authors on request).

Beard, T.R., Kaserman, D.L., and Mayo, J.W. 1999. "Regulation, Vertical Integration, and Sabotage," Auburn University Working Paper (March).

Bernheim, B.D. and Willig, R. 1996. *The Scope of Competition in Telecommunications*, monograph, American Enterprise Institute Studies in Telecommunications Deregulation (October).

Cramton, P. 2002. "Spectrum Auctions," in Cave, M.E., Majumdar, S.K., and Vogelsang, I. (eds.), *Handbook of Telecommunications Economics*, Volume 1, Amsterdam: Elsevier Science B.V., 605-639.

Dewenter, R. and Haucap, J. 2007. "Incentives to License Virtual Mobile Network Operators (MVNOs)," in Dewenter, R. and Haucap, J. (eds.), *Access Pricing: Theory and Practice*, Amsterdam: Elsevier B.V., 303-323.

Dippon, C., and Banerjee, A. 2006. *Mobile Virtual Network Operators: Blessing or Curse?* White Plains, NY: NERA Economic Consulting.

Economides, N. 1998. "The Incentive for Non-Price Discrimination by an Input Monopolist," *International Journal of Industrial Organization*, 16, 271-284.

European Commission. 2004. Commission Decision of 5 October 2004 pursuant to Article 7(4) of Directive 2002/21/EC ("Withdrawal of a notified draft measure"). Case FI/2004/0082: Access and Call Origination on Public Mobile Telephone Networks in Finland.

Federal Communications Commission. 1996. In the Matter of Interconnection and Resale Obligations Pertaining to Commercial Mobile Radio Services, *First Report and Order*, 11 FCC Rcd 18455, 18457.

Gans, J.S., King, S.P. and Wright, J. 2005. "Wireless Communications," in Majumdar, S.K., Vogelsang, I., and Cave, M.E. (eds.), *Handbook of Telecommunications Economics*, Volume 2, Amsterdam: Elsevier Science B.V., 241-285.

International Telecommunication Union. 2006. *World Telecommunication/ICT Indicators*, Geneva: ITU.

Lewis, T., and Sappington, D.E.M. 1999. "Access Pricing with Unregulated Downstream Competition," *Information Economics and Policy*, 11, 73-100.

Mandy, D.M. 2000a. "Progress and Regress on InterLATA Competition," *Federal Communications Law Journal*, 52, 321-379.

Mandy, D.M. 2000b. "Killing the Goose that May Have Laid the Golden Egg: Only the Data Know Whether Sabotage Pays," *Journal of Regulatory Economics*, 17, 157-172.

Mandy, D.M. 2001. "Price and Vertical Control Policies for a Vertically Integrated Upstream Monopolist When Sabotage is Costly," University of Missouri Working Paper (December).

Mandy, D., and Sappington, D.E.M. 2000. "Incentives for Sabotage in Vertically-Related Industries," Manuscript (June).

Noam E. 1997. "Beyond Spectrum Auctions—Taking the Next Step to Open Spectrum Access," *Telecommunications Policy*, 21, 461-475.

Reiffen, D. 1998. "A Regulated Firm's Incentive to Discriminate: A Reevaluation and Extension of Weisman's Result," *Journal of Regulatory Economics*, 14, 79-86.

Sand, J.Y. 2003. "Regulation and Foreclosure," NCFS Working Paper Series in Economics and Management, University of Tromso, Norway, No. 09/03 (December).

Sibley, D.S., and Weisman, D.L. 1998a. "The Competitive Incentives of Vertically Integrated Local Exchange Carriers: An Economic and Policy Analysis," *Journal of Policy Analysis and Management*, 17, 74-93.

Sibley, D.S., and Weisman, D.L. 1998b. "Raising Rivals' Costs: The Entry of an Upstream Monopolist into Downstream Markets," *Information Economics and Policy*, 10, 451-470.

Valetti, T. 2001. "Spectrum Trading," *Telecommunications Policy*, 25, 655-670.

Weisman, D.L. 1995. "Regulation and the Vertically Integrated Firm: The Case of RBOC Entry into InterLATA Long Distance," *Journal of Regulatory Economics*, 8, 249-266.

Weisman, D.L. 1998. "The Incentive to Discriminate by a Vertically-Integrated Regulated Firm: A Reply," *Journal of Regulatory Economics*, 14, 87-91.

Weisman, D.L., and Kang, J. 2001. "Incentives for Discrimination When Upstream Monopolists Participate in Downstream Markets," *Journal of Regulatory Economics*, 20, 125-139.

Web References

Hau, L. 2006. "Mobile ESPN Bites the Dust," Forbes.com, September 28. Available at http://www.forbes.com/technology/2006/09/28/mobile-espn-disney-killed-tech-media-cx_lh_0928espn.html.

Takashi Mobile MVNO/SP list, 2006: http://www.takashimobile.com/mvno.html.