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Abstract

This paper examines the preferences of a foreign firm and a welfare-maximizing host country government over two modes of foreign direct investment (FDI): de novo entry by the foreign firm and acquisition of the domestic incumbent. Two crucial features of the model are the presence of network externalities and (endogenously determined) partial incompatibility between the technology of the domestic incumbent and that introduced by the foreign firm. The relative impact of the modes of entry on local welfare is determined by the degree of competition (more intense under de novo entry) and the magnitude of the positive network externality (greater under acquisition). The clash between the foreign firm's equilibrium choice and the local government's ranking of the two modes of entry might be a potential motivation for policy restrictions that limit the degree of foreign ownership.

JEL classification numbers: F13, F23, O32

Keywords: Foreign Direct Investment, Oligopoly, Acquisition, Network Externalities, Technology Transfer, Technical Compatibility.

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1. Introduction

The increased importance of foreign direct investment (FDI) in the world economy is now well recognized. [1] But perhaps what is less appreciated is that a large proportion of FDI occurs via international mergers and acquisitions (M&A) that frequently involve large multinational firms – in fact, market concentration and the prevalence of multinational firms often go hand-in-hand. [2] In recent years, the bulk of cross-border M&A transactions have been in services such as finance, transport, and telecommunications. In fact, the service sector has become the major driving force behind global flows of foreign direct investment (FDI): in 1999, the share of services in the global stock of inward FDI was over 50% in major industrialized countries and over 37% in developing countries (UNCTAD, 2001).

Multiple factors lie behind this increase in FDI in services. Market driven changes have been complemented by policy initiatives: until fairly recently, many countries prohibited FDI in important services such as banking, finance, communications, and transport. At present, while many obstacles to FDI in services have been removed, several important ones remain. Policy restrictions that limit the degree of foreign ownership in services such as telecommunications and finance still persist in many countries. The most frequently observed policy restrictions in basic telecommunications services are those on the number of foreign firms and on the extent of foreign ownership allowed. The pattern of these restrictions differs across countries. At one end, in the Philippines, a high degree of competition co-exists with limitations on foreign equity partnership. Bangladesh and Hong Kong are examples of countries that have no limitations on foreign ownership, but both have monopolies in the international telephony and oligopolies in other segments of the market. Pakistan and Sri Lanka have allowed limited foreign equity participation in monopolies to strategic investors, and deferred the introduction of competition for several years. Korea, however, is allowing increased foreign equity participation more gradually than competition.

An important characteristic of many services markets (e.g., telecommunications, information technology, transport, and banking) is the presence of network effects. For example, the benefit to a consumer of being part of a telecom network depends upon how many other consumers belong to the same network. Given the frequent prevalence of network effects in services markets and the importance

[1] The importance of FDI can be gauged from the fact that sales of subsidiaries of multinational firms now exceed worldwide exports of goods and services. In 1998, the total estimated value of foreign affiliate sales in the world was 11 trillion dollars, whereas the value of global exports was 7 trillion dollars (UNCTAD, 1999). Furthermore, developing countries are increasingly becoming important host countries for FDI: approximately 32 percent of the total stock of FDI today is in developing countries (UNCTAD, 2001).

[2] Global mergers and acquisitions (M&A) rose more than five-fold between 1995 and 2000 (compared to an increase of only 24% during 1990-1995). Even through the 1980s and 1990s, the world economy witnessed major waves of mergers and acquisitions (World Bank, 2003).

of M&As as a vehicle for FDI, the effects of the entry of multinationals in services markets (as well as of the policy restrictions faced by them) on market participants and aggregate local welfare deserve investigation.

This paper has two objectives. First, it develops a duopoly model that examines a foreign firm's choice between de novo entry and the acquisition of its local rival when the product market is characterized by network externalities and the degree of compatibility between products is endogenously determined.[3] Second, it explores the welfare impact of such entry and asks whether the potential clash between market equilibrium and local welfare can shed light on some policy restrictions that confront foreign investors in services. In particular, we examine restrictions on the degree of foreign ownership permitted by the local government.

Under de novo entry, the foreign firm establishes a new firm (a wholly owned subsidiary in the host country market) that competes with the local incumbent. Under acquisition, the (new) merged firm operates as a two-product monopolist.[4] The technological know-how controlled by the foreign firm allows it to choose the degree of compatibility between the two products under either entry mode. Specifically, the foreign firm can make an investment that increases the degree of compatibility between the two products. Thus, the foreign firm's entry affects the degree of competition in the host country market and the extent of the network externality enjoyed by the domestic users. However, the relative strengths of these effects depend on the form that entry takes. The competition effect of foreign entry is present only under de novo entry. But one mode does not unambiguously dominate the other in terms of the network externality effect. On the one hand, the relative size of the two networks is closer to the social optimum under acquisition than under de novo entry. On the other hand, the degree of compatibility between the technologies underlying the two networks is greater under de novo entry due to the foreign firm's strategic incentives for compatibility enhancement when competing with the domestic firm. Our results show that divergence between the foreign firm's preferences between the two entry modes and the welfare interest of the host country can create a basis for policy intervention.

One of the frequently cited benefits of foreign direct investment (FDI) is that it is associated with transfer of new generations of technologies and the managerial practices that are needed to make good the profitable opportunities created by these new technologies (Markusen, 1995). However, due to the special

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[3] Our model abstracts from the choice between technology licensing and direct entry (i.e. the internalization issue). For contractual models that explore the internalization question see Ethier (1986), Horstmann and Markusen (1987 and 1996), and Ethier and Markusen (1996).

[4] Therefore, we assume that the merged firm cannot immediately discontinue offering the product based on the domestic technology even though the transferred technology is better. This can be explained by technical and economic considerations (such as users' switching costs). In many countries, there exist laws and regulations aimed at protecting those users who have invested in the incumbent technology from getting stranded. See more on this below.

nature of markets with network effects (such as telecommunications networks) and the high degree of concentration under which multinationals frequently operate, the welfare implications of the adoption of new technologies introduced by them in such markets are not immediately obvious. As is well known, network externalities often lead to user inertia and lock-in. Distortions in the technology adoption pattern among users can be particularly severe if the costs of switching to a new technology are high. Our analysis shows that the welfare effects of technology transfer are sensitive to the degree of compatibility between the domestic and foreign technologies as well as market structure under which the foreign technology is introduced.

The model considered in this paper sheds light on the experience of many developing and transition countries that seek to achieve the modernization of their wireless telecommunications networks. Such countries face the problem of upgrading their incumbent first-generation and second-generation wireless networks to the third-generation high-speed digital wireless standard (3G) suitable not only for voice but also for multimedia applications. While in principle, national operators in these countries can acquire certain elements of the 3G network infrastructure technology on the world market, network operators and equipment manufacturers from industrialized countries possess critical know-how, which can only be obtained only through FDI. [5] To promote the modernization of their telecommunications networks, many governments face a critical policy choice between promoting actual (de novo) entry of foreign firms that have critical expertise in deploying advanced digital network infrastructure, and entry of these firms through acquisition of domestic firms that operate the old-generation wireless networks.

For example, many governments in East Europe (e.g., Russia, Romania, Latvia, Byelorussia), recently began to issue licenses for the introduction of the 3G wireless communication services in the 450 MHz spectrum band presently occupied by wireless operators using the outdated analogue standard called NMT (for Nordic Mobile Telephony). Governments in Argentina, Brazil, Chile, Mexico, and Venezuela recently made similar decisions regarding the modernization of the wireless network deployed in the 800 MHz frequency band, which is occupied by the operators using a second-generation digital standard called Time Division Multiple Access (TDMA). In these East European and Latin American countries, FDI played an important role in the migration of the outdated networks to next generations of communication technology. For example, a U.S. firm holding key patents to a 3G technology based on Code Division Multiple Access protocol (CDMA), Qualcomm Inc, has been acquiring stakes in NMT operators in Romania, Bulgaria, Russia and many of the former Soviet Republics with a goal of migrating them to the third-generation standard CDMA2000. In Latin America, major U.S. and E.U.

[5] Examples of critical know-how that can be transferred only through FDI, include experience in integration and achieving interoperability between legacy networks and new network elements during the migration period (e.g. billing systems), and balancing and optimization of hybrid networks based on a combination of old and new infrastructure equipment.

telecommunications companies with the 3G expertise have been investing in both existing 2G TDMA wireless operators as well as in new 3G license awards employing 800 MHz band.[6]

Despite the advantages of the 3G technology, substantial switching costs make it inevitable that a large number of users in these countries will continue to rely on the outdated 2G mobile terminals and network infrastructure. Therefore, one of the regulatory goals during the period of transition to 3G networks is to ensure that the users who cannot afford to upgrade to the new technology are not stranded. This goal can be attained if during the transition period, new and old elements of the network infrastructure remain interoperable.[7] Since our analysis considers the effects of the foreign firm's entry mode and equity restrictions on FDI in industries with network externalities, it can be useful for guiding policy decisions faced by the regulators overseeing the modernization of wireless communication networks.[8]

Some of the issues addressed here have been studied separately before, but we know of no analytical study of the relationship between technology transfer and mode of FDI (as in de novo entry versus acquisition) in the presence of network externalities.[9] The paper closest to ours is Matto et. al. (2003). This paper studies the preferences of a foreign firm and a welfare-maximizing host country government over de novo entry and acquisition in a Cournot oligopoly in the absence of network effects. Other related papers on international mergers and joint ventures include Svejnar and Smith (1984), Al-Saadon and Das (1996), Roy et al. (1999), and Horn and Persson (2001). We add value to this line of research by examining the role network externalities and endogenous compatibility play in determining the effects of foreign entry on domestic welfare. Existing research, of course, sheds light on issues not captured by our model. For example, unlike us, Svejnar and Smith (1984) focus on the interaction of transfer pricing and local policy. Similarly, Al-Saadon and Das (1996) model an international joint venture in which ownership shares are determined via bargaining while Horn and Persson (2001) provide a novel model of endogenous mergers in which firms can merge both nationally as well as internationally.

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[6] The largest foreign investor in the region, in terms of subscribers, BellSouth, is involved in upgrading TDMA wireless networks in more than a dozen Latin American countries. Other major investors include Spain's operator Telefónica (which acquired most of its cellular affiliates through privatization processes), Verizon Communications and Luxembourg-based international cellular company Millicom. These four companies account for around 60 per cent of all TDMA subscribers in Latin America. A U.S. telecommunication equipment vendor Motorola has been involved in a number of TDMA cellular operators. More recently, a few Canadian and Asian companies -- such as TIW of Canada and DDI of Japan -- have also entered the Latin mobile telephony market (see Blois, 2001.)

[7] Interoperability may range from its crudest form of offering users two phones (one 2G and one 3G) with one number and one bill to deploying infrastructure based on dual-mode 2G/3G base stations and phones. The latter option is more costly but better in terms of preserving network benefits during the transition period.

[8] Although this is the first paper to consider FDI policies in the environment with network externalities, there is literature studying the effects of trade policies and compatibility standards in open economies with network externalities. See, for example, Krishna (1988), Gandal and Shy (2001) and Barrett and Yang (2001).

[9] The literature has tended to focus on licensing and de novo entry where the foreign firm seeks to prevent the dissipation of its technological advantage (see, for example, Ethier and Markusen, 1996, and Markusen, 2001).

The remainder of the paper is organized as follows. Sections 2 and 3 present the theoretical setup and describe the foreign firm's decisions regarding the extent of compatibility between the transferred technology and the incumbent technology. Section 4 analyzes the foreign firm's choice of the mode of entry (acquisition vs. de novo entry) into the host country. Section 5 focuses on welfare analysis. Section 6 draws welfare implications for the host government incentives for policy intervention. Section 7 concludes.

2. A model with demand-side scale economies

The host country's user population is characterized by heterogeneous preferences regarding products *H* and *F* (produced respectively by a home firm and a foreign firm). There is a unit mass of domestic users, each of which has a unit inelastic demand. Each user values compatibility between the product she chooses and the one chosen by other users because compatibility allows her to experience a positive network externality. Users can achieve perfect compatibility only if they adopt the same technology (i.e., products designed by the same firm). The extent of compatibility enjoyed by users of different products is determined by the parameter $\gamma \in [0, 1]$ that represents the fraction of the full compatibility benefit enjoyed by users of the same product.

The users differ in terms of their taste index $S \in [0,1]$ that determines the "stand-alone" value of the product to them (i.e., users' willingness to pay for the product regardless of the network externality). Assuming that the relative preference for product *H* over product *F* increases in *S*, the stand-alone utility of a user with index *S* is given by:

$$\begin{cases} a_H + S \;\; \text{if she adopts product } H; \\ a_F + (1-S) \;\; \text{if she adopts product } F, \end{cases} \tag{1}$$

where constants a_i ($i = H, F$) represent the part of the utility that is common to all users. Let $\tilde{a} = a_F - a_H > 0$ measure the superiority of the transferred foreign technology.

If the share of users who adopt product *H* is *x*, then the network-related component of the user's utility is $n[x + \gamma(1 - x)]$ if she adopts product *H* and $n[(1-x) + \gamma x]$ if she adopts product *F* where the parameter $n > 0$ measures the strength of the network externality.[10] The consumer surplus of user S equals:

$$\begin{cases} a_H + S + n[x + \gamma(1-x)] - P_H & \text{if she adopts product } H; \\ a_F + (1-S) + n[(1-x) + \gamma x] - P_F & \text{if she adopts product } F \end{cases} \tag{2}$$

where P_H and P_F are the prices for products H and F.

We assume that the products are incompatible ex ante (i.e., by design) but (partial) compatibility between them can be achieved by means of an ex post compatibility-enhancing modification, which can be incorporated into the main technical design of one or both rival products. Typically, the amount of control the rival producers have over the degree of compatibility between their products depends upon the allocation of the intellectual property (IP) rights over the technical interfaces. Given the structure of our model, both firms prefer greater compatibility and can coordinate on its jointly efficient level for any allocation of the intellectual property rights over the interface. In practical terms, such an outcome can be achieved through a cross-licensing arrangement that ensures that costs and benefits of compatibility-enhancement are allocated according to the bargaining powers of firms regarding the division of joint surplus that results from greater compatibility. To simplify the analysis, we assume that the foreign firm determines the degree of compatibility (γ) via a compatibility-enhancing modification of its product. [11] Moreover, we follow the existing literature by focusing on symmetric compatibility enhancement that is carried out by only one of the two rival products but confers the same network benefit on the users of both products (see, for example, the discussion of the symmetric two-way converters in Choi, 1997).

For simplicity, the production cost of each firm under complete incompatibility is assumed to be zero. However, the foreign firm's compatibility-enhancing decision affects its production cost. We

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[10] More generally, for a network benefit function $N(\bullet)$, the network-related component of the user's utility is $N(x + \gamma(1-x))$ if she adopts product H and $N((1-x) + \gamma x)$ if she adopts product F. $N(\bullet)$ is increasing and concave (convex) if the network externality is characterized by decreasing (increasing) returns to the average level of compatibility attained by the users. We assume that the network benefit function is linear in order to facilitate analytical derivations. Our results would remain valid as long as the network benefit function is not too convex.

[11] Another justification for this assumption is that typically the incumbent domestic firm's interface-related IP rights have already expired while those of the foreign firm have not because the transferred foreign technology is newer than the domestic. For a discussion of the problems that arise due to the unilateral control of the interface by one of the producers (of two complementary products) see MacKie Mason and Netz (2002). They discuss technical design strategies that allow a firm (or a consortium of firms) controlling the IP rights over one of the two complementary technical systems to extend the boundary of its control to include the IP rights over the entire interface through which the two systems can interoperate. According to MacKie Mason and Netz, such strategies are quite common in the information technology industry.

assume that to achieve the degree of compatibility γ the foreign firm has to incur a fixed cost $K(\gamma)$.[12] Moreover, after the compatibility-enhancing modification, the unit cost of the foreign product becomes $c > 0$ regardless of the level of compatibility (γ) chosen by the foreign firm.

In order to ensure the existence of an interior equilibrium with positive sales of both products we assume that (*i*) the compatibility enhancing technology is not too inefficient: $c - \tilde{a} < 2(1 - n(1 - \gamma))$; (*ii*) the fixed cost of attaining compatibility γ is strictly increasing and sufficiently convex for all $\gamma \in [0, 1]$; and that (*iii*) $K(0) = K'(0) = 0$, and $\lim_{\gamma \to 1} K'(\gamma) = \infty$.[13]

As discussed above, the foreign firm has two options for entering the domestic market. It can either acquire the domestic firm or it can set up a wholly owned subsidiary that directly competes with the domestic firm. The game proceeds as follows. In the first stage, the foreign firm chooses its mode of entry (*D* denotes de novo entry and *A* denotes acquisition). If it wants to acquire the domestic firm, it makes a take-it-or-leave-it offer to the domestic firm, which specifies both a fixed transaction price (v) and a share of the new firm's total profits (θ). If the domestic firm accepts the offer, they form a new firm in which the domestic firm gets $1-\theta$ of the total profit and the foreign firm the rest. If the domestic firm refuses the foreign firm's offer, the foreign firm can enter the market by establishing its own subsidiary. In section 6, we show that the foreign firm never chooses partial acquisition unless local policy constrains the degree of foreign ownership permitted. Thus, under no such restrictions, we must have $\theta = 1$. Till section 6 (where we examine policy restrictions), we focus on the choice between full acquisition and de novo entry.

After selecting its mode of entry, the foreign firm chooses the degree of compatibility between its own network technology and the technology of the incumbent network. By incurring the fixed cost $K(\gamma)$ and the unit cost c the foreign firm can attain the degree of compatibility γ between the two network technologies. If the foreign firm opts to keep the two networks completely incompatible, the marginal cost of its subsidiary equals that of the domestic firm (which is zero).

The last stage of the game involves the product market where the firms (or the merged firm) choose prices. The perfect equilibrium of this game is found by solving backwards; first, for the product

[12] $(1-\gamma)$ can be interpreted as the loss of the network benefit that can be attributed to product performance degradation due to the imperfections of the compatibility-enhancing technology. For example, in wireless telephony, users of multi-mode wireless phones usually experience a greater number of dropped calls and shorter battery life when these phones are used for roaming in wireless networks based on communication protocols or radio frequencies that are different from the users' "native" networks. Therefore, although multi-mode handsets create compatibility across technologies, the quality of communication enjoyed by the users of the two ex ante incompatible technologies made partially compatible ex post by the adoption of the multi-mode handset by one group of the users is inferior compared to the quality of communication enjoyed by the users of the same technology.

[13] An example of the function satisfying these assumptions is $K(\gamma) = \beta\gamma(1 - (1 - \gamma)^{\alpha})$, where $1 > \alpha > 0$, $\beta > 0$.

market equilibrium, then for the extent of compatibility enhancement, and finally the choice of the mode of entry.

3. Prices and the degree of compatibility

3.1 De novo entry

First, consider the price competition stage of the game. Assuming that both firms have positive sales,[14] the condition identifying the marginal consumer S_F^D, who is indifferent with respect to the domestic product H and the foreign product F, is given by

$$a_F + (1 - S_F^D) + nS_F^D + n\gamma(1 - S_F^D) - P_F^D = a_H + S_F^D + n(1 - S_F^D) + n\gamma S_F^D - P_H^D \qquad (3)$$

where P_H^D and P_F^D are the prices for products H and F under duopoly.

Rearranging equation (3) gives the demand functions for the two products:

$$S_F^D = \frac{1}{2} - \frac{\left(P_F^D - P_H^D\right) - \tilde{a}}{2(1 - n(1-\gamma))} \text{ and } S_H^D = 1 - S_F^D = \frac{1}{2} + \frac{\left(P_F^D - P_H^D\right) - \tilde{a}}{2(1 - n(1-\gamma))}. \qquad (4)$$

If the foreign firm chose to set up a wholly owned subsidiary that directly competes with the domestic firm, the post-entry profits of firms H and F are: $\Pi_H^D = P_H^D S_H^D = P_H^D (1 - S_F^D)$ and $\Pi_F^D = (P_F^D - c) S_F^D$. The first order conditions for profit maximization are given by:[15]

$$\begin{cases} 1 - n(1-\gamma) - \tilde{a} + P_F^D - 2P_H^D = 0 \\ 1 - n(1-\gamma) + c + \tilde{a} + P_H^D - 2P_F^D = 0 \end{cases}$$

It is clear from the above equations that the two firms' strategic variables (i.e., prices) are *strategic complements:* $dP_H^D / dP_F^D = dP_F^D / dP_H^D = 1/2$.

[14] Under duopoly this is guaranteed by assuming that the stand-alone utility parameters a_H and a_F are large enough that in equilibrium no user abstains from purchase: $a_F + a_H > 1 + c$. This assumption also guarantees full market coverage under two-product monopoly.

[15] The second order condition $d^2\Pi_H^D / dP_H^2 = d^2\Pi_F^D / dP_F^2 = -(1 - n(1-\gamma))^{-1} < 0$ is always satisfied if $n < 1$. We assume that $n < 1$ throughout this paper.

Equilibrium prices under de novo entry are obtained by simultaneously solving the first order conditions for profit maximization for the two firms.

$$\begin{cases} P_H^D = 1 - n(1-\gamma) + \dfrac{c - \widetilde{a}}{3} \\ P_F^D = 1 - n(1-\gamma) + \dfrac{2c + \widetilde{a}}{3} \end{cases} \tag{5}$$

Inspection of the equilibrium prices above shows:

Remark 1: *Under de novo entry, an increase in the level of compatibility* (γ) *between products leads to higher prices for both products*.

The above remark highlights a result that is not immediately obvious. It is often suggested that greater compatibility reduces product differentiation.[16] Under standard price competition without network effects, the more similar the products, the lower are equilibrium prices. So why does greater compatibility lead to higher prices in our model? This is because higher *incompatibility* is not the same as greater *product differentiation*. In fact, greater compatibility with the rival's product reduces the dependency of a firm's profit on the size of its own network and, therefore, makes the profit less sensitive to its own market share. This effect blunts competition for market share between the rival firms and leads to higher prices. Thus, as products become more compatible, firms exert weaker competitive pressure on each other and their profits increase.

Using the prices in equation (5) the equilibrium sales and profits of the two firms are easily obtained:

$$S_H^D = \frac{1}{2} + \frac{c - \widetilde{a}}{6(1 - n(1-\gamma))}; \quad S_F^D = \frac{1}{2} - \frac{c - \widetilde{a}}{6(1 - n(1-\gamma))} \tag{6}$$

and

$$\Pi_H^D = \frac{\left(1 - n(1-\gamma) + (c - \widetilde{a})/3\right)^2}{2(1 - n(1-\gamma))}; \quad \Pi_F^D = \frac{\left(1 - n(1-\gamma) - (c - \widetilde{a})/3\right)^2}{2(1 - n(1-\gamma))}. \tag{7}$$

[16] Greater compatibility between the rival products can make them better complements and substitutes at the same time. Greater compatibility increases complementarity in the sense that consumer willingness to pay for each product increases with compatibility. By making the networks based on the two rival technologies better substitutes, greater compatibility can also lead to more intense competition between the firms. See Economides (1991) on the effects of firms' horizontal compatibility choices in a closed economy with network externalities.

If the unit costs of the foreign and domestic products were the same, the foreign firm would have higher sales than the domestic firm since its product is technically superior (recall that $\tilde{a} = a_F - a_H > 0$). However, since compatibility enhancement provides symmetric benefits for users of both products but raises the unit cost of only the foreign product, the market shares of firms also depend on whether the unit cost of enhancing compatibility between the rival technologies is greater or less than the stand-alone technical superiority of the transferred technology. Denote the difference between the unit cost of compatibility and the incremental stand-alone value of the foreign technology by $L = c - \tilde{a}$ and interpret it as a *composite measure* of technological asymmetry between the two firms.

Remark 2: *As can be seen from Eq. (6), the market share of the domestic firm exceeds that of the foreign firm iff $L > 0$.*

As noted before, past literature on technology transfer has given us a rich array of insights on the impact of technology transfer undertaken by foreign firms (see Saggi, 2002 for a survey). However, this literature has said little about the impact of foreign entry under network effects. In order to have the costs of compatibility (and network considerations in general) be more dominant than the utility based technological superiority of the foreign firm (i.e., the traditional technology transfer considerations), for the rest of the paper we assume that $L > 0$.

We refer to the product of the firm with the larger market share as the dominant product and to its competitor's product as the minority product. The level of compatibility (γ) chosen by firm *F* satisfies the following first-order condition for maximization of profit net of the fixed cost of attaining compatibility:

$$\frac{d\Pi_F^D(\gamma)}{d\gamma} - \frac{dK(\gamma)}{d\gamma} = \frac{n}{2}\left(1 - \frac{(L/3)^2}{(1-n(1-\gamma))^2}\right) - \frac{dK(\gamma)}{d\gamma} = \frac{(n-2K'(\gamma))(1-n(1-\gamma))^2 - n(L/3)^2}{2(1-n(1-\gamma))^2} = 0\,. \quad (8)$$

The above first-order condition is equivalent to

$$(n - 2K')(1 - n(1-\gamma))^2 - n(L/3)^2 = 0\,. \quad (9)$$

Totally differentiating the above equation and solving for the foreign firm's choice of the compatibility level (γ) delivers the equilibrium level of compatibility under de novo entry:

$$\gamma^D = g^D(n, L) \quad (10)$$

Lemma 1: *The function* $g^D(n, L)$ *is characterized by* $g^D(n, L) \geq 0$, $\frac{\partial g^D(\cdot, L)}{\partial L} < 0$,

$\frac{\partial^2 g^D(\cdot, L)}{\partial L^2} < 0$, $\left.\frac{\partial g^D(n, \cdot)}{\partial n}\right|_{n=0} > 0$, *and* $\frac{\partial^2 g^D(n, \cdot)}{\partial n^2} < 0$ *for* $L \geq 0$ and $n \in [0, n^*]$, where

$$n^* \leq \frac{\left(K''^2 + 4K''\right)^{1/2} - K''}{2}.$$

In other words, $g^D(n, \cdot)$ is a concave function of n and it attains its maximal value at some $n^* \in (0,1)$.[17]

Proof: See Appendix.

3.2 Entry through acquisition

After acquiring the local firm, the foreign firm becomes a two-product monopolist. Depending on the model parameters, it may choose prices for goods H and F in such a way that some domestic consumers abstain from purchase. To focus on distortions related to incompatibility rather than price effects of the acquisition, assume that the stand-alone utility parameters (a_H and a_F) are large enough to ensure that in equilibrium no user abstains from purchase. Therefore, prices chosen by the foreign firm, given that it covers the entire market, are given by

$$P_H^A = a_H + S_F^A + n(1 - S_F^A) + n\gamma S_F^A \quad \text{and} \quad P_F^A = a_F + 1 - S_F^A + nS_F^A + n\gamma(1 - S_F^A) \tag{11}$$

where S_F^A is the marginal user who is indifferent between buying product H or F.

Following the merger and the compatibility-enhancing investment, the foreign firm maximizes the profit $(P_F^A - c)S_F^A + P_H^A(1 - S_F^A)$. Setting P_F^A and P_F^A equal to the right-hand sides of (11) and maximizing the profit with respect to S_F^A yields:

$$S_H^A = \frac{1}{2} + \frac{L}{4(1 - n(1-\gamma))}; \quad S_F^A = \frac{1}{2} - \frac{L}{4(1 - n(1-\gamma))}. \tag{12}$$

Therefore, prices under acquisition equal:

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[17] A discussion of the second order conditions and other parameter restrictions implied by the model is available on request from the authors.

$$\begin{cases} P_H^A = a_H + n + \dfrac{\left(1-n(1-\gamma)\right)}{2} - \dfrac{L}{4} \\ P_F^A = a_F + n + \dfrac{\left(1-n(1-\gamma)\right)}{2} + \dfrac{L}{4} \end{cases} \tag{13}$$

Remark 3: *An increase in the degree of compatibility* (γ) *leads to larger increases in prices under de novo entry relative to that under acquisition:* $\partial P_H^D / \partial \gamma = \partial P_F^D / \partial \gamma = n$ *and* $\partial P_H^A / \partial \gamma = \partial P_F^A / \partial \gamma = n/2$.

Let where $\bar{a} = (a_H + a_F)/2$, then using (12) and (13), total profit of the foreign firm equals

$$\Pi_{HF}^A = \bar{a} + \frac{1}{2}\left(\frac{L^2}{4(1-n(1-\gamma))} + n(1+\gamma) + 1 - c \right) \tag{14}$$

The level of compatibility chosen by the foreign firm under acquisition satisfies the following first-order condition:

$$\frac{d\Pi_{HF}^A(\gamma)}{d\gamma} - \frac{dK(\gamma)}{d\gamma} = \frac{n}{2}\left(1 - \frac{(L/2)^2}{(1-n(1-\gamma))^2}\right) - \frac{dK(\gamma)}{d\gamma} = \frac{(n-2K'(\gamma))(1-n(1-\gamma))^2 - n(L/2)^2}{2(1-n(1-\gamma))^2} = 0 \tag{15}$$

The above first-order condition is equivalent to

$$(n-2K')\left(1-n(1-\gamma)\right)^2 - n(L/2)^2 = 0. \tag{16}$$

Totally differentiating (16) and solving for the foreign firm's choice of compatibility yields:

$$\gamma^A = g^A(n, L) \tag{17}$$

where the function $g^A(n, L)$ is characterized by the same properties as the function $g^E(n, L)$ – these were discussed in subsection 3.1 (see Lemma 1). To compare γ^A and γ^E notice that

$$\frac{d\Pi_{HF}^A}{d\gamma} = \frac{n}{2}\left(1 - \frac{(L/2)^2}{(1-n(1-\gamma))^2}\right) < \frac{n}{2}\left(1 - \frac{(L/3)^2}{(1-n(1-\gamma))^2}\right) = \frac{d\Pi_F^E}{d\gamma}.$$

In other words, the foreign firm's marginal benefit of choosing a greater level of compatibility is higher under de novo entry than under acquisition. The following result is immediate:

Proposition 1: *The foreign firm chooses a greater degree of compatibility between the new and the incumbent networks under de novo entry than under acquisition:*

$$g^A(n, L) < g^D(n, L). \tag{18}$$

To understand the above result note that there are two effects of compatibility on the foreign firm's profit: a *direct effect* and a *strategic effect*. The direct effect is caused by the consumers' preference for greater compatibility. When compatibility between the rival products is high, consumers are willing to pay more for them (see equation 13). The strategic effect, which is present only under duopoly, has to do with the strategic complementarity of the firms' strategies under price competition. As compatibility increases, the domestic firm competes *less aggressively* allowing the foreign firm to earn a higher profit (see Remark 1). Since the strategic effect is eliminated under acquisition, the price increases that result from greater compatibility are higher under de novo entry (see Remark 3). As a result, the foreign firm's incentive for making the two products compatible is stronger under de novo entry relative to acquisition.

4. Choice of entry mode

As we noted earlier, in the absence of any policy restrictions, it is sufficient to focus on the choice between full acquisition and de novo entry since partial acquisition does not arise in equilibrium. To determine the foreign firm's choice between full acquisition and de novo entry, we first need to pin down its equilibrium offer v under an acquisition. The incumbent domestic firm is willing to accept any offer that leaves it with a net payoff equal or greater than the profit, which it can realize by refusing the acquisition offer and competing directly against the foreign entrant. Assuming that the foreign firm has all the bargaining power, the domestic firm will settle for the offer:

$$v = \Pi_H^D(\gamma^D) \tag{19}$$

where $\Pi_H^D(\gamma^D)$ denotes the profits of the domestic firm under duopoly, which follows if the foreign firm enters directly. The foreign firm prefers acquisition to de novo entry iff:

$$\Delta\Pi \equiv \Pi_{HF}^A(g^A(n,L)) - K(g^A(n,L)) - \Pi_H^D(g^D(n,L)) - \left(\Pi_F^D(g^D(n,L)) - K(g^D(n,L))\right) > 0 \tag{20}$$

As might be expected, the expression for $\Delta\Pi$ is quite cumbersome and non-linear in L and n even for the simplest forms of the cost function $K(\gamma)$. However, we can plot it and analyze graphically using the cost function $K(\gamma) = \gamma\left(1-(1-\gamma)^{\frac{1}{2}}\right)$. Figure 1 depicts the surface ΔΠ for the parameter values 0 < *L* < 1.5 and 0 < *n* < 0.6. As Figure 1 demonstrates, *the foreign firm prefers acquisition to de novo entry for all plausible parameter values*. This result is consistent with the fact that a duopolist prefers to buy out its competitor and become a monopolist, which is established elsewhere in the literature (see Kamien and Zang (1990) for the quantity-competing duopolists and Deneckere and Davidson (1985) for the price-competing duopolists).

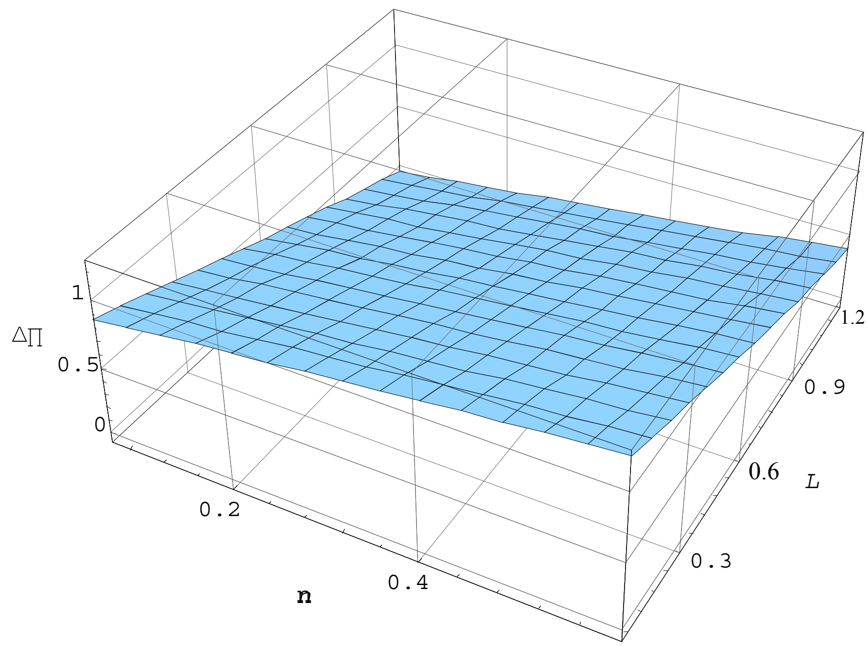

Figure 1: Equilibrium Mode of Entry

Figure 1 also shows that the attractiveness of entry through acquisition increases with *n*. When *n* is small, the foreign firm's profit as a two-product monopolist's is small while the acquisition price $v = \Pi_H^D(g^D(n,L))$ is high. The reason for this is that for small *n* competition under de novo entry is more relaxed implying a higher incumbent profit and, therefore, a higher acquisition price. As *n* increases, the foreign firm's profit increases while the acquisition price declines (since the incumbent faces more intense competition under de novo entry). Therefore, as *n* goes up Π_H^D and Π_F^D decrease while Π_{HF}^A increases.

The main reason why ΔΠ decreases as *L* goes up is because a greater marginal cost disadvantage of the entrant, *c*, (or lesser value of the transferred technology, $\tilde{a}$) implies a greater profit of the incumbent firm under de novo entry and, therefore, a greater acquisition price. Thus, from the foreign firm's point of view, when L is large and n is small, acquisition does not have a big advantage over de novo entry.

5. Host country welfare

In this section, we compare total domestic welfare (defined as the sum of consumer surplus and the profit of the domestic firm or the proceeds from its sale to the foreign firm) under the two modes of entry. One might think that since the foreign firm prefers to enter via acquisition, the host government's preference should be de novo entry, under which the rents earned by the foreign firm are lower. However, as our analysis indicates, the host government's preferences with regard to the mode of entry depend on the degree of technological asymmetry between the rival technologies (measured by the composite L) and the strength of the network externality, n.

Under partial compatibility between the two networks (i.e., $\gamma < 1$), the introduction of the foreign firm into the domestic market undermines the integrity of the domestic network and may have a negative effect on the home country welfare. Specifically, if the unit cost of attaining partial compatibility between the products is greater than the additional stand-alone benefit derived by a user of the foreign product compared to the domestic product (i.e., $L > 0$), then more than half of all users adopt the domestic product H. Therefore, given that the networks based on rival products are only partially compatible, each user who adopts the minority product F would have conferred greater total network externality on the society by adopting the dominant product H. Since F users do not take into account the negative effect of their product adoption decisions on the society, in equilibrium there are more F users than is socially optimal. In contrast, when $L < 0$, the dominant network is based on the foreign product F and there is excessive adoption of the domestic product H among the minority of users. Farrell and Saloner (1992) demonstrated that in the context of a closed economy the problem of overadoption of the minority product (i.e., the product with a lesser market share) by users occurs regardless of whether the two products are supplied by a monopolist or duopoly. However, under duopoly the problem is more severe because the producer of the minority product lures users away from the dominant firm by undercutting the above-cost price of the dominant firm.[18]

In the context of an open economy with FDI, the extent of the product adoption distortion is not as clear-cut because of the rents captured by the foreign firm. Nevertheless, we can still evaluate the extent

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[18] In a closed economy with a domestic duopoly, the extent of the overadoption distortion can be measured by the wedge between the socially optimal share of the domestic minority firm $\hat{s} = \frac{1}{2} - \frac{L}{2(1-2n(1-\gamma))}$ and its equilibrium share $s = \frac{1}{2} - \frac{L}{6(1-n(1-\gamma))}$.

of the consumption distortion due to overadoption of the minority product by comparing the equilibrium market shares of the foreign firm under the two modes of entry with the foreign firm's market share that maximizes the total surplus for given n and L: $\hat{S} = \frac{1}{2} - \frac{L}{2(1-2n(1-\gamma))}$.

Remark 4: *Under acquisition, prices for both products are higher relative to de novo entry but the relative price is such that the distortion in product adoption by users is less severe.*

Comparing (6) and (12), we observe that the size of the network based on the minority technology is always greater under duopoly than under two-product monopoly:

$S_F^D(\gamma,n,L) > S_F^A(\gamma,n,L) > \hat{S}(\gamma,n,L)$ if $L > 0$ (i.e., foreign product users is the minority)

and $S_H^D(\gamma,n,L) > S_H^A(\gamma,n,L) > \hat{S}(\gamma,n,L)$ if $L < 0$ (i.e., home product users is the minority)

Note that the second inequality is equivalent to $S_F^D(\gamma,n,L) < S_F^A(\gamma,n,L)$.

The above result pertains to a given level of compatibility between products. In our model, compatibility is endogenous and taking that into account delivers the following conclusion:

Proposition 2: *The extent of overadoption distortion is greater under de novo entry relative to acquisition:* $S_F^D(g^D(n,L),n,L) > S_F^D(g^A(n,L),n,L) > S_F^A(g^A(n,L),n,L)$ if $L > 0$ *and* $S_F^D(g^D(n,L),n,L) < S_F^D(g^A(n,L),n,L) < S_F^A(g^A(n,L),n,L)$ if $L < 0$.

Therefore, under de novo entry, the amount of consumer surplus forgone due to the excessive size of the minority network is greater than under acquisition. The above proposition shows that the standard intuition of greater competition delivering more consumer surplus fails in the presence of network effects. In fact, we show below that depending on the extent of the product adoption distortion, the price level and the incentive to make the products compatible, the host country welfare may be higher either under acquisition or under de novo entry.

The host country's welfare under de novo entry mode is given by

$$W^D = \hat{a}(\gamma^D) + \frac{1}{2} + n + (1-2n(1-\gamma^D))S_F^D(\gamma^D)(1-S_F^D(\gamma^D)) - S_F^D(\gamma^D)P_F^D(\gamma^D) \tag{21}$$

where $\hat{a}(\gamma^D) = a_H(1-S_F^D(\gamma^D)) + a_F S_F^D(\gamma^D)$ and γ^D, $S_F^D(\gamma^D)$ and $P_F^D(\gamma^D)$ are defined, respectively, by (10), (5), and (6).

Similarly, host country welfare under acquisition is given by

$$W^A = \hat{a}(\gamma^A) + \frac{1}{2} + n$$
$$+ (1-2n(1-\gamma^A))S_F^A(\gamma^A)(1-S_F^A(\gamma^A)) - S_F^A(\gamma^A)P_F^A(\gamma^A) - S_H^A(\gamma^A)P_H^A(\gamma^A) + \Pi_H^D(\gamma^D) \quad (22)$$

where $\hat{a}(\gamma^A) = a_H(1-S_F^A(\gamma^A)) + a_F S_F^A(\gamma^A)$ and γ^A, $S_F^A(\gamma^A)$, $S_H^A(\gamma^A)$ and $P_H^A(\gamma^A), P_F^A(\gamma^A)$ are defined, respectively, by (17), (12) and (13) and $\Pi_H^D(\gamma^D)$ by (7).

Let ΔW denote the amount by which host country welfare is higher under acquisition relative to de novo entry:

$$\Delta W(n, L) \equiv W^A(n, L) - W^D(n, L). \quad (23)$$

As can be expected, the expression for ΔW is quite complicated and non-linear in L and n for almost any form of the function $K(\gamma)$ satisfying our assumptions. However, we can plot ΔW using the function $K(\gamma) = \gamma\left(1-(1-\gamma)^{\frac{1}{2}}\right)$. Figure 2 depicts the surface ΔW as well as the zero level surface for the parameter values $0 < L < 1.5$ and $0 < n < 0.6$.

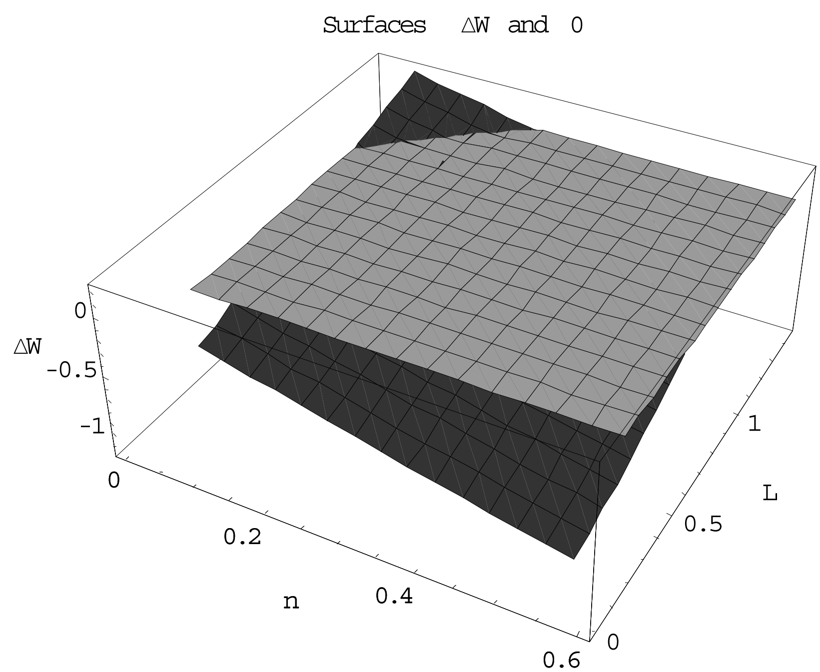

Figure 2: Welfare Comparison of the Two Entry Modes

Figure 2 shows that acquisition is welfare preferred to de novo entry for small *n* and large *L* while the opposite is true for large *n* and small *L*. In conjunction with Figure 1, the above figure reveals that the preferences of the government with regard to the mode of entry coincide with those of the foreign firm only when *n* is small and *L* is large -- in which case both the government and the foreign firm prefer acquisition to de novo entry. When *n* is large and *L* is small, the government prefers de novo entry leading to domestic competition, whereas the foreign firm prefers acquisition.

Why do the government's preferences toward the mode of entry change with *n* and *L*? When *n* is small competition is less intense. Therefore, the acquisition price and the duopoly profit of the entrant are higher. As a result, when *n* decreases the profit of the two-product monopolist net of the acquisition price becomes smaller while the profit of the foreign duopolist becomes larger. Therefore, when *n* is small, de novo entry (that leads to duopoly) is less attractive for the government than acquisition (that leads to a two product monopoly).

An important consideration in our model is that when network externalities are small (i.e., when *n* is close to zero), compatibility enhancement is unimportant because incompatibility is not costly in terms of the lost network benefit. When the unit cost of compatibility enhancement is large (i.e., *L* is large), the welfare loss caused by the distortion in the product adoption pattern among home users' is greater. Therefore, when *n* is small and *L* is large, it is more important to minimize the loss from the product adoption distortion, than to ensure greater compatibility between the rival networks. Since the extent of overadoption distortion is smaller when the two-product monopolist serves the market, the government prefers entry through acquisition. By contrast, when *n* is large and *L* is small, the cost of incompatibility in terms of foregone network benefits is large while the inefficiency due to the overadoption distortion is small. Therefore, the government prefers duopoly under which the tendency for overadoption of minority technology is stronger but the foreign firm chooses higher level of compatibility between the networks. The above discussion implies:

Remark 5: *Local welfare is higher under the mode that delivers a greater degree of compatibility between products only when incompatibility is quite costly in terms of forgone network benefits (i.e. n is high).*

To understand how the foreign firm's entry mode preferences compare with those of a welfare-maximizing host government, in Figure 3 we plot the zero level iso-curve of the change in welfare ΔW, i.e., the locus of (n, L) at which ΔW intersects the zero surface.

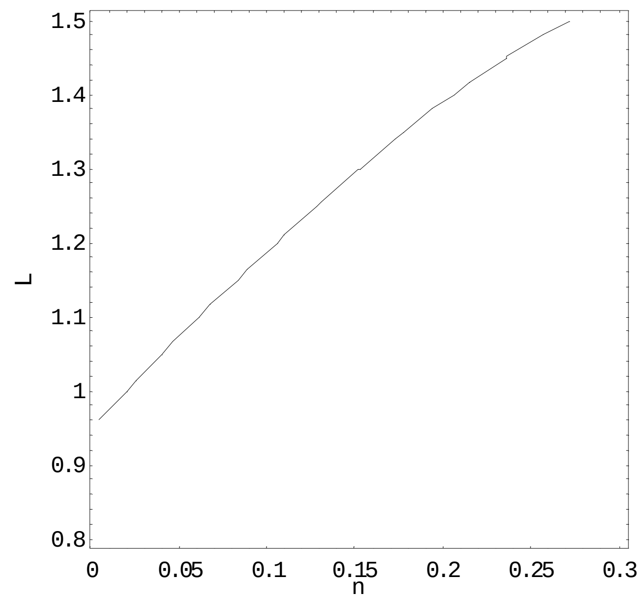

Figure 3: Iso-Welfare Curve

In Figure 3, in the region above the iso-welfare curve (i.e., for low levels of *n* and high *L*), the local government prefers acquisition. (Recall that the foreign firm always prefers acquisition). In the region below the iso-welfare curve (i.e., for high levels of *n* and low *L*), the government prefers de novo entry. Thus, in the region below the iso-welfare curve, there is room for government intervention. Specifically, policy measures that induce de novo entry and/or discourage acquisition can improve domestic welfare. In the next section, we examine what role policy restrictions on the degree of foreign ownership of domestic firms play in determining the foreign firm's equilibrium mode of entry and whether such restrictions can help induce a mode of entry that is preferred from a local welfare perspective.

6. Restrictions on the degree of foreign ownership

Suppose that θ_M represents the maximum degree of foreign ownership of a local firm permitted by the host government. Such an equity restriction can be implemented in one of two ways. First, it might be applied *symmetrically* in that government policy restricts the degree of foreign ownership of both the domestic incumbent and the newly established subsidiary of the foreign firm. Second, it might be *asymmetric* in nature wherein government policy restricts the degree of foreign ownership of the domestic incumbent but not that of the foreign firm's subsidiary. As Mattoo et. al. (2003) note, while symmetric restrictions occur more frequently than asymmetric one's, there are some prominent examples of asymmetric equity restrictions. For example, in Japan's telecommunications sector, ownership share of foreign firms in existing firms (NTT and KDD) is limited to a maximum of 20% whereas there are no restrictions on new entry (foreign or domestic) and neither any foreign equity cap for these new firms. Similarly, foreign participation in Korea Telecom is limited to 20% whereas there are no restrictions on new entry. Foreign firms can have 100% participation in new resale-based telecommunications service companies or 49% (above 20%) in new facility-based telecommunications service firms.[19] Thus, in what follows we analyze both types of policy restrictions. Before doing so, we show that an equity restriction (regardless of whether its symmetric or not) is binding in equilibrium.

6.1. Equilibrium ownership under an equity restriction

To determine the foreign firm's choice of mode of entry, we first need to pin down its equilibrium offer (θ^*, v^*) under an acquisition. Consider the decision of the domestic firm, which faces an arbitrary offer (θ, v) from the foreign firm to enter into joint production. The domestic firm is willing to accept any offer that leaves it with a net payoff equal to the profit, which it can realize by refusing the acquisition offer and competing directly against the foreign entrant.

Thus, any offer (θ, v) that satisfies the following constraint is acceptable to the domestic firm:

$$(1-\theta)\Pi_{HF}^{A}(\gamma^{A})+v\geq\Pi_{H}^{D}(\gamma^{D}) \tag{24}$$

where $\Pi_{H}^{D}(\gamma^{D})$ denotes the profits of the domestic firm under duopoly, which follows if the foreign firm enters directly. Since the foreign firm has all the bargaining power, the above constraint binds in equilibrium. Thus, there exist multiple potential combinations (θ, v) that are acceptable to the incumbent domestic firm.

Of course, the foreign firm chooses (θ, v) to solve the following problem:

$$\max\left[\theta\Pi_{HF}^{A}(g^{A}(\theta,n,L))-K(g^{A}(\theta,n,L))-v\right]$$

subject to $\theta\leq\theta_{M}$ and the constraint given in (24) from where we have

$$v=\Pi_{H}^{D}(g^{D}(n,L))-(1-\theta)\Pi_{HF}^{A}(g^{A}(\theta,n,L)) \tag{25}$$

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[19] Mattoo et. al. (2003) note that the quite common presence of public monopolies in the service sector in general (i.e., not only in telecommunications), which make acquisition by foreign firms a complex political decision, also tends to lead to a de facto discrimination between foreign equity participation in existing domestic firms (public firms) and new firms in the sector (when these are allowed). For example, Uruguay and Korea also discriminate between foreign participation in existing domestic firms and new firms in the banking sector.

Thus the problem confronting the foreign firm is to choose θ to solve

$$\max\left[\Pi_{HF}^{A}(g^{A}(\theta,n,L))-K(g^{A}(\theta,n,L))-\Pi_{H}^{D}(g^{D}(n,L))\right]$$

subject to $\theta \leq \theta_M$. Differentiating the above objective function we have:

$$\left[\frac{d\Pi_{HF}^{A}}{d\gamma}-\frac{dK}{d\gamma}\right]\frac{\partial g^{A}(\theta,n,L)}{\partial\theta} \tag{26}$$

Since $\gamma^A = g^A(\theta, n, L)$ is optimally chosen by the foreign firm to maximize $\theta\Pi_{HF}^{A}(\gamma)-K(\gamma)$, by the envelope theorem (26) can be rewritten as:

$$(1-\theta)\frac{d\Pi_{HF}^{A}}{d\gamma}\frac{\partial g^{A}(\theta,n,L)}{\partial\theta}>0 \tag{27}$$

Since $d\Pi_{HF}^{A}/d\gamma>0$, the foreign firm's first order condition with respect to θ is always positive, implying that the foreign firm always chooses the maximum permissible ownership share:

$$\theta^* = \theta_M .$$

Inequality (27) explains the reason why the foreign firm opts for a full acquisition when there are no equity restrictions. Since γ^A is chosen optimally at a later date to maximize the foreign firm's share of profits of the new firm, $\Pi_{HF}^{A}(\cdot)$ is strictly increasing in θ and the foreign firm fully acquires the domestic firm to fully internalize the benefits of compatibility enhancement. Since the foreign firm has all the bargaining power, the domestic firm accepts the offer since it fares no worse as an acquired firm than it does as a competitor after refusing the acquisition offer.

Proposition 3: *In equilibrium, the foreign firm choose the maximum permissible degree of ownership under acquisition, i.e.* $\theta^* = \theta_M$ *and* $v^* = \Pi_{H}^{D}(g^{D}(\theta_M, n, L))$.

Consider now the effects of the two types of equity restrictions.

6.1. Compatibility under equity restrictions

When facing a symmetric equity restriction, under de novo entry the foreign firm forms a new enterprise and collects θ_M of its total profit, with the rest accruing to the domestic economy. Similarly, if the foreign firm enters via a (partial) acquisition, its share of total profit of the partially acquired firm is given by θ_M.

It is easy to solve for the level of compatibility between the products under the two entry modes. Under de novo entry, the level of compatibility chosen by the new venture competing against the incumbent firm satisfies the following first-order condition for maximization of the foreign share in the new firm's profit with respect to γ:

$$(\theta_M n - 2K')(1 - n(1-\gamma))^2 - \theta_M n(L/3)^2 = 0\,.$$

Totally differentiating the above equation and solving for the foreign investor's choice of the compatibility level shows:

$$\gamma^D(\theta_M) = g^D(\theta_M\ , n, L), \qquad (28)$$

where the function $g^D(\theta_M\ , n, L)$ is characterized by the same properties as the function $g^D(n, L)$ and $dg^D(\theta_M,\cdot,\cdot)/d\theta_M > 0$.

Similarly, the level of compatibility under acquisition satisfies the following first-order condition with respect to γ:

$$(\theta_M n - 2K')(1 - n(1-\gamma))^2 - \theta_M n(L/2)^2 = 0\,.$$

Totally differentiating the above equation and solving for the foreign firm's choice of the degree of compatibility shows:

$$\gamma^A(\theta_M) = g^A(\theta_M, n, L), \qquad (28)$$

where the function $g^A(\theta_M, n, L)$ is characterized by the same properties as the function $g^A(n, L)$ and $dg^A(\theta_M,\cdot,\cdot)/d\theta_M > 0$.

Given the properties of the functions $g^D(\theta_M\ ,n, L)$ and $g^A(\theta_M, n, L)$, the following result obtains:

Proposition 4: *A symmetric equity restriction lowers the level of compatibility chosen by the foreign firm under both entry modes:* $g^A(\theta_M, n, L) < g^A(1, n, L) = g^A(n, L)$ *and* $g^D(\theta_M, n, L) < g^D(1, n, L) = g^D(n, L)$ *for any* $0 < \theta_M < 1$. *Moreover, as in the case of no equity restrictions, under a symmetric equity restriction the foreign firm chooses a greater level of compatibility under de novo entry relative to acquisition:* $g^A(\theta_M, n, L) < g^D(\theta_M, n, L)$.

As might be expected, a symmetric equity restriction does not affect foreign investor's ranking of the modes of entry. It still prefers entry through acquisition. Therefore a symmetric equity restriction doesn't induce a change in the entry mode. What does this policy accomplish then? It merely lowers the degree of compatibility enjoyed by the users and thus lowers domestic welfare.

Now consider an asymmetric equity restriction that limits the degree of foreign ownership of the domestic incumbent but not that of a newly established subsidiary. As before, θ denotes the foreign firm's share of the total profit of the partially acquired firm. By contrast, under de novo entry, the foreign firm fully owns its subsidiary. Therefore, the choice of compatibility under de novo entry is determined by $g^D(n, L)$, while under acquisition by $g^A(\theta_M, n, L)$. As we showed above, $g^D(n, L) > g^A(n, L) > g^A(\theta_M, n, L)$.

Under the equity restriction θ_M, the foreign firm opts for a partial acquisition iff the following holds:

$$\Delta\Pi(\theta_M) \equiv \Pi^A_{HF}(g^A(\theta_M, n, L)) - K(g^A(\theta_M, n, L)) - \Pi^D_H(g^D(n, L)) - \left(\Pi^D_F(g^D(n, L)) - K(g^D(n, L))\right) > 0 \qquad (29)$$

Although the expression $\Delta\Pi(\theta_M)$ is quite complicated, we can plot it for $\theta_M \in [0,1]$ (for the parameter values $L = 1$ and $n = 0.25$).

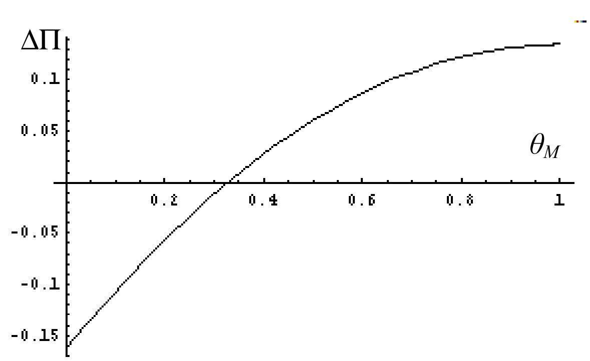

Figure 4: Entry Modes under an asymmetric equity restriction

Figure 4 shows that unlike a symmetric equity restriction, an asymmetric equity restriction can actually make de novo entry relatively more attractive to the foreign firm which chooses de novo entry iff $\theta_M < \theta^{**}$ where θ^{**} is defined by $\Delta\Pi(\theta^{**}) = 0$. The reason for this result is that a sufficiently low equity restriction forces the foreign firm to adopt such a low level of compatibility under acquisition, that its profit net of acquisition price becomes lower than that under de novo entry. Therefore, it chooses to enter directly rather than through acquisition.

Thus, if domestic policy becomes restrictive enough (i.e. θ_M is small enough) then the foreign firm can be induced to enter the market directly. What are the welfare implications of an asymmetric equity restriction? We have already shown that when the network externality is strong and the cost of compatibility enhancement is low, de novo entry yields higher welfare than acquisition. Thus, when *n* is high and *L* is low, a stringent enough asymmetric equity restriction, can induce the foreign firm to adopt a mode of entry that results in higher domestic welfare. However, if the restriction is lax (i.e. $1 > \theta_M > \theta^{**}$), then it will fail to induce de novo entry and merely lowers domestic welfare by lowering the level of compatibility between the two products. The following proposition summarizes the results of this section:

> **Proposition 5:** *Both a symmetric equity restriction and a weak asymmetric equity restriction on the degree of foreign ownership lower domestic welfare by reducing the degree of compatibility chosen by the foreign firm. However, when the network externality is strong and the products are not too asymmetric in terms of the stand-alone utility and the unit cost of compatibility enhancement, a sufficiently strong asymmetric equity restriction improves domestic welfare by inducing de novo entry.*

One final point is worth noting: asymmetric equity restrictions are not the only means of inducing de novo entry. Fiscal and financial incentives (such as the frequently witnessed tax breaks and subsidies to FDI) can also be used to induce de novo entry. Of course, such concessions impose budgetary costs on the government that equity restrictions do not.

7. Conclusion

In a duopoly model, this paper has explored a foreign firm's choice between acquisition and de novo entry where the foreign firm not only transfers a new network technology but also chooses the degree of compatibility between its own network and that of the existing one. It turns out that despite the presence of network effects, the foreign firm prefers to buy out its competitor and become a monopolist rather than to enter de novo and face competition from the incumbent. In fact, the presence of network externality reinforces the incentive to reduce competition because a stronger network effect leads to greater monopoly profit and a lower acquisition price.

A welfare-maximizing host government on the other hand prefers the mode of entry that not only delivers a new network technology but also minimizes rents captured by the foreign firm and the welfare losses caused by incompatibility between the old and the new network. We find that the preferences of the host government with regard to the mode of entry coincide with the preferences of the foreign firm only when the network externality effect is weak and the technologies are asymmetric in terms of the unit cost of compatibility enhancement. In that case, both the government and the foreign firm prefer acquisition to de novo entry. On the other hand, if the network externality effect is strong and there is not much asymmetry between products, the government prefers de novo entry, while the firm still prefers acquisition. Under this scenario, there is room for government intervention. More specifically, policy measures that induce de novo entry and/or discourage acquisition can improve domestic welfare. In particular, we find that certain types of equity restrictions on FDI might arise from attempts of local governments to improve local welfare in an environment of imperfect competition, network externalities and costly technology transfer. Of course, it also shows that other types of policy restrictions can be quite counter-productive.

While it would be desirable to conduct an analysis such as ours in a general oligopoly model, the presence of network effects makes the oligopoly case quite complicated. Under a duopoly, a consumer chooses only between two networks whereas under oligopoly, each consumer would face a greater choice set and the product market equilibrium is not as straightforward. Also, in such a model the notion of compatibility would be difficult to define. In addition to the degree of compatibility, the foreign entrant would have to decide on the number of products it wants its product to be compatible with. Analytical progress on the type of questions addressed in our paper seems rather unlikely under such a scenario.

References

Al-Saadon, Yousef and Satya P. Das (1996) "Host-country policy, transfer pricing and ownership distribution in international joint ventures: A theoretical analysis," *International Journal of Industrial Organization* 14, 345-364.

Barrett, Christopher and Yi-Nung Yang (2001) "Rational incompatibility with international product standards," *Journal of International Economic*s 54, 171-191.

Blois, Roberto (2001) "A wireless brave new world: challenges and opportunities for Latin America" *Connect-World Latin America*, no. 2.

Choi, Jay Pil (1997) "The provision of (two-way) converters in the transition process to a new incompatible technology," *Journal of Industrial Economics* 45, 139-53.

David, P. A. and S. Greenstein (1990), "The economics of compatibility standards: An introduction to recent research," *Economics of Innovation and New Technology* 1, 3-41.

Deneckere, Raymond and Carl Davidson (1985) "Incentives to form coalitions with Bertrand competition," *RAND Journal of Economics* 16, 473-486.

Economides, N., (1991) "Compatibility and the creation of shared networks," in *Electronic Services Networks: A Business and Public Policy Challeng*e, edited by Margaret Guerrin-Calvert and Steven Wildman, Praeger Publishing Inc., New York: 1991.

Ethier, W.J., (1986) "The multinational firm," *Quarterly Journal of Economics* 101, 805-33.

Ethier, W.J., and J. R. Markusen (1996) "Multinational firms, technology diffusion and trade," *Journal of International Economics* 41, 1-28.

Farrell, J., and G. Saloner (1992) "Converters, compatibility, and the interfaces," *Journal of Industrial Economics* 40, 9-36.

Gandal, N., and O. Shy (2001) "Standardization policy and international Trade," *Journal of International Economics* 53, 363-383.

Horn, H. and Persson, L., (2001) "The equilibrium ownership of an international oligopoly," *Journal of International Economics* 53, 307-33.

Horstmann, I. J. and J. R. Markusen (1987) "Strategic investments and the development of multinationals," *International Economic Review* 28, 109-121.

Horstmann, I. J. and J. R. Markusen (1996) "Exploring new markets: direct investment, contractual relations and the multinational Enterprise," *International Economic Review* 37, 1-20.

Kamien, Morton I. and Israel Zang (1990) "The limits of monopolization through acquisition," *Quarterly Journal of Economics* 105, 465-499.

Katz, M. and C. Shapiro (1986) "Product compatibility choice in a market with technological progress," *Oxford Economic Papers* 38, 146-165.

Krishna, Kala (1988) "High-tech trade policy," in R. Baldwin, C. Hamilton and A. Sapir, eds. *Issues in US-EC Trade Relations*. Chicago: University of Chicago Press, 285-311.

MacKie Mason, Jeffrey and Janet S. Netz (2002) "Manipulating interface standards as an anti-competitive strategy," Mimeo, presented at 2002 Telecommunications Policy Research Conference.

Markusen, James R., (1995) "The boundaries of multinational enterprises and the theory of international trade," *Journal of Economic Perspectives* 9, 169-89.

Markusen, James R., (2001) "Contracts, intellectual property rights, and multinational investment in developing countries," *Journal of International Economics* 53, 189-204.

Mattoo, Aaditya, Marcelo Olarreaga, and Kamal Saggi (2003) “Mode of foreign Entry, technology transfer, and FDI policy,”*Journal of Development Economics*, forthcoming.

Reynolds, Robert J. and Brad Snapp (1986) “The competitive effects of partial equity interests and joint ventures,” *International Journal of Industrial Organization* 8, 559-574.

Roy, Prithvijit, Tarun Kabiraj, and Arijit Mukherjee (1999) “Technology transfer, merger, and joint venture: A comparative welfare analysis,” *Journal of Economic Integration* 14, 442-466.

Saggi, Kamal (2002) “Trade, foreign direct investment, and international technology transfer: a survey,” *World Bank Research Observer* 17, 191-235.

Svejnar, Jan and Stephen Smith (1984) “The economics of joint ventures in less developed countries,” *Quarterly Journal of Economics* 99, 149-168.

The World Bank (2003) *Global Economic Prospects: Investing to Unlock Global Opportunities*, Washington DC.

UNCTAD (1999*) World Investment Report: Foreign Direct Investment and the Challenge of Development*. New York, NY: United Nations.

_____ (2001) *World Investment Report: Promoting Linkages*. New York: United Nations.

Appendix

Proof of Lemma 1:

Functions $g^D(n, L)$ and $g^A(n, L)$ are well defined assuming that the conditions of concavity with respect to γ of the entrant’s profits under the two entry modes net of the fixed compatibility cost are satisfied:

$$\frac{d^2\Pi_F^D}{d\gamma^2} - K'' = \frac{n^2}{(1-n(1-\gamma))}\frac{L^2}{9(1-n(1-\gamma))^2} - K'' \leq 0$$

and

$$\frac{d^2\Pi_{HF}^A}{d\gamma^2} - K'' = \frac{n^2}{(1-n(1-\gamma))}\frac{L^2}{4(1-n(1-\gamma))^2} - K'' \leq 0 \cdot$$

These conditions are assured by our earlier assumption that the compatibility enhancing technology is not too inefficient, $L < 2(1-n(1-\gamma))$ and by the assumption that the network effect is not too strong:

$$n \leq \frac{\left(K''^2 + 4K''\right)^{1/2} - K''}{2}.$$

For example, in the case where $K(\gamma) = \gamma\left(1-(1-\gamma)^{\frac{1}{2}}\right)$, we need $n \leq 0.6$.

Given our assumptions about the compatibility enhancing technology, we have $\left.\frac{d\Pi_F^D}{d\gamma}\right|_{\gamma=o} - \left.\frac{dK}{d\gamma}\right|_{\gamma=o} = \frac{n}{2}\left(1-\frac{L^2}{9(1-n)^2}\right) - 0 \geq 0$ for $0 \leq n \leq 1$ and $L \geq 0$. Therefore, $g^D(n, L) \geq 0$ for $0 \leq n \leq 1$ and $L \geq 0$. Similarly, we have $\left.\frac{d\Pi_{HF}^A}{d\gamma}\right|_{\gamma=o} - \left.\frac{dK}{d\gamma}\right|_{\gamma=o} = \frac{n}{2}\left(1-\frac{L^2}{4(1-n)^2}\right) - 0 \geq 0$ for $0 \leq n \leq 1$ and $L \geq 0$.

Therefore, $g^A(n, L) \geq 0$ for $0 \leq n \leq 1$ and $L \geq 0$.

Given that $K(\gamma)$ does not depend on n and L, we can derive the rest of the results in the Lemma by verifying the signs of the appropriate derivatives of the entrant's profit function:

$$\frac{d^2\Pi_F^D}{d\gamma dL} = -\frac{nL}{9(1-n(1-\gamma))^2} < 0 \text{ and } \frac{d^3\Pi_F^D}{d\gamma dL^2} = -\frac{n}{9(1-n(1-\gamma))^2} < 0;$$

$$\left.\frac{d^2\Pi_F^D}{d\gamma dn}\right|_{n=0} = -L^2 + 9 > 0 \text{ and } \frac{d^3\Pi_F^D}{d\gamma dn^2} = -\frac{C^2(2+n(1-\gamma))(1-\gamma)}{9(1-n(1-\gamma))^4} < 0.$$

Similarly, the remaining properties of $g^A(n, L)$ can be derived by verifying the signs of the appropriate derivatives of the two-product monopolist's profit function:

$$\frac{d^2\Pi_{HF}^A}{d\gamma dL} = -\frac{nL}{4(1-n(1-\gamma))^2} < 0 \text{ and } \frac{d^3\Pi_{HF}^A}{d\gamma dL^2} = -\frac{n}{4(1-n(1-\gamma))^2} < 0;$$

$$\left.\frac{d^2\Pi_{HF}^A}{d\gamma dn}\right|_{n=0} = -L^2 + 4 > 0 \text{ and } \frac{d^3\Pi_{HF}^A}{d\gamma dn^2} = -\frac{C^2(2+n(1-\gamma))(1-\gamma)}{4(1-n(1-\gamma))^4} < 0.$$