Multinationals, Linkages, and Economic Development

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This paper explores how multinationals affect underdeveloped regions through the generation of linkages. It is shown that the linkage effect of multinationals on the host country is more likely to be favorable when the good that multinationals produce uses intermediate goods intensively, when there are large costs of communication between the headquarters and the production plant, and when the home and host countries are not too different in terms of the variety of intermediate goods produced. If these conditions are reversed, then multinationals could even hurt the developing economy, formalizing the idea that multinationals may create enclave economies within developing countries. (*JEL* F23, O11)

After decades of skepticism, there is now a shared belief that multinationals can be an important element in a country's development strategy. As a consequence, "governments all around the world, especially in developing countries, are queuing up to attract multinationals" (*Economist*, March 27, 1993). Formal economic reasoning has contributed little to the emergence of this optimistic consensus.[1] It is well known that, when multinationals arise because of large international differences in factor endowments that prevent factor-price equalization through trade, as by modeled Elhanan Helpman and Paul R. Krugman (1985 chapter 12), multinationals are a way through which the equilibrium can approach the integrated equilibrium. In this case, multinationals increase world welfare by serving as a channel through which the host country effectively obtains access to resources that are relatively abundant in the home country. Unfortunately, very little is known about how multinationals affect the host country through other important channels, such as the transfer of technology, the training of workers and the generation of linkages. Ironically, these are the issues that the empirical literature emphasizes (see Sanjaya Lall, 1978; and the articles in Eric D. Ramstetter, 1991).

This paper focuses on the impact of multinationals on developing countries through the generation of backward and forward linkages. Since the appearance of Albert O. Hirschman's (1958) famous book on economic development, a large empirical literature has emerged on this topic (see Lall, 1978). This literature, however, has suffered from the absence of a formal concept of linkages and a formal theory of their importance. The most sophisticated studies use the inverse of the Leontief input-output matrix to construct indexes of backward and forward linkages for each industry (for example, Richard Weisskoff and Edward Wolff, 1977). Other studies simply use the ratio of local to total purchases as a proxy for

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[1] The literature on multinational corporations has developed considerably in recent years (see S. Lael Brainard, 1993a; Wilfred J. Ethier, 1986; Elhanan Helpman, 1984; and James R. Markusen, 1991) and a consensus seems to be emerging about the reasons for their existence (see Brainard, 1993b). Still, this issue, together with multinationals' impact on the pattern of international trade (interindustry versus intraindustry and intrafirm trade) has occupied almost all of the attention, and little effort has been devoted to understanding the welfare effects of multinationals on the home and host countries.

backward linkages (for example, Philip J. McDermott, 1979; Patricia A. Wilson, 1992). Moreover, in many countries fiscal incentives favor multinationals with a high percentage of domestic value-added, presumably because they generate more backward linkages. Without a formal concept of linkages, however, it is hard to know what these estimates and measures really mean. Accordingly, the first objective of this paper is to formalize the concept of backward and forward linkages.

The formalization of linkages in this paper is based on three premises: 1) production efficiency is enhanced by the use of a wider variety of specialized inputs; 2) the proximity of supplier and user is essential for many of these inputs;[2] 3) the size of the market limits the available variety of specialized inputs. In this paper these premises are captured, respectively, by assuming that there is love of variety for inputs in the production of final goods (as in Ethier, 1982; Paul M. Romer, 1990), that domestic firms must buy all of their inputs locally, and that inputs are produced with increasing returns to scale. Under these circumstances, by increasing the demand for inputs, a final-good firm helps bring forth a greater variety of specialized inputs, thus generating a positive externality to other final-good producers. This is the concept of backward linkages. In turn, local production of more specialized inputs allows the production of more complex goods (that is, goods that use specialized inputs with high intensity) at competitive costs. This is the concept of forward linkages.[3,4]

Evidence for the existence of local externalities through backward linkages is provided by Thomas J. Holmes (1995). He shows that manufacturing establishments located in areas where their industry is concentrated use purchased inputs more intensively than do relatively isolated establishments. This evidence suggests that the geographic concentration of an industry expands the local market for specialized inputs and allows the local production of a wide variety of those inputs. Firms located in the region where the industry is concentrated can then choose to rely more heavily on purchased inputs and specialize further on their main line of business.[5]

In another paper (Rodríguez-Clare, 1996) I have shown that an economy where backward and forward linkages exist may exhibit multiple Pareto-rankable equilibria. In the "good" equilibrium the economy specializes in the production of complex final goods, a large variety of specialized inputs is produced, and wages are high. In the "bad" equilibrium, the economy specializes in the production of simple final goods (that is, labor-intensive goods), a low variety of specialized inputs is produced, and wages are low. In other words, when both forward and backward linkages

[2] This second premise deserves elaboration. Producer services (for example, banking, auditing, consulting, wholesale services, transportation, machine repair), usually regarded as *nontradable* goods, are clear examples of inputs for which proximity between suppliers and producers is essential. But even for physical intermediate goods, it may be costly to rely on suppliers located far away since this implies a higher risk that the inputs will not arrive at the necessary time or with the correct specifications, forcing firms to hold high inventories of such inputs (see Wilson [1992 pp. 101–4] for some concrete examples). As Michael E. Porter (1992) argues, the domestic presence of suppliers is an important determinant of the comparative advantage of nations because it provides "efficient, early, rapid, and sometimes preferential access to the most cost-effective inputs" (p. 102). See Rodríguez-Clare (1993) for more on this.

[3] Hirschman (1956) himself made similar assumptions in his analysis of linkages. He argued that domestically produced inputs were more conducive to the development of further economic activity (pp. 99–100) and he believed that there was a "minimum economic size" for the profitable operation of most activities (p. 101). Finally, he implicitly assumed that a set of inputs was indispensable for the production of each good, an extreme form of love of variety.

[4] Notice that according to this definition of forward and backward linkages, backward linkages are a necessary condition for forward linkages to materialize. I thus focus on the generation of backward linkages by multinationals.

[5] Additional evidence is provided by Niles Hansen (1993), who shows that the density of metropolitan producer services (a good example of intermediate goods for which the proximity of suppliers and users is very important) has a significant and positive association with per capita metropolitan income, even after controlling for education and population size. J. Neill Marshall (1988) cites several empirical studies that also suggest that the proximity of specialized providers of producer services contributes positively to firm performance.

materialize, the economy ends up with a deep division of labor and high wages. Such linkages may fail to materialize, however, and in this case the economy remains underdeveloped.

Whenever economies in the good and bad equilibrium coexist (developed and developing economies, respectively), a firm producing final goods would benefit from having access to the wide variety of specialized inputs produced in the developed economy and the cheap labor available in the developing economy. Domestic firms in the poor economy cannot do this, however, because by assumption they cannot import specialized inputs from another country. I assume that firms can do this only by becoming multinational, or in other words, by locating their "headquarters" in the developed economy and a production plant in the poor economy. Essentially, I assume that specialized inputs are nontradable, but can be used by multinationals to produce "headquarter services" to complement the production process in another country.

This concept of multinationals is closely related to that of Ethier (1986), Helpman (1984) and Markusen (1984, 1991).[6] Markusen (1991), for instance, argues that multinationals are in the business of supplying certain inputs and producer services such as management, engineering, marketing and financial services to their foreign subsidiaries. Levi Strauss & Co. offers a good example of this phenomenon. The headquarters, which is located in San Francisco, is responsible for strategy, marketing, design and the management of worldwide flow of inputs and merchandises, but most of the production process is carried out in low-wage countries. For instance, there is an affiliated company in Costa Rica that produces jeans, slacks and shirts. The designs and the marketing strategy, as well as some inputs such as cloth, buttons and zippers come from suppliers in the United States. The production plant in Costa Rica finishes the production process by combining these inputs with labor and additional intermediate goods bought locally such as thread, cloth (lining) and some producer services.

To see how multinationals affect the host country through the generation of linkages, this paper develops a two-country model in which multinationals exist precisely because of these considerations. I explore an equilibrium that entails a large variety of specialized inputs and high wages in country A and the opposite in country B. As a result, domestic firms in country A specialize in the production of complex goods and domestic firms in country B specialize in the production of simple goods. Multinational firms, if they exist, locate their headquarters in country A and their production plant in country B. Intermediate goods are nontradable and only multinationals have access to intermediate goods from both countries.[7]

The impact of multinationals on country B (the developing country) depends on the linkages they generate compared to the linkages that would be generated by the domestic firms they displace from the labor market. I must then compare the linkages generated per unit of labor hired by multinationals and by domestic firms. The model indicates that this can be measured by the ratio of employment generated in upstream industries (through demand for specialized inputs) to the labor hired directly by the firm. I refer to this ratio as the *linkage coefficient* of the firm. When a multinational has a higher linkage coefficient than domestic firms, it leads to a higher equilibrium variety of specialized inputs. In this case I say that the multinational has a *positive linkage effect*. The contrary occurs when a multinational has a lower linkage coefficient than domestic firms, in which case I say that the

[6] Gordon H. Hanson (1994) uses a similar idea to model the relationship between firms that produce designs for goods and the firms to whom they subcontract for assembly.

[7] It should be noted that my model does not address the complicated issue of whether it is more efficient to have transactions carried out inside the firm rather than through some type of inter-firm relationship (for example, subcontracting). (For an analysis of the multinational firm that focuses on this issue see Ethier [1986].) Fortunately, this is not necessary for the purposes of this model: whether international input transactions are done inside the firm, through subcontracting or through some other type of relationship is irrelevant for the main results of this model *so long as* there is some firm-specific fixed cost associated with international trade of intermediate goods.

multinational has a *negative linkage effect*. Because of love of variety for inputs, a positive (negative) linkage effect leads to an increase (decrease) in the productivity of domestic firms and a consequent increase (decrease) in the wage level in the economy.

What determines whether the linkage coefficient of multinationals is higher or lower than that of domestic firms? Because they produce more complex goods, multinationals have a higher demand for specialized intermediate goods per unit of labor hired than do domestic firms. Since they have access to specialized inputs produced in country A, however, multinationals demand only a fraction of these inputs from country B. This fraction is higher when the communication costs (to be defined more precisely) between the headquarters and the production plant are high and when the home and host economies are not too different. As a consequence, multinationals are more likely to have a positive linkage effect when the good that multinationals produce is more complex, the costs of communication between the headquarters and the production plant are higher, and the home and host countries are more similar.[8]

In *Cities and the Wealth of Nations*, Jane Jacobs (1985) provides an example of what appears to be a case of a negative linkage effect. She contrasts the local effects that Lockheed Aircraft had on Los Angeles, where the company started, with the local effects it had on the northern region of Georgia, where the company built a production plant at a later stage. When the company started, it had to scramble in the local economy for hundreds of goods and services to make the first airplanes. The company bought many of these inputs locally, it imported others (using the services of distributors, agents and importers who were operating in the city), and it contracted with local producers for the inputs that it could not find at all. It thus seems that the company had a strong positive linkage effect on the local economy. Something very different happened later on, when Lockheed built a factory to produce military aircraft in Marietta, Georgia. Almost all inputs and services needed were then obtained through the headquarters, which remained in Los Angeles, so the company did not help support the production of new kinds of goods and services in Marietta. Jacobs explains how, even after many other firms had set up factories in the region, the local economy of north Georgia remained "unresilient, fragile and limited. The transplants, in short, proved to be a barren foundation for indigenous industrial development" (p. 97).

This pessimistic conclusion does not apply in all circumstances, however. For instance, Linda Y. C. Lim and Pang Eng Fong (1982) provide some examples of multinationals in the export-oriented electronics industry in Singapore that apparently had a positive linkage effect. According to Lim and Fong, these firms actively promoted the establishment of local suppliers because the cost savings of local procurement more than compensated the low quality and reliability of locally produced parts. Furthermore, by creating a large enough local demand, these firms were able to induce many of the parent company's home-country suppliers to establish local subsidiaries.[9]

The rest of this paper proceeds as follows. The next section presents the basic assumptions of the model. Section II shows the possibility of multiple Pareto-rankable equilibria for a single country when there are no multinationals. It is established that firms have an incentive to become multinational, since this would give them access to the low-wage workers of the poor economy (that is, the economy in the bad equilibrium) and the large variety of intermediate goods produced in the rich economy (that is, the economy in the good equilibrium). Section III then performs a partial-equilibrium comparative-statics analysis to understand how multinationals affect

[8] While his main focus was the impact of international subcontracting rather than of multinationals on developing countries, Michael Sharpston (1995) proposes a related conjecture. He argues that "sub-contracting of single processes is likely to have the least widespread effects and certain operations of this type seem natural to be of an enclave nature" (p. 129).

[9] Allen J. Scott (1987) argues that American semiconductor firms that located assembly plants in South-East Asia had similar positive linkage effects on the local economy.

country B, which is assumed to be in the "bad" equilibrium. Section IV extends and qualifies the results of Section III by deriving an equilibrium of the two-country model and analyzing the comparative statics of an increase in the number of multinationals. Section V shows that multinationals with a low linkage coefficient prefer to locate in underdeveloped regions. Section VI contains a few concluding remarks.

I. Basic Assumptions

I consider two countries, A and B, with labor internationally immobile. There is a continuum of workers in each country, with measure L_R ($R = A, B$). There are two final goods, z and y, and one intermediate good x, which comes in a continuum of varieties. Variety is indexed by the real number j. Goods z and y can be traded freely in the world market, and both countries are "small" in the sense that they do not affect the international prices of z and y, denoted respectively by P_z and P_y (in terms of some international numeraire).[10]

The intermediate good x is nontradable. Therefore a variety of x is available in country R if and only if it is produced in country R. The measure of varieties of x actually produced in country R will be denoted by the real number $n_R \geq 0$ (that is, variety j of x is available in country R if $j \leq n_R$). $p^R(j)$ will denote the price of variety j of intermediate good x in country R.

Even though intermediate goods cannot be traded across the two countries through the market, I assume that firms can gain access to the intermediate goods of both countries by becoming multinational. This assumption will be discussed in more detail in Section III.

A. *The Technology*

Each variety of the intermediate good x is produced with a simple decreasing average-cost technology: there is a fixed requirement of one unit of L and each additional unit of $x(j)$ requires one additional unit of L.

Both final goods are produced with a Cobb-Douglas production function using labor and a composite intermediate good, X, which is assembled from a continuum of differentiated intermediate goods:

$$(1a) \qquad Q_s = \delta(s) L_s^{\beta(s)} X_s^{1-\beta(s)}$$

$$(1b) \qquad X_s = \left(\int_0^n x(j)_s^{\alpha} \, dj \right)^{1/\alpha}$$

for $s = z, y$, where $\delta(z)$, $\delta(y)$, $\beta(z)$, $\beta(y)$ and α are constant parameters and we assume that $\beta(z)$, $\beta(y)$, $\alpha \in (0, 1)$.[11] It is assumed that $\beta(z) > \beta(y)$, which implies that the y industry uses intermediate goods more intensively than the z industry.

The specification of the production function in (1) implies that there are returns from the division of labor in the production of intermediate goods. To see this, note that because of convexity and symmetry among varieties of x, efficiency requires final-good firms to use the same quantity of all available varieties; that is, efficiency requires that $x(j) = x$ for all $j \leq n$. Letting L_x denote the amount of labor devoted to the production of intermediate goods (excluding the labor used to produce the fixed requirement per variety), we have $L_x = \int_0^n x(j) \, dj = nx$. The production function for good s ($s = z, y$) can then be written as:

$$(2) \qquad Q_s = \delta(s) n^{\phi(s)} L_s^{\beta(s)} L_x^{1-\beta(s)}$$

where $\phi(s) \equiv (1 - \beta(s))(1 - \alpha)/\alpha$. Equation (2) shows that an increase in the available variety of intermediate goods increases total factor productivity in the production of final goods. This property is commonly referred to as *love of variety* for inputs. Since $\beta(z) > \beta(y)$ then $\phi(y) > \phi(z)$, which implies that producers of y have stronger love of variety than pro-

[10] Alternatively, I could assume that the economy composed of countries A and B is closed but z and y are perfect substitutes in consumption. What is important is that the relative price of z and y remains constant. This assumption is made to simplify the analysis and focus on the most important issues.

[11] The production function of the composite intermediate good X uses the functional form first proposed by Avinash K. Dixit and Joseph E. Stiglitz (1977) as a specification for a utility function and later applied to production theory by Ethier (1982).

ducers of z. This will play an important role in this model.

B. *Market Specification for Intermediate Goods*

Each firm producing a variety of x is better-off choosing a variety that is not already being produced by another firm; therefore variety j of x, if it is produced, is produced by a single firm which then chooses price $p(j)$ to maximize profits. In other words, there is monopolistic competition in the intermediate goods sector.

Since multinationals buy specialized inputs from both countries, this logic also implies that firms in countries A and B produce different varieties of x. That is, if variety j is produced in country A, it will not be produced in country B. I use a different index for variety in the two countries, in order to keep the convenient convention that if variety j is produced in a country, then all varieties k with $k < j$ are also produced there.

II. Equilibria in a Single Country with No Multinationals

This section shows the possibility of multiple equilibria for a single country in which there are no multinationals. The next section then shows that firms have an incentive to become multinational to take advantage of the special conditions of countries in the good and bad equilibrium.

With no multinationals, all firms in a country have to obtain their inputs from the country in which they locate; hence, there is no interaction between countries A and B. I can then derive the equilibria for the two countries independently, and accordingly, in this section I drop the subindex for country. Since most details of this kind of model are well-known, I leave the formal derivation of most of the equations to Appendix A and focus here on the intuition underlying the main results.

Since there is only one nonproduced factor of production (labor), Paul A. Samuelson's Nonsubstitution Theorem (see Hal R. Varian [1992 p. 354] for a formal statement and proof of this theorem) implies that, for a given level of n, the marginal rate of transformation be-

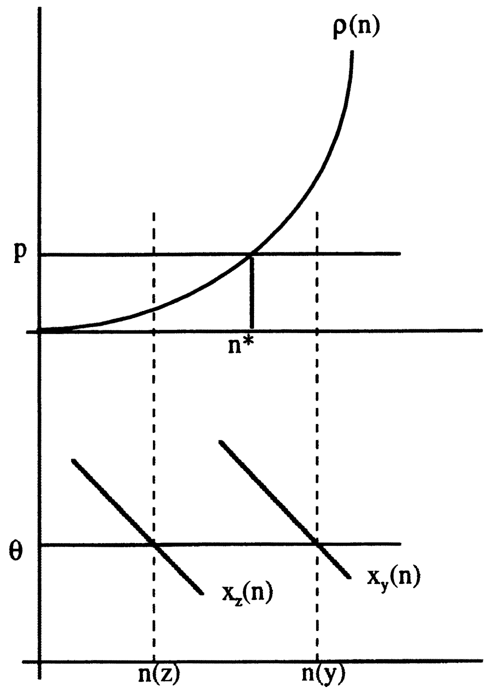

FIGURE 1. DETERMINATION OF EQUILIBRIUM LEVELS OF n FOR THE CASE IN WHICH $n(z) < n^* < n(y)$

tween z and y is constant (that is, the production possibilities frontier is linear). Formally, the ratio of unit costs is given by

$$(3) \quad c_z / c_y = \rho(n) \equiv \alpha^{\beta(z) - \beta(y)} n^{\phi(y) - \phi(z)}.$$

Except for the knife-edge case in which $p \equiv P_z/P_y = \rho(n)$, there will be complete specialization in the production of final goods: there is complete specialization in the production of y if $\rho(n) > p$ and there is complete specialization in the production of z if $\rho(n) < p$.

Since $\phi(y) - \phi(z) = (\beta(z) - \beta(y))(1 - \alpha)/\alpha > 0$, then $\rho(n)$ is increasing, as shown in Figure 1. Therefore, as n increases, the production possibilities frontier rotates so that the marginal cost of z in terms of y increases. As we can see in Figure 1, there is a level of n, n^*, such that if $n > n^*(n < n^*)$ there is complete specialization in $y(z)$. The intuition is simple: since y uses intermediate goods more intensively than z, it benefits comparatively more from an increase in the variety of intermediate goods, so as n increases, the unit cost of y falls relative to the unit cost of z.

To determine the equilibrium level of n I must now consider the zero-profit condition for intermediate-good producers. As is well known, in this kind of model all monopolists producing intermediate goods maximize profits by charging a fixed mark-up over marginal cost, $p(j) = w/\alpha$, and they make zero profits if and only if at this price they sell a quantity equal to $\theta \equiv \alpha/(1 - \alpha)$. That is, the zero-profit condition in the intermediate-goods sector is

$$(4) \qquad x(j) = \theta \qquad \text{for all } j.$$

It is easily verified that given $p(j) = w/\alpha$ for all j, the quantity of each variety of x that producers of final good s purchase per unit of labor hired, which is denoted by v_s, is given by

$$(5) \qquad v_s(n) = \alpha m(s)/n,$$

where $m(s) \equiv (1 - \beta(s))/\beta(s)$. Therefore, when there is complete specialization in final good s, the zero-profit condition for the intermediate-goods sector is $v_s(n)L_s = \theta$, where L_s is the total quantity of labor hired by firms producing final good s. Combining this with the full-employment condition $L = n + nv_s(n)L_s + L_s$, I obtain the quantity sold by each input supplier when there is complete specialization in s as a function of n, $x_s(n)$, which is shown in Figure 1. The curve $x_y(n)$ lays everywhere above the curve $x_z(n)$ because, since the y sector uses intermediate goods more intensively than the z sector, the demand for intermediate goods is higher when there is complete specialization in y than when there is complete specialization in z. As Figure 1 shows, this leads to the intuitive result that when the economy specializes completely in y the equilibrium variety of inputs is higher than when the economy specializes completely in z; that is, $n(z) < n(y)$.

I can now derive the set of equilibria for this economy. Figure 1 illustrates the case in which n^* lies in the interval $[n(z), n(y)]$. In this case there are multiple equilibria. If $n = n(z)$, then $n < n^*$, so there is complete specialization in final good z and $x(j) = x_z(n) = \theta$ for all j, so the zero-profit condition holds. Similarly, if $n = n(y)$, then $n > n^*$, so there is complete specialization in final good y and the zero-profit condition holds.[12] If n^* lies outside the interval $[n(z), n(y)]$ there is a single equilibrium: if $n^* < n(z)$, the unique equilibrium involves $n = n(y)$ and complete specialization in y; if $n^* > n(y)$, the unique equilibrium involves $n = n(z)$ and complete specialization in z.

For future purposes, I derive the wage in each equilibrium. Let $w_s(n)$ denote the wage level for a given level of n when there is complete specialization in final good s. From the zero-profit condition for producers of s, $c_s = P_s$,

$$(6) \qquad w_s(n) = P_s \alpha^{1-\beta(s)} n^{\phi(s)}.$$

From the definition of n^* it follows that $w_z(n^*) = w_y(n^*)$. Therefore, since both $w_z(n)$ and $w_y(n)$ are increasing and since $n(z) < n^* < n(y)$, then necessarily $w_z(n(z)) < w_y(n(y))$. The wage is thus higher in the equilibrium with complete specialization in y (called the y equilibrium) than in the equilibrium with complete specialization in z (called the z equilibrium). Given that there are zero profits in equilibrium, this implies that the y equilibrium is Pareto superior to the z equilibrium.[13] In the z equilibrium there is a coordination failure: everyone would be better-off in the y equilibrium but no single individual wants to produce y given the small variety available of intermediate goods. But it is not profitable for anyone to produce a new variety of the intermediate good because of the low demand for intermediate goods that

[12] It is straightforward to establish that in this case there exists a third equilibrium, for which $n = n^*$ and both goods are produced. However, this equilibrium is unstable under "naive Marshallian" dynamics and therefore the rest of the paper focuses on the equilibria with complete specialization. (Under "naive Marshallian" dynamics, entrepreneurs slowly enter the intermediate-good sector if profits there are positive and slowly exit when they incur losses in that sector.)

[13] For a more extensive treatment of the multiple equilibria result in a more general version of this model see Rodríguez-Clare (1996).

arises in an economy that is completely specialized in the production of z.[14]

III. Effects of Multinationals on Underdeveloped Countries

The previous results imply that firms have an incentive to become multinational whenever countries in the good and bad equilibria coexist. To see this, assume that country A is in the y equilibrium and country B in the z equilibrium. This requires that $n_B < n^* < n_A$, which implies that the shadow price of the composite input X is lower in A than in B while the wage is higher in A than in B (see Appendix B for a formal proof of this claim). As a result, firms would want to buy specialized inputs in country A and hire labor in country B. In this paper I assume that firms can only do this by becoming multinational, locating their headquarters in country A and a production plant in country B. In this way, a firm can achieve lower unit costs than firms located in only one country. The rest of the paper will be concerned with understanding the impact of multinationals on the equilibrium in countries A and B.

I first introduce some additional assumptions concerning multinationals in this model. It is assumed that a multinational's headquarters buys specialized inputs from the home country to produce a composite input that it then sends to the production plant in the host country. The production plant produces the final good using this composite input together with labor and other specialized inputs obtained in the host country. It is assumed that the transfer of the composite input across countries A and B is subject to an "iceberg" transportation cost equal to τ (that is, a fraction τ of the composite input melts down during transportation). Henceforth τ is referred to as a communication cost, since it is likely that the most important part of the composite input is information.

Further I assume that multinationals have to hire someone in the home country to manage the headquarters. People are homogeneous in terms of their abilities as workers but differ in their management abilities. In particular, managers with higher ability can effectively manage a bigger multinational, in terms of the size (that is, quantity of labor hired) of the production plant. Formally, I assume that each person has an index i and that a multinational managed by somebody with index i can hire no more than $h(i)$ workers for the production plant.[15] Without loss of generality, I assume that $h(i)$ is decreasing (the importance of this assumption of heterogeneity is discussed in the next section). These assumptions imply that a multinational is like a domestic firm that hires a worker in another country to have access (although incurring a transportation cost) to the intermediate goods produced there.

To simplify the exposition of the main results, this section assumes that the variety of intermediate goods produced in country A, n_A, and the number of multinationals, M, are both exogenous and fixed. Furthermore, I assume that there are no multinationals with headquarters in country B and that multinationals choose to produce the final good y.[16] These assumptions will then be relaxed in the next section to derive the full equilibrium for the two-country economy.

To determine the equilibrium for economy B, I first determine the level of n at which there are zero profits in the intermediate-goods sector. (I only use the subindex for country B

[14] There are two types of distortions that could potentially justify government intervention in this context (but see Kiminori Matsuyama [1994] for the problems that such an intervention would face). First, for each equilibrium, as shown by Dixit and Stiglitz (1977), there is a suboptimal level of entry; that is, n_R is lower than the optimal level of n when the economy is completely specialized in R. Second, there is the coordination problem; the government would like to coordinate economic agents in such a way that the y equilibrium is chosen. (One way of doing this is by imposing a tariff on y so that the z equilibrium disappears.) The results of this paper depend critically on the assumption that for some reason the government can solve neither of these two distortions.

[15] Since there is a fixed cost of managing a multinational, the absence of a limit on the size of multinationals would create incentives for the formation of only one large multinational in the host country. The assumption of a limit on the size of multinationals is therefore needed to get the more realistic situation with several multinationals.

[16] If the multinational chooses to produce z then it can be shown that the effects on the domestic economy are worse than those that result when it chooses to produce y.

when necessary to avoid confusion.) The only difference between the analysis of this section and the previous one is that here I take into consideration the demand for intermediate goods by multinationals; this affects the full-employment condition and the zero-profit condition for the intermediate-goods sector.

Given that $h(i)$ is decreasing, if a person with index i is managing a multinational then all those with index $k < i$ will also be managing a multinational. Therefore, if there are M multinationals, the set of people managing multinationals in country A is $\{i: i \leq M\}$ and the quantity of labor hired by multinationals in country B is $L_m(M) \equiv \int_0^M h(i)\,di$. Now, let $v_s(n)$ be defined as in the previous section, and let $v_m(n)$ be the quantity of each variety of x produced in country B that multinationals demand per unit of labor *hired in country B* as a function of n. Given that the domestic sector in economy B is completely specialized in final good z, the full-employment condition for country B is now given by

$$(7) \quad L = n + nv_z(n)L_z + nv_m(n)L_m(M) + L_z + L_m(M).$$

Let $L_x(n, M)$ denote the total demand for labor by the producers of intermediate goods as a function of n and M: $L_x(n, M) \equiv nv_z(n)L_z + nv_m(n)L_m(M)$. From (7)

$$(8) \quad L_x(n, M) = (L - n - L_m(M)) \times \frac{nv_z(n)}{1 + nv_z(n)} + \frac{nv_m(n)}{1 + nv_z(n)} L_m(M).$$

Given the symmetry of producers of varieties of x, each of them will sell $x(n, M) \equiv L_x(n, M)/n$ given n. The zero-profit condition can then be written as $x(n, M) = \theta$. This is illustrated in Figure 2, where the intersection of the curve $x(n, M)$ and the horizontal line at θ determines the level of n at which the zero-profit condition for producers of intermediate goods is satisfied. As long as $n(M) < n^*$ (so that domestic final-good producers in country B indeed produce good z), this gives the equilibrium for country B when there are M multinationals in country B. As I verify below, under plausible conditions the curve $x(n, M)$

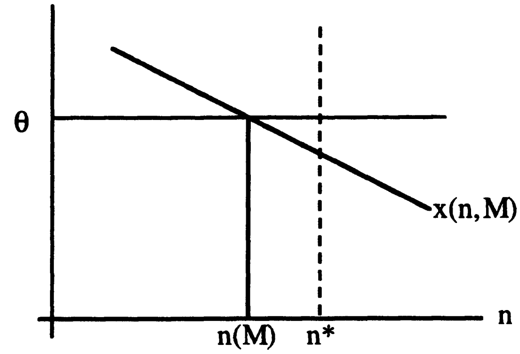

FIGURE 2. DETERMINATION OF THE EQUILIBRIUM LEVEL OF n WHEN THERE ARE M MULTINATIONALS

intersects θ from above (as drawn in Figure 2), so the equilibrium determined by the equality $x(n, M) = \theta$ is stable in the Marshallian sense.

I now consider how multinationals affect the equilibrium wage in country B. Since the wage is still determined by equation (6), I just have to determine how M affects the equilibrium variety of intermediate goods in country B. It is easy to see from Figure 2 that this hinges on how M affects the curve $x(n, M)$, which in turn depends on the sign of $\partial L_x/\partial M$ (since $\partial x/\partial M = (1/n)(\partial L_x/\partial M)$). If this partial derivative is positive when evaluated at $x(n; M) = \theta$, then an increase in M leads to an increase in the demand for intermediate goods at $n(M)$, leading to an increase in n and w. The opposite occurs if $\partial L_x/\partial M < 0$.

To determine the sign of $\partial L_x/\partial M$, note from (8) that

$$(9) \quad \text{sign}(\partial L_x / \partial M) = \text{sign}(nv_m(n) - nv_z(n))$$

$nv_z(n)$ and $nv_m(n)$ represent the level of employment generated in the intermediate-goods sector per unit of labor hired directly by domestic firms and multinationals, respectively. In the Introduction I referred to this factor as the *linkage coefficient* of a firm. Equation (9) and the arguments above lead to the following proposition.

PROPOSITION 1: *Given n_A, if the linkage coefficient of multinationals is higher than the linkage coefficient of domestic firms ($nv_m(n) > nv_z(n)$), then an increase in M generates an increase in n and w. The opposite occurs if $nv_m(n) < nv_z(n)$. More generally, multinationals are more beneficial—or less harmful—to the host economy when their linkage coefficient is higher; that is, any parameter change that shifts the curve $v_m(n)$ up will lead to an increase in n and w in country B.*

This proposition has a very intuitive interpretation. Because of love of variety, the wage in country B increases with the variety of intermediate goods produced there. Whenever their linkage coefficient is lower than that of domestic firms, multinationals decrease the total demand for intermediate goods as they hire labor that domestic firms were previously employing. This decreases n and w in equilibrium. In some sense, the industrial structure becomes ''shallower'' as multinationals displace domestic firms from the labor market. In this case, multinationals have a *negative linkage effect* ($nv_m(n) < nv_z(n)$).[17] The opposite occurs when the linkage coefficient of multinationals is higher than that of domestic firms, in which case multinationals have a *positive linkage effect* ($nv_m(n) > nv_z(n)$).

An interesting corollary of this result is that when multinationals have a positive linkage effect, a policy of attracting multinationals could push n above n^*. At this point domestic firms in country B would start producing good y, and country B would get out of the bad equilibrium. This is a case in which the backward linkages generated by multinationals are strong enough to induce a forward linkage, since domestic firms in country B start producing a new good. This is why *the right kind* of multinationals may make it easier for a developing country to get out of an underdevelopment trap.

Next the factors that determine the sign of the linkage effect are examined. To this end, I must consider how the different parameters of the model affect the difference between $nv_m(n)$ and $nv_z(n)$. The first step is to derive $v_m(n)$ explicitly. To maximize profits, the demand for X per unit of labor hired by a multinational is equal to $\psi(y)(P_y/P_{xm})^{1/\beta(y)}$, where $\psi(s) \equiv [\delta(s)(1-\beta(s))]^{1/\beta(s)}$ and P_{xm} is the shadow price of X for multinationals. Letting X_m denote the total demand for X by multinationals,

$$(10) \quad X_m = \psi(y)(P_y/P_{xm})^{1/\beta(y)} L_m(M).$$

Now, given a desired level of the composite input X_m, multinationals' demand for an individual variety of x in country B is given by

$$(11) \quad x_m(j) = p^B(j)^{-\theta/\alpha} P_{xm}^{\theta/\alpha} X_m.$$

From (10) and (11), and noting that $p^B(j) = w_z(n)/\alpha$, I finally obtain

$$(12) \quad v_m(n) = \psi(y) P_y^{1/\beta(y)} (w_z(n)/\alpha)^{-\theta/\alpha} \times P_{xm}(n)^{\theta/\alpha - 1/\beta(y)}$$

where

$$(13) \quad P_{xm}(n) = \left(\int_0^{n_A} [p^A(j)/(1-\tau)]^{-\theta} \, dj + \int_0^{n_B} p^B(j)^{-\theta} \, dj \right)^{-1/\theta} = ((1-\tau)^{\theta} P_{xA}^{-\theta} + P_{xB}(n)^{-\theta})^{-1/\theta}$$

and P_{xR} is the shadow price of the composite input X for domestic firms in country R.

[17] This result is consistent with the view that a multinational can create an enclave, as has been generally conjectured (for example, Lall, 1978; UNCTAD, 1975; J. C. Stewart, 1976; Weisskoff and Wolff, 1977). It should be stressed, however, that the analysis assumes full employment. Yet under some conditions there may be unemployment or subemployment, as in Michael P. Todaro's (1971) model of rural-urban migration and unemployment. In this case, by increasing the demand for labor, multinationals have a positive effect on the host country which is not captured by our model. Similarly, the model does not take into account that multinationals usually increase the effective supply of capital in the host country, leading also to an increase in the demand for labor that has an independent positive effect on the host country.

Because of love of variety, $P_{xB}(n)$ is decreasing in n, and from (13) this implies that $P_{xm}(n)$ also decreases with n. Therefore, from (12) it is immediately seen that $v_m(n)$ decreases with n if the elasticity of substitution between varieties of x is higher than the price elasticity of the demand for X by multinationals; that is, if $\theta/\alpha > 1/\beta(y)$. Now recall that, for the equilibrium to be stable in the Marshallian sense, the curve $x(n, M)$ needs to intersect the horizontal line $x = \theta$ from above. But noting from (5) that $nv_z(n) = \alpha m(z)$, (8) implies that a sufficient condition for this to happen is that $v_m(n)$ be decreasing in n. Therefore, the condition $\theta/\alpha > 1/\beta(y)$ is sufficient to ensure the stability of equilibrium, and the remainder of the paper assumes this inequality to hold.

It can now be seen how the main parameters affect the difference between $nv_m(n)$ and $nv_z(n)$. The *zero-linkage-effect curve* is drawn in Figure 3, defined by the equality $n_B v_m(n_A, n_B) = n_B v_z(n_B)$ (notice that the subindex for country B is reintroduced). Given that $n_B v_z(n_B)$ is constant, the slope of this curve is determined entirely by the way the linkage coefficient of multinationals, $n_B v_m(n_A, n_B)$, varies with n_A and n_B. In Appendix C I show that $n_B v_m(n_A, n_B)$ is decreasing in n_A and increasing in n_B. Intuitively, an increase in n_A makes multinationals spread their demand for inputs more thinly across more varieties, so the demand for each variety of x—including the varieties from country B—falls. On the other hand, the condition $\theta/\alpha > 1/\beta(y)$ ensures that the elasticity of substitution between varieties of x is high enough that when n_B increases, multinationals will reallocate their input purchases from country A to country B in such a way that $n_B v_m$ increases. Given that $n_B v_m(n_A, n_B)$ is decreasing in n_A and increasing in n_B, the zero-linkage-effect curve is upward sloping, with a positive linkage effect for points above the curve and a negative linkage effect for points below the curve.

Working under the assumption that economy A is in the y equilibrium and economy B in the z equilibrium, which implies that $n_B < n^* < n_A$, there exists a region where the linkage effect is positive only if the zero-linkage-effect curve lies below the point (n^*, n^*). Some algebra shows that this holds if and only if the following condition is satisfied:

$$(14) \quad \frac{m(y)}{m(z)} > (1 + (1 - \tau)^{\theta})^{1 - m(y)/\theta}.$$

Intuitively, the fact that multinationals produce a more complex good than domestic firms, which is reflected in $m(y) > m(z)$ (recall that $m(s) = (1 - \beta(s))/\beta(s))$, leads multinationals to demand a higher quantity of intermediate goods per unit of labor hired, but since multinationals have access to intermediate goods from country A then they will exert this demand only partially in country B. If the communication cost τ is lower, a smaller part of this demand is exerted in country B, and the condition $nv_m > nv_z$ is less likely to be satisfied.[18] The zero-linkage-effect curve will lie above point (n^*, n^*) if the inequality in condition (14) is reversed. The most important result to note here is that the linkage effect is more likely to be positive when $m(y)$ is higher in comparison to $m(z)$, when the communication cost is high and when the level of n in the underdeveloped economy is not too small in comparison with the level of n in the developed economy, so that (n_A, n_B) lies in the shaded area of Figure 3.

This result points out how the basic parameters determine the sign of the linkage effect of multinationals. It is also interesting to consider how these parameters affect the strength of the linkages that multinationals can generate; this is necessary for underdeveloped regions to be able to rank multinationals by their linkage-generating potential. As discussed above, $nv_m(n)$ is decreasing in n_A, so the linkage coefficient of multinationals is decreasing in the variety of intermediate goods available in the home country. This leads to the surprising result that multinationals that come from richer countries (with high n) will benefit the host economy less than if they come from less developed countries (with

[18] Note that (14) implies that if $\tau = 1$ (infinite communication costs) then $nv_m > nv_z$ for all points (n_A, n_B) below $n_B = n^*$ and to the right of $n_A = n^*$. This is simply a result of the fact that multinationals produce a more complex good $(m(y) > m(z))$.

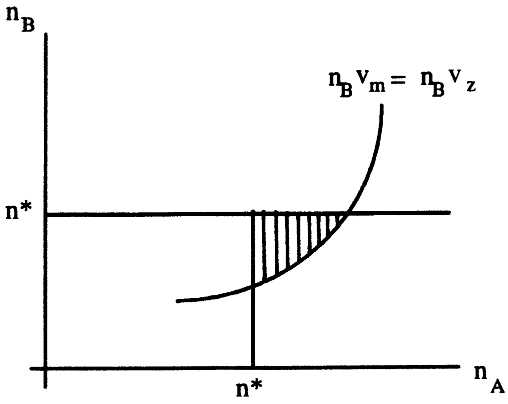

FIGURE 3. THE SHADED AREA SHOWS THE POINTS (n_A, n_B) FOR WHICH MULTINATIONALS HAVE A POSITIVE LINKAGE EFFECT ON THE HOST COUNTRY

low n).[19] On the other hand, $nv_m(n)$ is increasing in τ, so the linkage coefficient of multinationals is increasing in the communication cost. Intuitively, when the communication cost decreases, multinationals will want to import more varieties from country A through their headquarters and less of their demand for intermediate goods will be exerted in country B.[20]

IV. Equilibria in the Two-Country Model with Multinationals

The previous section assumed that n_A and M were exogenous variables to simplify the understanding of the main insights of this paper. In this section I relax this restriction to derive an equilibrium for the two-country model in which n_A and M are determined endogenously. It is shown that the linkage effect of multinationals on the host country is less favorable once n_A is allowed to change in response to changes in M.

The analysis is restricted to an equilibrium in which domestic firms in country A specialize in final good y, domestic firms in country B specialize in final good z and all multinationals have their headquarters in country A and produce good y. I first conjecture that domestic firms in country A produce final good y and domestic firms in country B produce final good z, and then check that this is so in equilibrium. The condition for this is $n_B < n^* < n_A$. Similarly, I first conjecture that multinationals produce final good y and that there are no multinationals with headquarters in country B, and then check that these two conditions are satisfied in equilibrium. To the extent possible, this section focuses on the main ideas and leaves the technical details to Appendix D.

Let $x_R(n_A, n_B, M)$ denote the quantity that each supplier of intermediate goods in country R will sell given n_A, n_B and M. As in the previous sections, the zero-profit condition for intermediate-good producers in countries A and B is

$$x_R(n_A, n_B, M) = \theta \tag{15}$$

for $R = A, B$. From these conditions I obtain the pair (n_A, n_B) that determines the equilibrium in both countries given M. To see this graphically, let AA and BB be the curves in (n_A, n_B) space along which condition (15) is satisfied for countries A and B respectively. As long as curves AA and BB (drawn in Figure 4) intersect in the quadrant with $n_B < n^* < n_A$, the intersection gives the zero-profit levels of n in both countries as a function of M: $n_A(M)$ and $n_B(M)$. As it was shown in the previous section, $x_B(n_A, n_B, M)$ is decreasing in both n_A and n_B.[21] This implies that the curve BB is downward sloping. For the same reasons,

[19] Of course, this result should be interpreted with care, because multinationals that come from LDCs are likely to be engaged in the production of rather simple goods, which would tend to decrease their linkage coefficient.

[20] One would also expect that multinationals producing more complex goods (that is, operating technologies with a smaller β) would generate stronger linkages. This result does not hold here, however, because multinationals are not minimizing unit cost (because of the constraint on the quantity of labor they can hire). That is, v_m is not necessarily decreasing in $\beta(y)$.

[21] Recall that the condition $\theta/\alpha > 1/\beta(y)$, which is needed for the equilibrium to be stable in the Marshallian sense, ensures that $v_{mB}(n_A, n_B)$ is decreasing in both n_A and n_B. In turn, this ensures that $x_B(n_A, n_B, M)$ is decreasing in both n_A and n_B.

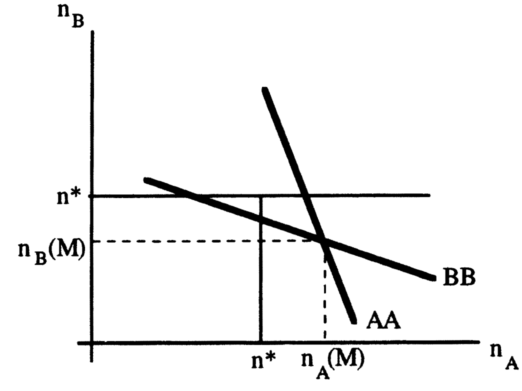

FIGURE 4. DETERMINATION OF EQUILIBRIUM LEVELS OF n_A AND n_B WHEN THERE ARE M MULTINATIONALS

$x_A(n_A, n_B, M)$ is decreasing in both n_A and n_B, so the curve AA is also downward sloping, as depicted in Figure 4. The intuition here is that as n increases in one country, multinationals will spread their demand for inputs across more varieties and hence their demand for each variety of x in the other country decreases; a decrease in n in that country is then needed to restore the zero-profit condition.[22]

To determine the equilibrium level of M I introduce the zero-profit condition for multinationals that have their headquarters in country A and produce good y. Let g^A_{my} denote operating profits (that is, not counting the fixed cost of managing the headquarters) made by these multinationals per unit of labor hired. If $g^A_{my} > 0$, then operating profits, $h(i)g^A_{my}$, is decreasing in i, so the equilibrium number of multinationals M, denoted by M^*, is determined by the following condition:

$$h(M^*)g^A_{my} = w_A. \tag{16}$$

The pair $(n_A(M^*), n_B(M^*))$ constitutes an equilibrium if two additional equilibrium conditions are satisfied: that multinationals prefer to produce y rather than z, and that there are no incentives for the formation of multinationals with headquarters in country B. Appendix D derives sufficient conditions under which these two equilibrium requirements are satisfied.

I now explore the linkage effect of multinationals on countries A and B when n_A is allowed to change in response to changes in M. Consider an increase in the equilibrium number of multinationals M^* that results as a consequence of a subsidy or tax break given to multinationals operating in country B. Starting with the effect of such an increase in M on curve AA, there are two opposite effects. First, an increase in M leads to an increase in the demand for intermediate goods from country A by multinationals, increasing x_A. Second, as they hire managers, multinationals decrease the quantity of labor left in country A for domestic production, decreasing x_A. It seems reasonable to think that the second effect is relatively small, since the proportion of the labor force in country A that is working as managers for multinationals is likely to be very small. Therefore, the net effect of an increase in M is to increase x_A, leading to a rightward shift in AA.[23] Intuitively, as M increases there is an effective increase in the scale of the market in country A which leads to an increase in n_A when n_B remains constant.

The rightward shift in AA caused by the increase in M by itself would lead to a decrease in n_B: the increase in n_A reduces multinationals' demand for intermediate goods produced in country B, leading to a reduction in n_B. Of course, the net effect of an increase in M on n_B may be positive or negative because the curve BB will also shift as M increases. What is important here is to note that once n_A is made

[22] The slope of AA could be higher or lower in absolute value than that of BB. If the slope of AA is lower in absolute value (less negative) than the slope of BB at an intersection of AA and BB, then the equilibrium is unstable in the Marshallian sense; that is, if the adjustment dynamics are that n_R increases (decreases) when profits in the intermediate-good sector in country R are positive (negative). Following Samuelson's Correspondence Principle, the rest of this paper restricts the analysis to stable equilibria, that is, to cases in which curve AA crosses curve BB from above, as assumed in Figure 4. This occurs, for instance, when τ is low or when M is low, because then changes in the level of n in one country have a small impact on the level of n in the other country through the linkage effect of multinationals.

[23] Appendix D shows that a necessary and sufficient condition for $\partial x_A/\partial M > 0$ is that $h(M^*)$ be sufficiently high.

endogenous, the effect of multinationals on country B is less beneficial than when n_A is fixed.

n_B will increase with an increase in M if and only if the curve BB shifts to the right *and* by more than the shift in curve AA. Appendix D derives a necessary and sufficient condition for this to happen. This condition, which referred to as condition (P), implies that the change in x_B as a direct consequence of the operation of multinationals in country B is positive and greater than the negative and indirect effect through the consequent increase in the demand for intermediate goods in country A. This negative effect on n_B will of course be small if the presence of multinationals in country B is small (that is, low M) or if the communication cost is large (that is, high τ), so that the increase in M has a small effect on n_B through its impact on n_A.

The results obtained thus far allow me to state formally the effects on countries A and B of a policy of attracting multinationals to country B.

PROPOSITION 2: *If the multinationals' linkage effect is negative or if condition* (P) *is not satisfied then* $\partial n_B/\partial M < 0$ *and* $\partial n_A/\partial M > 0$. *If the multinationals' linkage effect is positive and condition* (P) *is satisfied, then* $\partial n_B/\partial M > 0$ *and the sign of* $\partial n_A/\partial M$ *is not determined.*

An interesting implication of this proposition is that a country is more likely to enjoy an increase in n when its firms become multinational if such firms establish their production plants in poor regions (that is, countries with low n) and/or regions with which they have low communication costs.

V. Choice of Location by Multinationals and the Linkage Effect

Developing countries would like to attract multinationals with a high-linkage coefficient, but is it realistic to expect multinationals with high-linkage coefficients to choose poor regions for the location of their production plant? Some authors are pessimistic on this point. For instance, Stewart (1976) has argued that the very nature of poor regions "precludes the establishment of industry with significant or potentially significant linkages" (p. 246).

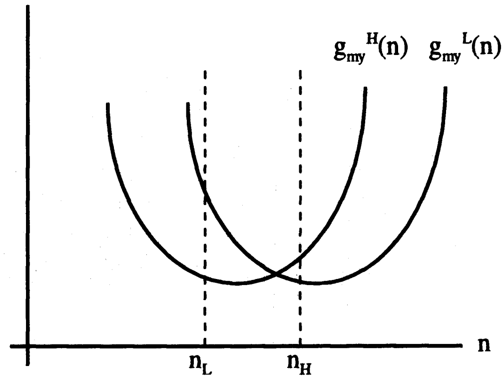

FIGURE 5. MULTINATIONALS TYPE-L PREFER TO LOCATE IN ECONOMIES WITH A LOW n (SUCH AS n_L), WHEREAS MULTINATIONALS TYPE-H PREFER TO LOCATE IN ECONOMIES WITH A HIGH LEVEL OF n (SUCH AS n_H).

To gain some insight into this issue consider the optimal choice of location for two types of multinationals which differ only in their communication cost τ. Specifically, assume that the communication cost is τ_L for multinationals of type-L and $\tau_H > \tau_L$ for multinationals of type-H.

Recall that multinationals' operating profits per unit of labor hired are g_{my}. It can be checked that

$$(17)\quad \partial g_{my}/\partial n = (\phi(z)/\alpha m(z))(v_m - v_z)w$$

where n is the variety of intermediate goods in the host country and v_m is the demand for each variety of x produced in the host country that multinationals demand per unit of labor hired in there. Since nv_z is constant, while nv_m is increasing in n and goes to zero as n goes to zero, it follows that $g_{my}(n)$ is first decreasing, reaches a minimum for some n and increases with n thereafter, as illustrated in Figure 5. Therefore, multinationals prefer countries with either very low or very high n.

Since the linkage effect is stronger when communication costs are higher, then v_m is lower for type-L than for type-H multinationals. Therefore, if there are two possible host countries with different levels of n, either both types of multinationals prefer the same country, or type-L multinationals prefer the country with low n (such as n_L in Figure 5) and type-H multinationals prefer the country with high n (such as n_H in Figure 5). This means that if the two types of multinationals sort themselves differently with the two countries, the multinational with the lower communication cost (which has a lower linkage coefficient) prefers the low-n country, while the multinational with the higher communication cost prefers the high-n country.[24] This result is in agreement with the view that poor regions attract firms with a low linkage potential.

This result may explain why so many underdeveloped regions have failed in their attempt to develop through policies designed to attract firms from more developed regions (Jacobs, 1985). Our model leads us to a pessimistic view of the potential effect of these policies, because the firms that move to those underdeveloped regions are precisely the firms that do not depend on a wide variety of local inputs, so their linkage effect is likely to be small or even negative.

One interesting implication of this analysis concerns the location of production plants for multinationals based on different countries. For example, consider the location choice of U.S. and Japanese multinationals in the same sector that want to take advantage of Mexico's maquiladora program. It is likely that Japanese multinationals—which presumably have high communication costs with the headquarters in Japan—would want to locate their production plant in the interior, where intermediate goods are readily available. In contrast, one would expect U.S. multinationals—which presumably have a low communication cost with the headquarters in the United States—to locate their production plant in the border region, where low wages more than compensate for the local scarcity of specialized inputs.

[24] In our model developing countries could have different equilibrium levels of n because of different levels of L. To obtain a more realistic result assume, as in Dani Rodrik (1994), that intermediate goods are intensive in human capital or skilled labor. In this case, it can be shown that the equilibrium level of n would be higher for an economy with a more educated labor force.

VI. Concluding Remarks

The concept of linkages is meaningful given three basic assumptions: 1) love of variety for inputs in the production of final goods, 2) high transportation costs (broadly conceived) for specialized intermediate goods, and 3) increasing returns in their production. The analysis has shown that the strength of a multinational's linkage effect depends on the cost of communication between the headquarters and the production plant, the complexity of the production process, and the level of development of the home and host countries. This section discusses some concrete implications of these results and some limitations of the model.

The model implies that the linkage effect of multinationals on the host country is stronger when the cost of communication between the headquarters and the production plant is higher, since this provides a stronger incentive to buy specialized inputs in the host country. It is reasonable to expect communication costs to increase with geographical distance and with the cultural, social and legal differences between the regions wherein the headquarters and the production plant are located.[25] Hence I expect multinationals to generate more linkages when they come from regions that are farther away and more different in terms of their cultural, social and legal structures. It is interesting to consider the implications of this result for Mexico's maquiladora program. As several authors have pointed out (for example, Wilson, 1992; Leslie Sklair, 1989), U.S. maquiladoras in Mexico can obtain their inputs and services from suppliers in their home country at a lower cost than maquiladoras from Europe or East Asia. Thus, I expect U.S.

[25] There are significant costs of having plants located far away from the location where decisions are made. Marshall cites research based on London that suggests "that savings in rents, rates, and salaries through office decentralization beyond 80 miles from the capital are outweighed by the increased communication costs" (Marshall, 1988 p. 190). Moreover, Peter W. Daniels (1985), points out that in France, Britain and Denmark "manufacturing firms are not prepared to place branches more than two hours' traveling time from sources of specialized services or from headquarters" (p. 179).

maquiladoras to generate fewer linkages than similar maquiladoras coming from other industrialized countries. Additionally, as Joseph Grunwald and Keneth Flamm (1985) and Sklair (1989) have pointed out, U.S. firms that locate production plants in interior regions of Mexico, such as Guadalajara, would generate more linkages than similar firms that locate in the border region.

This last implication of the model is reinforced by the result that, other things equal, the linkage coefficient of multinationals is higher the more developed the host country (that is, the higher the level of n). In the context of Mexico's maquiladora program, this suggests a potential benefit from providing incentives for firms to locate in interior regions rather than in the border region, which is quite underdeveloped (see Wilson, 1992). More generally, underdeveloped countries should consider disentangling policies of regional development from policies aimed at attracting foreign investment. For example, it may be unwise to locate Export Processing Zones in backward regions, since linkages are unlikely to materialize there.[26]

Finally, the model implies that multinationals that operate technologies that use intermediate goods more intensively will generate stronger linkages. This result is not confined to multinationals. In general, activities that use intermediate goods more intensively generate stronger linkages. It could be argued that this provides a basis for industrial policy. As Hirschman stated several decades ago, "some interference, through tariffs, excise taxes, and subsidies, with the developing consumption of a country may be justified if it can be demonstrated that a certain growth pattern of consumption would exert far more powerful backward linkages than the pattern that is likely to develop in the absence of such interference" (Hirschman, 1958, p. 115). Ideally, one would want to measure the linkage coefficient of different economic activities and promote those with the highest linkage coefficient.

My model indicates a measure that captures the economic impact of a firm through the generation of linkages. This is the quantity of employment generated in upstream industries per unit of labor employed directly; the linkage effect of the firm becomes more favorable as this ratio increases. This measure differs from those commonly used in that, derived in a general-equilibrium framework, it considers how the expansion of one activity comes at the expense of other activities that would also generate linkages. The contribution of this paper to the measurement of linkages is thus especially relevant for economies with no surplus labor.

The measure of linkages suggested by this paper, however, relies on several restrictive assumptions made to keep the model tractable. To evaluate whether this measure can serve as a useful guide for development policy, the following considerations should be kept in mind: 1) the model assumes that all inputs are nontradable whereas in the real world most inputs are tradable, although subject to transportation costs. All else equal, one would prefer an investment that generates demand for inputs with high transportation costs. 2) Some inputs may rely intensively on resources that are very scarce locally (that is, skilled labor), in which case the economy cannot take advantage of the linkages that could arise from some new economic activities. In other words, supply constraints may break the chain of reactions that build linkages. 3) Some inputs may exhibit particularly strong degrees of love of variety, and—all else equal—the economy would benefit more from investments that generate a great demand for these inputs. 4) Some inputs may be produced with constant returns to scale, in which case an increase in their demand would not lead to any positive externalities.[27] 5) I have assumed that all industries use

[26] See Dean Spinanger (1984) for a comparison of the linkages generated in the Export Processing Zone established in Penang, Malaysia—a region which Spinanger refers to as an "agglomerated area"—and Bataan, Philippines, an area that is "almost entirely underdeveloped" (pp. 74–75).

[27] Hirschman was careful on this point. He noticed that certain linkages do not significantly affect the rest of the economy, as in the case of what he called "satellite industries," a characteristic of which is that they require only a small economic size to be profitable. See Hirschman (1958), p. 102.

the same inputs, but in reality some inputs are industry specific. As a consequence, the linkages generated by the expansion of one particular industry may not benefit the rest of the economy.

There is one limitation of the model that should be emphasized. It was shown in Section III that—other things equal—multinationals from more developed countries are less likely to generate a positive linkage effect. This result arises because, as the variety of intermediate goods available in their home country expands, multinationals reduce their demand for intermediate goods in the host country. In this sense, varieties of intermediate goods in the home and host countries behave as substitutes. This need not be the case under alternative assumptions. For instance, if the elasticity of substitution between labor and the composite intermediate good is significantly higher than one, a larger variety of specialized inputs in the home country could lead multinationals to substitute intermediate goods for labor in such a way that the demand for intermediate goods increased in *both* countries. Alternatively, if there are more than two final goods, it is likely that multinationals with headquarters in more developed economies will choose to produce a more sophisticated good, and this could lead to a *higher* demand for specialized intermediate goods in the host country.

APPENDIX A

This appendix derives equations (3) to (6), (11) and (13). Cost minimization by producers of final good s can be decomposed into two stages: first, choose $x(j)$ to minimize the unit cost of X, and second, choose quantities of X and L to minimize the cost of s. As is well known (see Helpman and Krugman, 1985 chapter 6), the first stage of this cost minimization yields a demand for $x(j)$ of

$$\text{(A1)} \qquad x(j) = p(j)^{-\theta/\alpha} P_x^{\theta/\alpha} X_s$$

where $\theta \equiv \alpha/(1-\alpha)$ and P_x is the minimum unit cost—or shadow price—of X, and is given by

$$\text{(A2)} \qquad P_x = \left(\int_0^n p(j)^{-\theta}\, dj \right)^{-1/\theta}.$$

In the second stage producers of s choose quantities of X and L such that

$$\text{(A3)} \qquad X_s = m(s)(w / P_x) L_s$$

where $m(s) \equiv (1 - \beta(s))/\beta(s)$. Given the demand function in (A1), the monopolist producing $x(j)$ maximizes profits by charging a price

$$\text{(A4)} \qquad p(j) = w/\alpha.$$

From equations (A1)–(A4) the minimum unit cost of s as a function of w and n is

$$c_s(w, n) \equiv \alpha^{\beta(s)-1} n^{-\phi(s)} w$$

where it is assumed $\delta(s) = \beta(s)^{-1} m(s)^{\beta(s)-1}$ to simplify the notation. This immediately leads to equation (3) in the text.

Now, given (A4), the monopolist producing $x(j)$ has profits given by $\pi(j) = [(w/\alpha) - w]x(j) - w$. Rearranging,

$$\pi(j) = [(1/\theta)x(j) - 1]w.$$

The zero-profit condition for the producer of $x(j)$ is then $x(j) = \theta$, as in equation (4). From equations (A1)–(A4) I can easily obtain equation (5), and from the condition $P_s = c_s(w, n)$ and (A4) I obtain equation (6). Equation (A1) immediately leads to equation (11) in the text, and equation (13) follows from (A2).

APPENDIX B

This appendix proves the claim that with no multinationals we have $w_B < w_A$ and $P_{xA} < P_{xB}$. $w_B < w_A$ follows immediately from (6) and the fact that $w_B = w_z(n_B)$, $w_A = w_y(n_A)$, $w_z(n^*) = w_y(n^*)$ and $n_B < n^* < n_A$. To verify that $P_{xA} < P_{xB}$ note that, from (A4), (6) and the fact that $p = \rho(n^*)$, $P_{xA}/P_{xB} = (n^*/n_A)^{\beta(y)/\theta}(n^*/n_B)^{-\beta(z)/\theta}$, which is clearly less than one as long as $n_B < n^* < n_A$.

APPENDIX C

This appendix proves the claim that $n_B v_m(n_A, n_B)$ is decreasing in n_A and increasing in n_B. From (6), (A2) and (A4)

$$P_{xR} = n_R^{-1/\theta}(w_R/\alpha)$$
$$= P_{s(R)}\alpha^{-\beta(s(R))} n_R^{-\beta(s(R))/\theta}$$

where $s(A) = y$ and $s(B) = z$. Plugging this into (13) and substituting into (12)

$$n_B v_m(n_A, n_B) = a n_B^{1-\phi(z)\theta/\alpha}$$
$$\times (b n_A^{\beta(y)} + P_z^{-\theta}\alpha^{\theta\beta(z)} n_B^{\beta(z)})^{-[\theta/\alpha - 1/\beta(y)](1/\theta)}$$

where a and b are positive constants. Given $\theta/\alpha > 1/\beta(y)$, then this is clearly decreasing in n_A. To verify that this term is increasing in n_B, I differentiate this term with respect to n_B and note that $n_B v_m(n_A, n_B)$ is increasing in n_B if and only if

$$\frac{1}{\theta}\left(\frac{\beta(z)}{\beta(y)} - 1\right) P_z^{-\theta}\alpha^{\theta\beta(z)} n^{\beta(z)}$$
$$+ b n_A^{\beta(y)}(\beta(z) - \alpha/\theta) > 0.$$

Given $\beta(z) > \beta(y)$ the first term is positive, and given $\theta/\alpha > 1/\beta(y)$, then $\beta(z) > \beta(y) > \alpha/\theta$, so the second term is also positive.

APPENDIX D

This appendix proves some of the results mentioned in Section IV. I first derive the functions $x_R(n_A, n_B, M)$ used in the text. Both multinationals and domestic firms in country R demand intermediate goods in country R. The labor-market equilibrium condition for country B is just as in equation (7) whereas for country A it is given by

$$L_A = n_A + n_A v_y(n_A) L_y^A + L_y^A + M$$
$$+ n_A v_{mA}(n_A, n_B) L_m(M)$$

where $v_y(n_A)$ is the demand for each variety of x per unit of labor hired by producers of y in country A and $v_{mA}(n_A, n_B)$ is the demand for each variety of x in country A per unit of labor hired by multinationals in country B. As in the previous section, let $L_{xR}(n_A, n_B, M)$ denote the total derived demand for labor by producers of intermediate goods in country R as a function of n_A, n_B and M. From the definitions of $v_{mR}(n_A, n_B)$ I can check that $L_{xR}(n_A, n_B, M) \equiv n_R v_{s(R)}(n_R) L_{s(R)}^R + n_R v_{mR}(n_A, n_B) L_m(M)$, where $s(A) = y$ and $s(B) = z$. From the full-employment conditions in countries A and B,

$$\text{(D1)}\quad L_{xA}(n_A, n_B, M)$$
$$= (L_A - n_A - M)\frac{n_A v_y(n_A)}{1 + n_A v_y(n_A)}$$
$$+ \frac{n_A v_{mA}(n_A, n_B)}{1 + n_A v_y(n_A)} L_m(M)$$

$$\text{(D2)}\quad L_{xB}(n_A, n_B, M)$$
$$= (L_B - n_B - L_m(M))\frac{n_B v_z(n_B)}{1 + n_B v_z(n_B)}$$
$$+ \frac{n_B v_{mB}(n_A, n_B)}{1 + n_B v_z(n_B)} L_m(M)$$

$x_R(n_A, n_B, M)$ is then simply $L_{xR}(n_A, n_B, M)/n_R$.

We now derive a sufficient condition for multinationals with headquarters in country A to prefer to produce good y rather than good z. The maximum operating profits per unit of labor hired for a multinational producing final good s with headquarters in country R are given by

$$\text{(D3)}\qquad g_{ms}^R \equiv \eta(s) P_{xmR}^{-m(s)} - w_{-R}$$

where $\eta(s) \equiv P_s^{1/\beta(s)}$ and P_{xmR} is the price of the composite input X for multinationals with headquarters in country R

$$\text{(D4)}\quad P_{xmR} \equiv (P_{x-R}^{-\theta} + (1-\tau)^{\theta} P_{xR}^{-\theta})^{-1/\theta}.$$

From (D3) it follows that multinationals with headquarters in country A prefer to produce good y rather than good z, if and only if the following condition is satisfied:

$$\text{(D5)} \qquad \eta(y)P_{xmA}^{-m(y)} \geq \eta(z)P_{xmA}^{-m(z)}.$$

This inequality must be satisfied at $(n_A(M^*), n_B(M^*))$ for this to be an equilibrium.

The following lemma establishes a sufficient condition under which a multinational with headquarters in country B makes negative profits for all the relevant (n_A, n_B) pairs.

LEMMA D1: *If* $h(0) < \hat{h} \equiv 1/[(1 + (1 - \tau)^{\theta})^{m(y)/\theta} - 1]$, *then profits for multinationals with headquarters in country B are negative for all* (n_A, n_B) *such that* $n_B < n^* < n_A$.

PROOF:

Restricting the analysis to an equilibrium in which domestic firms in country A produce final good y, effectively limits interest only to levels of n_A above n^*. For $n_A \geq n^*$, producing y is more profitable than producing z for domestic firms. Since multinationals with headquarters in country B have access to intermediate goods in country B in addition to the intermediate goods produced in country A, then this is even more so for such multinationals $(P_{xmB} < P_{xA})$. Therefore, if multinationals with headquarters in country B make negative profits producing y, profits are also negative producing z. Hence, since operating profits are highest for a multinational managed by the worker with index 0, a sufficient condition for profits to be negative for multinationals with headquarters in country B is

$$\text{(D6)} \qquad h(0)g_{my}^{B} \leq w_B.$$

Let $h_0 \equiv [m(z)/m(y)][(1 + (1 - \tau)^{\theta})^{1-m(y)/\theta}/(1 - \tau)^{\theta}]$. It can be shown that if $\tau < 1$, then $\hat{h} > h_0$. I now show that $hg_{my}^{B} - w_B$ is negative for $h \in [h_0, \hat{h}]$. Since h denotes the *maximum* amount of workers that a multinational can hire this also implies that profits are negative for any $h < \hat{h}$; that is, (D6) is satisfied if $h(0) < \hat{h}$.

From (D3),

$$\text{(D7)} \qquad hg_{my}^{B} - w_B = h\eta(y)P_{xmB}^{-m(y)} - hw_A - w_B.$$

Since there are zero profits in the production of y in country A and in the production of z in country B then $w_A = \eta(y)P_{xA}^{-m(y)}$ and $w_B = \eta(z)P_{xB}^{-m(z)}$. Substituting for w_A and w_B in (D7)

$$\text{(D8)} \qquad hg_{my}^{B} - w_B = f(P_{xA}, P_{xB}) \equiv (h\eta(y)P_{xA}^{-\theta} + (1 - \tau)^{\theta}P_{xB}^{-\theta})^{m(y)/\theta} - h\eta(y)P_{xA}^{-m(y)} - \eta(z)P_{xB}^{-m(z)}.$$

Differentiating f with respect to P_{xA} and simplifying

$$\text{(D9)} \qquad \partial f/\partial P_{xA} = h\eta(y)m(y)P_{xA}^{-m(y)-1} \times [1 - (1 + (1 - \tau)^{\theta}v)^{m(y)/\theta - 1}]$$

where $v \equiv (P_{xA}/p_{xB})^{\theta}$. Since $\theta/\alpha > 1/\beta(y)$ (an assumption made in the text), then $\theta > m(y)$, and hence $(1 + (1 - \tau)^{\theta}v)^{m(y)/\theta-1} < 1$, so $\partial f/\partial P_{xA} > 0$.

Differentiating f with respect to P_{xB} and simplifying:

$$\text{(D10)} \qquad \partial f/\partial P_{xB} = \eta(y)m(y)P_{xB}^{-m(y)-1} \times \left[-h(1 - \tau)^{\theta}(1/v + (1 - \tau)^{\theta})^{m(y)/\theta - 1} + \frac{\eta(z)m(z)}{\eta(y)m(y)} P_{xB}^{\Delta m}\right]$$

where $\Delta m \equiv m(y) - m(z) > 0$. I now show that if $h > h_0$ and $f(P_x^*, P_x^*) < 0$—where P_x^* is the level of P_{xR} at $n_R = n^*$—then $f(P_x^*, P_{xB}) < 0$ for all $P_{xB} > P_x^*$. Using the fact that $\eta(y)P_x^{*-m(y)} = \eta(z)P_x^{*-m(z)}$ by definition of n^*, then from (D10)

$$\text{sign}[\partial f(P_x^*, P_x^*)/\partial P_{xB}] = \text{sign}[m(z)/m(y) - h(1 - \tau)^{\theta}(1 + (1 - \tau)^{\theta})^{m(y)/\theta-1}].$$

Hence, if $h > h_0$ then $\partial f(P_x^*, P_x^*)/\partial P_{xB} < 0$. Also note from (D10) that $\partial f/\partial P_{xB}$ converges to zero from above as P_{xB} goes to infinity. Therefore, since there is a unique solution for $\partial f/\partial P_{xB} = 0$, if $h > h_0$ then necessarily $\partial f/\partial P_{xB}$ is negative for $P_x^* \leq P_{xB} < P_{xB}^o$ and positive for $P_{xB}^o < P_{xB}$ for some positive P_{xB}^o. Finally, note that $f(P_{xA}, P_{xB})$ converges to zero as P_{xB} goes to infinity. Therefore, if $f(P_x^*, P_x^*) < 0$ then necessarily $f(P_x^*, P_{xB}) < 0$ for all $P_{xB} \geq P_x^*$. But, from (D8)

$$f(P_x^*, P_x^*) = \eta(y) P_x^{*\,-m(y)}$$
$$\times [h((1 + (1 - \tau)^\theta)^{m(y)/\theta} - 1) - 1]$$

which is negative if $h < \hat{h}$. Therefore, if $h \in [h_0, \hat{h}]$, $f < 0$ for all points (P_{xA}, P_{xB}) such that $P_{xA} = P_x^*$ and $P_{xB} > P_x^*$. But since $\partial f/\partial P_{xA} > 0$ then this implies that $f < 0$ for all points (P_{xA}, P_{xB}) such that $P_{xA} < P_x^*$ and $P_{xB} > P_x^*$. Given that n_R is decreasing in P_{xR}, Lemma D1 follows.

To understand this lemma, recall that multinationals can always attain higher operating profits than domestic firms, simply because they have access to a larger variety of intermediate goods. Multinationals incur the additional cost of managing the headquarters, however, and the lower is $h(i)$, the more significant this fixed cost becomes. Lemma 1 states that if $h(0) < \hat{h}$ the fixed cost of managing the headquarters is high enough that multinationals with headquarters in country B cannot earn positive profits.

I assume that $h(0) < \hat{h}$. Hence, if the zero-profit condition for multinationals, given by equation (16), is satisfied for the point $E = (n_A(M^*), n_B(M^*))$ at the intersection of curves AA and BB and if E satisfies condition (D5) and lies below the line $n_B = n^*$ and to the right of the line $n_A = n^*$, then E constitutes an equilibrium. If $h'(i)$ is sufficiently high (which happens when there is enough heterogeneity among workers in terms of their multinational-management abilities) then this equilibrium is stable in the Marshallian sense; that is, for M slightly below M^*, $h(M)g_{my}^A > w_A$ so that by hiring the next best manager a firm can gain by becoming multinational; similarly, for M slightly above M^*, $h(M)g_{my}^A < w_A$, so that the multinational hiring the least able manager earns negative profits.[28]

The following lemma formally shows that if $h(M^*)$ is sufficiently high then the curve AA moves to the right with an increase in M.

LEMMA D2: *If $h(M^*) > \tilde{h}$, where $\tilde{h} \equiv (1 - \tau)^{-\theta/\alpha}(1 + (1 - \tau)^\theta)^{-(1 - m(y)/\theta)}$, then $\partial x_A/\partial M > 0$ for all (n_A, n_B) such that $n_B < n^* < n_A$.*

PROOF:

From (D1) and the definition of $x_R(n_A, n_B, M)$ $\partial x/\partial M = [n_A/(1 + n_A v_y)](v_{mA} h(M^*) - v_y)(1/n_A)$ so $\partial x_A/\partial M > 0$ if and only if $v_{mA} h(M^*) > v_y$. From (A1) and (10)

$$\text{(D11)} \quad v_{mA} = \psi(y) P_y^{1/\beta(y)} (1 - \tau)^{\theta/\alpha}$$
$$\times (w_z(n_A)/\alpha)^{-\theta/\alpha} P_{xm}^{\theta/\alpha - 1/\beta(y)}.$$

But at (n^*, n^*), $P_{xm} = (1 + (1 - \tau)^\theta)^{-1/\theta} P_x^*$, and substituting into (D11)

$$v_{mA} = (1 - \tau)^{\theta/\alpha}$$
$$\times (1 + (1 - \tau)^\theta)^{1 - m(y)/\theta} \psi(y) P_y^{1/\beta(y)}$$
$$\times (w_z(n_A)/\alpha)^{-\theta/\alpha} P_x^{*\,\theta/\alpha - 1/\beta(y)}.$$

But $\psi(y) P_y^{1/\beta(y)} (w_z(n_A)/\alpha)^{-\theta/\alpha} P_x^{*\,\theta/\alpha - 1/\beta(y)}$ is exactly $v_y(n^*)$, so at (n^*, n^*)

$$v_{mA} = (1 - \tau)^{\theta/\alpha}$$
$$\times (1 + (1 - \tau)^\theta)^{1 - m(y)/\theta} v_y(n^*).$$

Consequently, $h v_{mA}(n^*, n^*) > v_y(n^*)$ if and only if $h > \tilde{h}$. But $n_A v_{mA}(n_A, n_B)$ is increasing in n_A and decreasing in n_B while $n_A v_y(n_A)$ is constant. Therefore, if $h v_{mA}(n^*, n^*) > v_y(n^*)$ then $h n_A v_{mA}(n_A, n_B) > n_A v_y(n_A)$ for all (n_A, n_B) such that $n_B < n^* < n_A$.

[28] It turns out that the assumption that there is heterogeneity in the management ability of workers is important to ensure the stability of the equilibrium. If there is no heterogeneity ($h(i) = h$ for all i), then it is likely that the equilibrium is unstable in the Marshallian sense; that is, at an equilibrium like the one characterized in this section, profits made by multinationals may be increasing in M. A previous version of this paper investigates this issue.

It can be shown that the condition $h(M^*) > \tilde{h}$ is compatible with the condition $h(0) < \hat{h}$: for α sufficiently close to 0 we have $\hat{h} > \tilde{h}$. In any case, the assumption that $h(M^*) > \tilde{h}$ is made to simplify the statement of the main results; it does not play a fundamental role in their derivation.

Finally, condition (P) is derived. Substituting $L_{xR}(n_A, n_B, M)/n_R$ for $x_R(n_A, n_B, M)$ in equation (15) and differentiating shows that the curve BB shifts to the right by more than the shift in curve AA at the equilibrium if and only if

$$\text{(D12)} \qquad \frac{\partial L_{xB}/\partial M}{\partial L_{xA}/\partial M} > \frac{-\partial L_{xB}/\partial n_A}{\theta - \partial L_{xA}/\partial n_A}$$

which can be shown to be equivalent to

$$\text{(P)} \qquad \frac{(n_B^* v_{mB}^* - \alpha m(z))h(M^*)}{n_A^* v_{mA}^* h(M^*) - \alpha m(y)}$$

$$> \frac{-n_B^* L_m^*(\partial v_{mB}/\partial n_A)}{\theta + \alpha(\theta - 1)m(y) - L_m^*(\partial n_A v_{mA}/\partial n_A)}$$

where I have used n_R^*, v_{mR}^* and L_m^* for $n_R(n^*)$, $v_{mR}(n_A(M^*), n_B(M^*))$ and $L_m(M^*)$ respectively. The numerator of the left-hand side of (P) is positive and so is the denominator, since $\theta - \partial L_{xA}/\partial n_A = -n_A(\partial x_A/n_A) > 0$. Therefore, the condition $n_B^* v_{mB}^* > \alpha m(z)$ (that is, the linkage coefficient of multinationals is higher than the linkage coefficient for domestic firms in country B) is necessary but not sufficient for condition (P) to hold. This condition is satisfied when M is sufficiently small, and also when τ is close to 1, since it can be checked that $\partial v_{mB}/\partial n_A$ goes to zero as τ goes to 1.

A simulation of the model reveals that with $\alpha = 0.5, P_z = P_y = 1, L_A = 20, L_B = 22, \beta(z) = 0.82$, $\beta(y) = 0.75$, $\tau = 0.4$ and $h(M) = 5.8 - 100M$ the equilibrium values are $n_A^* = 2.52008$, $n_B^* = 1.98012$, $M^* = 0.00409$ and the conditions $h(0) < \hat{h}$, $h(M^*) > \tilde{h}$ and (P) are satisfied. Increasing L_A to 25 decreases the linkage coefficient of multinationals in such a way that condition (P) is violated even though the linkage coefficient of multinationals is still higher than that of domestic firms (in this case $n_A^* = 3.19631$, $n_B^* = 1.98001$, $M^* = 0.00873$). Increasing L_A to 30 makes the linkage coefficient of multinationals lower than that of domestic firms (in this case $n_A^* = 3.90198$, $n_B^* = 1.97975$, $M^* = 0.01219$).

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