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Multinationals and Linkages: An Empirical Investigation

Policymakers and academics often argue that foreign direct investment (FDI) can be a source of valuable productivity externalities for developing countries.[1] Prominent among the mechanisms often highlighted for these externalities are knowledge spillovers and "linkages" from multinational corporations to domestic firms in host countries. In pursuit of such benefits, governments in both developed and developing countries have not only reduced barriers to FDI over the last two decades, but have also offered special incentives to attract foreign firms and foster relationships between multinationals and local firms (especially suppliers).[2] Surprisingly, however, the empirical literature has not been able to confirm the existence of positive externalities from FDI to host countries.[3] There thus appears to be a significant gap between the consensus among

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1. The scholarly literature on foreign direct investment is vast. For recent surveys, see Markusen (1995); Caves (1996); Blomström and Kokko (1998); Hanson (2001); Lipsey (2002).

2. On the debate behind incentives to FDI, see Wint and Wells (2000); Hanson (2001); Blomström and Kokko (2003).

3. In a recent survey of empirical work, Hanson (2000, 2001) argues that there is weak evidence that FDI generates positive externalities for host countries. In a review of microeconomic data on externalities from foreign-owned to domestically owned firms, Görg and Greenaway (2002) conclude that the effects are mostly negative. Lipsey (2002) takes a more favorable view based on the microeconomic literature while concluding that the macroeconomic empirical research generally indicates that the size of inward FDI stocks or flows relative to gross domestic product is not consistently related with growth.

practitioners and the empirical literature regarding the importance of positive FDI externalities.

Policies to promote FDI take a variety of forms. In general, incentives fall into two categories: fiscal incentives, such as tax holidays and lower taxes for foreign investors; and financial incentives, such as government grants, credits at subsidized rates, government equity participation, and government insurance at preferential rates. Other incentives can include subsidized dedicated infrastructure, subsidized services, contract preferences or foreign exchange privileges, and even monopoly rights. In 1998, 103 countries offered tax concessions to foreign companies that set up production or administrative facilities within their borders.[4]

One popular argument is that this kind of policy is justified as a way to generate employment, but—of course—this is not a valid argument in economies under full employment. Even in the presence of unemployment, it is not clear that more investment will solve the problem; this would depend on the causes and nature of unemployment. A more sophisticated argument is that FDI incentives can increase the capital stock and thereby allow wages to increase. For this mechanism to be cost efficient, however, the rate of return to capital in the host country would have to be higher than in source countries—and if this were the case, then the subsidy would not be necessary. A related and valid reasoning is that FDI incentives are justified as part of an optimal tax policy, if it is believed that the investment elasticity to taxes is higher for FDI than for national investment. This is ultimately self-defeating, however, because countries would compete away the rents and pass them on to multinationals.

This paper focuses on productivity externalities arising from multinationals to domestic firms in the host country as a possibly valid reason for subsidizing FDI. Several recent papers use plant-level data and panel econometric techniques to carefully explore the existence of this type of externality. One conclusion that emerges from this literature is that it is difficult to find evidence of positive externalities from multinationals to local firms in the same sector (horizontal externalities). In fact, many studies find evidence of negative horizontal externalities stemming from multinational activity while confirming the existence of positive externalities from multinationals to local firms in upstream industries (vertical externalities). In this paper, we explore the channels through which these

4. Hanson (2001).

positive and negative externalities may materialize. We emphasize the role of backward linkages, which have not received enough rigorous theoretical and empirical attention.

Under certain conditions (benefits of specialization, increasing returns, and transportation costs), an increase in demand for specialized inputs would lead to the local production of new types of these inputs, which would bring positive externalities to other domestic firms that use those inputs. This mechanism, however, has been called into question because of the general finding that the share of inputs bought domestically by multinational corporations is lower than the share bought by local firms. Many papers interpret this finding as implying that multinationals generate fewer linkages than domestic firms. We argue that the share of inputs bought domestically is not a valid indicator of the linkages that multinational corporations can generate. Instead, we use the model of linkages developed by Rodríguez-Clare to propose an alternative indicator for the linkages that a firm can generate, and we then proceed to calculate it for several countries in Latin America.[5]

The alternative indicator of linkages we propose is the ratio of the value of inputs bought domestically to the total workers hired by the firm. This measure allows us to explore the validity of the claims made in the literature regarding linkages across different types of firms. We use plant-level data from Brazil (1997 to 2000), Chile (1987 to 1999), Mexico (1993 to 2000), and Venezuela (1995 to 2000) to test for differences in the linkage coefficients of foreign and domestic firms. In all countries analyzed, and consistent with previous findings in the literature, the share of inputs sourced domestically is lower for foreign firms than for domestic enterprises. In contrast, our proposed indicator shows that foreign firms have higher linkage coefficients than domestic firms in Brazil, Chile, and Venezuela. For Mexico, we cannot reject the hypothesis that foreign and domestic firms have the same linkage potential.

Our results thus suggest that some of the general notions in the literature may stem from linkage measures that are not properly derived from theory. Although multinationals probably do source a lower percentage of their inputs domestically relative to domestic firms, they also use more inputs in relation to the workers they hire. As a result, they do not necessarily generate weaker linkages than domestic firms. For linkages to be

5. Rodríguez-Clare (1996).

meaningful, however, the inputs must be nontradable (or, more generally, have high costs associated with importing them, relative to domestic procurement) and must be produced with increasing returns to scale.[6] The approach we follow here establishes an upper bounds on the linkages that can be generated by different firms.

The rest of the paper is organized as follows. The next section reviews the empirical literature on FDI spillovers. We then present a preliminary discussion on backward linkages and subsequently develop the model. After describing the data for Brazil, Chile, Mexico, and Venezuela and presenting the main results, we discuss the main findings in relation to the literature. The final section concludes the paper.

A View of the Recent Empirical Literature

What is the empirical evidence regarding spillovers and linkages?[7] One robust finding is that multinational corporations tend to be more productive than domestic firms in the same sector.[8] Under these circumstances, FDI would lead to a higher gross domestic product (GDP). If multinationals paid market wages, they would completely capture the increased GDP, and hence national welfare would not increase. Multinational corporations tend to pay above market wages, however, so it is very likely that some of their higher productivity is shared with nationals.[9] This could justify some kind of incentives for multinational corporations.

Of potentially much greater importance is the possibility that multinational corporations have a positive impact on the productivity levels of local firms. Most studies look for the presence of such productivity externalities without trying to understand the mechanism through which they occur. In other words, empirical studies focus on finding indirect evidence of externalities by exploring whether increases in the presence of multinational corporations in a country or sector are associated with increases

6. This point was originally made by Hirschman (1958) and is formalized by Rodríguez-Clare (1996), among others.

7. See Görg and Greenaway (2002) and Lipsey (2002) for recent overviews of the literature.

8. Haddad and Harrison (1993); Blomström and Wolff (1994); Kokko, Zejan, and Tansini (2001).

9. Blomström (1986); Haddad and Harrison (1993); Aitken, Harrison, and Lipsey (1996); Girma, Greenaway, and Wakelin (1999); Lipsey and Sjöholm (2001, 2002).

in the productivity of local firms in that country or sector or in upstream sectors.

The empirical evidence on whether FDI generates positive externalities for host countries is ambiguous, although the evidence for developing countries is more consistently pessimistic (see table 1 for an overview of the evolution of this literature). The literature, which employs careful econometric techniques, not only fails to detect the presence of positive productivity externalities for developing countries, but actually finds evidence of negative externalities.[10]

A first generation of industry-level (cross-section) studies generally finds a positive correlation between foreign presence and sectoral productivity.[11] At the macroeconomic level, cross-section empirical work by Borensztein, De Gregorio, and Lee and Alfaro and others finds little support that FDI has an exogenous positive effect on economic growth.[12] However, their evidence suggests that local conditions, such as the level of education and the development of local financial markets, play an important role in allowing the positive effects of FDI to materialize. For example, a widely cited paper in the literature uses a data set of FDI flows from industrialized countries to sixty-nine developing countries as the basis for arguing that FDI is an important vehicle for transferring technology and higher growth only when the host country has a minimum threshold of human capital.[13]

As Aitken and Harrison note, however, cross-section studies of this nature are subject to a critical identification problem.[14] At the micro-

10. See Haddad and Harrison (1993); Aitken and Harrison (1999). The evidence for industrialized countries tends to be more positive. Haskel, Pereira, and Slaughter (2002) find positive benefits from foreign to local firms in a panel data set of firms in the United Kingdom; Görg and Strobl (2002) find that foreign presence reduces exit and encourages entry by domestically owned firms in the high-tech sector in Ireland.

11. For example, the pioneering work of Caves (1974) finds positive FDI spillovers in Australia; Blomström (1986) and Blomström and Wolff (1994) find positive effects for Mexico; and Sjöholm (1999) reports a positive impact for Indonesia.

12. Borensztein, De Gregorio, and Lee (1998); Alfaro and others (forthcoming).

13. Borensztein, De Gregorio, and Lee (1998). Likewise, Xu (2000), who uses data on U.S.-based multinational corporations, finds that a country needs to reach a minimum human capital threshold to benefit from the technology transfer from multinationals and that most developing countries do not meet this threshold.

14. Aitken and Harrison (1999). Cross-sectional studies aggregated at the sector level fail to control for time-invariant differences in productivity across sectors, which might be correlated with, but not caused by, foreign presence. These studies therefore fail to establish causality and are likely to generate biased coefficients.

TABLE 1. Overview of Evidence on Spillovers from Foreign to Local Firms in Developing Countries

Type of study, author, and year	*Sample*	*Results*	*Issues*
Cross-sectional			
Blomström and Wolff (1994)	Mexico, 1970	Higher foreign shares in an industry in 1970 led to higher rates of productivity growth in locally owned firms over the next five years.	Cross-sectional studies do not control for time invariant differences in productivity across sectors, which might be correlated with, but not caused by, foreign presence.
Sjöholm (1999)	Indonesia, 1980–91	Positive effects from FDI to locally owned establishments.	
Kokko, Tansini, and Zejan (2001)	Uruguay, 1988	Positive spillovers from FDI to a subsample of locally owned manufacturing plants with moderate technology gaps vis-à-vis foreign firms.	
Seemingly unrelated regressions (SUR)			
Borensztein, De Gregorio, and Lee (1998)	FDI flows from industrialized countries to 69 developing countries, 1970–79 and 1980–89	FDI contributes to growth only when the host country has a minimum threshold stock of human capital.	SUR estimation does not fully control for simultaneity bias, country-specific effects, or the use of lagged dependent variables in growth regressions.
Panel			
Haddad and Harrison (1994)	Morocco, 1985–89	The study rejects the hypothesis that foreign presence accelerated productivity growth in domestic firms.	Fixed-effects estimations do not address the simultaneity bias that results from the dependence of factor inputs on productivity levels and exit decisions.
Aitken and Harison (1999)	Venezuela, 1976–89	Foreign investment has a small net impact: positive effect of foreign equity participation on plant productivity is robust only for small firms; foreign investment has a negative effect on domestically owned plants.	
Djankov and Hoekman (2000)	Czech Republic, 1992–96	Joint ventures and foreign direct investment have a negative spillover effect on firms that do not have foreign partnerships.	

Panel: Olley-Pakes			
Smarzynska (2002)	Lithuania, 1996–2000	Study finds no evidence of horizontal spillovers and some evidence of backward spillovers.	In differentiated product industries, sales revenues and input expenditures are not good proxies for physical outputs and inputs, respectively; this leads to underestimation of productivity measures.
Blalock and Gertler (2003)	Indonesia, 1988–96	Study finds strong evidence for backward spillovers.	
López-Córdova (2003)	Mexico, 1993–2000	Foreign capital improves TFP; positive interindustry spillovers from FDI prevail over a negative intraindustry effect.	
Generalized method of moments (GMM)			
Carkovic and Levine (2002)	72 countries, 1960–95 (five-year periods)	Exogenous component of FDI does not exert a robust, positive influence on economic growth.	

economic level, foreign firms may be located in high-productivity industries, as opposed to causing productivity externalities. At the macroeconomic level, high-growth countries may attract more FDI than low-growth countries as opposed to FDI causing this high growth. If this is the case, the coefficients on cross-section estimates are likely to overstate the positive impact of foreign investment. One could thus find evidence of positive externalities from foreign investment where no externalities occur.

At the macroeconomic level, Carkovic and Levine's work, for example, casts doubt on the findings on growth and FDI.[15] They use the generalized method of moments (GMM) estimator designed by Arrellano and Bover to account for simultaneity bias and country-specific effects.[16] They find that the exogenous component of FDI does not exert a robust positive influence on growth. At the microeconomic level, the work of Aitken and Harrison, which is based on a panel data set of Venezuelan plants, confirms that differences in productivity levels are correlated with the pattern of foreign investment, biasing previous results.[17] Once these productivity differences across industries are properly taken into consideration, they still find a positive relation between increased foreign equity participation and plant performance, suggesting that individual plants do benefit from foreign investment. However, the positive own-plant effect is only robust for small plants (defined as plants with fewer then 50 employees). They further find that productivity in domestically owned plants declines when foreign investment increases, in contrast with what would be expected in the presence of positive externalities. The overall effect of foreign investment is thus small in the case of Venezuela.

The paper by Aitken and Harrison spawned a second generation of empirical studies of FDI spillovers, in which panel data are used to deal with the endogeneity problem that affects previous studies. In the particular case of developing countries, these studies find no indication of the existence of positive horizontal externalities. Many studies find evidence of negative horizontal externalities. A recent review of the microeconomic evidence on externalities from foreign-owned to domestically owned

15. Carkovic and Levine (2002).
16. Arrellano and Bover (1995).
17. Aitken and Harrison (1999).

firms focuses on panel studies and concludes that the effects are mostly negative.[18]

One explanation for the lack of evidence on externalities is that multinationals have the incentive to minimize technology leakages to competitors while improving the productivity of suppliers by transferring knowledge to them. Thus, if FDI were to generate spillovers, they are more likely to be vertical in nature than horizontal. Most empirical studies of FDI spillovers have regressed local firm productivity on FDI activity within the same sector. Although such studies find no horizontal spillovers, the empirical work at the intraindustry level might not be suitable for capturing wider spillover effects on the host economy, such as those created between multinational corporations and their suppliers. For example, Kugler finds evidence of interindustry linkages based on industry-level panel data for ten Colombian manufacturing sectors from 1974 to 1998, but he only finds evidence of intraindustry spillovers in one sector.[19] He does not, however, explore the mechanisms that may be behind these intersector externalities.

A third generation of papers explores the existence of positive externalities from FDI for local firms in upstream industries (that is, suppliers). The findings are more encouraging than those of the earlier studies (see table 1). Furthermore, these papers address a series of methodological problems in the previous literature, such as the biases that result from the dependence of firm exit and usage of factor inputs on productivity levels. Three recent papers on FDI and vertical spillovers control for time-invariant differences in plant productivity through fixed effects estimation and for time-variant productivity shocks likely to affect plant productivity using the semiparametric estimation proposed by Olley and Pakes.[20] Using panel data for

18. Görg and Greenaway (2002). This survey of studies using panel data sets finds that only two studies for industrialized countries and none for developing countries report positive evidence for within-industry externalities; all other studies using panel data find either negative or statistically nonsignificant effects.

19. Kugler (2001). The paper uses cointegration techniques to determine whether a relation exists between capital accumulation by foreign firms and domestic productivity in a sector. The presence of such a relation is taken as evidence of productivity spillovers.

20. Olley and Pakes (1996) propose using investment as a proxy for idiosyncratic shocks, conditional on capital. Because capital responds to the shocks only in a lagged fashion through contemporaneous investment, the return to investment can be obtained by nonparametrically inverting investment and capital to proxy for the unobserved shock. See

Lithuania from 1996 through 2000, Smarzynska examines whether the productivity of domestic firms is correlated with the presence of multinationals in downstream sectors (that is, potential customers).[21] Her empirical results are consistent with the existence of productivity externalities from FDI taking place through contacts between foreign affiliates and their local suppliers in upstream sectors, but there is no indication of externalities occurring within the same industry.[22] Similarly, Blalock and Gertler find evidence of positive vertical externalities based on a panel data set of Indonesian manufacturing establishments from 1988 through 1996.[23] They also find that downstream FDI increases output and firm value added while decreasing prices and market concentration. Finally, López-Córdova examines plant-level data for manufacturing firms in Mexico from 1993 through 2000.[24] He finds that foreign capital improves total factor productivity (TFP), with positive interindustry externalities prevailing over a negative intraindustry effect.

Overall, however, the existing evidence needs to be taken with caution. Methodological issues remain regarding estimation techniques and measurement of variables, in particular productivity measures. As Tybout and also Katayama, Lu, and Tybout note, inputs and outputs are typically poorly measured, and physical outputs are not really observed; what is usually measured are nominal variables deflated by a broad price index.[25] This can lead to bias in the productivity measures. If, for example, firms that expand rapidly also tend to drive their output prices down relatively

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Pavcnik (2002) for an application of this estimation algorithm to study the effects of liberalized trade on plant productivity in Chile.

21. Smarzynska (2002).

22. Smarzynska (2002) uses Olley and Pakes (1996) to account for endogeneity of input demand and corrects standard errors to take into account the fact that the measures of potential spillover are industry specific while the observations in the data set are at the firm level—which could lead to a serious downward bias in the estimated errors. In her panel evidence without Olley-Pakes correction, she finds evidence consistent with the existence of positive spillovers from FDI taking place through backward linkages, but no indication of spillovers occurring through horizontal channels. When the Olley-Pakes correction is applied, the coefficients on the backward variable are positive but not significant at the conventional levels.

23. Blalock and Gertler (2003).

24. López-Córdova (2003).

25. See Tybout (2001) for an overview of the evidence and methodological issues regarding firm-level studies of TFP; see Katayama, Lu, and Tybout (2003) for an alternative approach.

rapidly (as one would expect in differentiated product markets), then output growth is underestimated when input growth is rapid. In this case, markups, productivity measures, and other derived calculations would be biased.

Summarizing, one conclusion that emerges from the empirical literature is that it is difficult to find robust evidence of positive externalities from multinationals to local firms in the same sector (horizontal externalities). Many studies for developing countries that pay particular attention to causality problems actually find evidence of negative horizontal externalities arising from multinational activity, while confirming the existence of positive externalities from multinationals to local firms in upstream industries (vertical externalities). Although methodological issues remain unsolved in the literature, our goal is to try to understand these findings and explore whether linkages can explain some of them.

Preliminary Discussion: Multinationals, Knowledge Spillovers, and Backward Linkages

The empirical literature reviewed in the previous section does not address the mechanisms behind the horizontal and vertical FDI externalities. We now need to look into this matter both because it could help determine the robustness of the findings and because it is important for devising appropriate policy interventions to maximize FDI externalities.

FDI could generate positive production externalities through different mechanisms. One such mechanism depends on the flow of workers out of multinational corporations.[26] For example, multinational corporations may devote more resources to labor training than domestic firms. Given that a large part of this labor training is not paid for by the workers and constitutes knowledge that is not completely firm specific, this constitutes a positive externality that leads to increased wages for these workers and raises the productivity of firms that hire these workers after they leave the multinationals. These labor training externalities would show up as horizontal knowledge spillovers, in the sense that they would benefit other firms in the same sector as the multinationals. Something very

26. Fallick, Fleischman, and Rebitzer (2003) investigate the role of knowledge spillovers owing to easy mobility of skilled employees among firms in Silicon Valley.

similar happens if workers increase their knowledge not through formal labor training, but through on-the-job training, learning by doing, or learning by observing. The spillover can also take place through spin-offs, in which workers leave the multinational corporation to set up their own firms and thus benefit from the knowledge they gained while at the corporation.

Fosfuri, Motta, and Ronde cite evidence that multinationals undertake substantial efforts in the education of local workers and offer more training to technical workers and managers than do local firms.[27] Pack finds evidence that trained managers in Taiwan often leave multinational corporations to create their own firms and that labor mobility from multinationals to domestic firms is important.[28] Multinationals sometimes also enter into training cooperation with local institutions in the host economy. For example, Intel in Costa Rica and Shell-BP in Nigeria have made contributions to local universities; in Singapore, the Economic Development Board has collaborated with multinational corporations to establish and improve training centers.[29]

Knowledge spillovers can also take place without formal flows of workers out of the corporations. Knowledge about production processes diffuse from one firm to others simply because of the regular human interaction among people performing similar jobs for different companies. For example, a multinational corporation in the *maquila* sector in Honduras introduced a simple innovation of providing a free breakfast to employees half an hour before the start of the morning shift. This not only provided incentives for workers to show up on time, but also helped to improve their productivity. This simple idea rapidly diffused to other firms and soon became the norm in the *maquila* sector. More sophisticated or tacit knowledge can also diffuse in cases of close interaction between foreign and local firms, as occurs with multinationals and their suppliers. Branstetter,

27. Fosfuri, Motta, and Ronde (2001) formalize this view through a model in which a multinational firm can use a superior technology only after training a local worker. Technological spillovers from FDI arise when a domestic firm hires such a worker; pecuniary spillovers arise when the foreign affiliate pays higher wages to prevent the worker from leaving. On the education of local workers, see Lindsey (1986) and Ritchie, Zhuang, and Whitworth (2001); on training of technical workers and managers, see Chen (1983) and Gerschenberg (1987).

28. Pack (1997).

29. World Bank (1995); Spar (1998); Larraín, López-Calva, and Rodríguez-Clare (2000).

for example, examines firm-level data on Japanese firms' FDI and innovation activity; he finds evidence that FDI increases the flow of knowledge spillovers (measured by patent citations) both from and to Japanese multinationals undertaking direct investment in the United States.[30]

An entirely different mechanism for FDI externalities occurs through backward and forward linkages. It is important to distinguish linkages from spillovers, as they are confused in the literature. We view linkages as pecuniary externalities that take place through market transactions, in contrast to knowledge spillovers.[31] Consider, for example, the case of a firm that invents a new good. Under realistic assumptions, this firm will not be able to capture the full consumer surplus generated by the introduction of the good. A positive pecuniary externality will thus take place from the firm to consumers when the good is introduced. The same phenomenon arises when, instead of inventing a new good, the firm is simply starting up its production in a developing country. Under constant returns to scale, all goods generating positive consumer surplus would be produced and there would be no inefficiency. A more realistic scenario, however, includes fixed or start-up costs. In this case, new goods will be introduced until the marginal good earns just enough profits to generate the market return on the firm's fixed investment. The problem is that this does not take into account the consumer surplus generated by each new good. The pecuniary externality is thus associated with a market inefficiency, resulting in suboptimal equilibrium variety.

This discussion implicitly assumes some kind of nontradability. If goods were perfectly tradable (that is, if there were no transportation costs), then it wouldn't make sense to talk about a firm introducing a good to a developing country: all existing goods would automatically be available everywhere as long as there was a demand. In reality, transportation costs are important, and producing inputs locally thus carries important benefits.

Backward and forward linkages are associated with pecuniary externalities in the production of inputs. Inputs that would generate a positive social value are not introduced because suppliers do not take into account the full producer surplus. In this case, that surplus is the increased productivity derived by firms that could use those inputs instead of less specialized

30. Branstetter (2000).
31. Following Hirschman (1958).

inputs that are hence less appropriate to the specific needs of the firm. Under these circumstances (that is, inputs produced with increasing returns, transportation costs, and benefits of specialization), backward linkages are said to arise when a firm increases the demand for inputs and this leads to the introduction of new input varieties. The introduction of these inputs generates an increase in productivity for downstream producers, owing to the benefits of specialization. Backward linkages thus entail a positive horizontal productivity externality.

Forward linkages take place when the introduction of new inputs lowers the production cost of certain goods, making their production profitable for downstream producers. For example, multinational corporations may create backward linkages that lead to the production of a larger variety of intermediate goods; this, in turn, allows the economy to gain a comparative advantage in the production of more sophisticated final goods.[32] The economy ends up with higher productivity and higher wages thanks to the backward and forward linkages generated by multinational corporations.

According to this view of linkages, multinationals could generate a negative backward linkage effect, as shown by Rodríguez-Clare.[33] For example, if multinationals behave as enclaves by importing all their inputs and restricting their local activities to hiring labor, then the demand for inputs will decrease as multinationals increase in importance relative to domestic firms. The result is a reduction in input variety and specialization. This would show up as a negative horizontal externality.[34]

A Simple Model of Backward Linkages

In this section, we present a simple model adapted from Rodríguez-Clare to formalize the idea of backward linkages in an economy with several sectors.[35] We then propose a way to measure a firm's potential for gener-

32. Rodríguez-Clare (1996).

33. Rodríguez-Clare (1996).

34. A key point in this argumentation it that multinationals displace national firms from the market: this can result from labor market constraints (in the case of exports) or from competition among multinationals and domestic firms in the local market, as in Markusen and Venables (1999).

35. See Rodríguez-Clare (1996).

ating linkage, discuss the conditions under which it would be valid, and consider alternative measures.

The Model

Consider an economy (the host country) producing J manufacturing goods and an agricultural good. The agricultural good is produced one for one with labor, L, and is perfectly traded, with an international price equal to one. This good thus acts as the numeraire, and sets the wage equal to one. Imagine for simplicity that this is a small economy that takes final goods prices as given, and let p_j represent the price of manufacturing good j. Both domestic firms and multinationals produce manufacturing good j. Domestic firms produce good j with labor that is specific to sector j (and available in total quantity $\bar{L}_j$ in the economy) and a composite intermediate good, X, according to the following Cobb-Douglas production function:

$$Q_j = A(j) L_j^{\beta(j)} X_j^{1-\beta(j)}, \tag{1}$$

where $0 < \beta(j) < 1$. In turn, X is assembled from a continuum of nontradable differentiated intermediate goods according to the following Dixit-Stiglitz-Ethier specification:

$$X = \left[\int_0^n x(i)^\alpha di \right]^{1/\alpha}, \tag{2}$$

where $0 < \alpha < 1$.[36] We assume that there is a fixed requirement of one unit of L to produce a variety of intermediate goods and that production of each additional unit of such goods requires one additional unit of L.

Multinationals produce good j with a production function that is the same as the one for domestic firms, except that the parameter $\beta(j)$ is denoted by $\tilde{\beta}(j)$ in the case of multinationals. In general, we think of $\tilde{\beta}(j) < \beta(j)$, to capture the idea that multinationals have a more complex, or roundabout, production process that depends more on intermediate goods and less on labor. An additional difference between multinationals and

36. Alternatively, we could assume that some inputs are tradable and others are nontradable, as long as the use of these inputs does not vary across domestic and multinational firms. We believe that the same results would arise if instead of making the extreme assumption of nontradability we assumed that inputs had significant transportation costs, something for which there is ample evidence.

domestic firms is that the former have access to intermediate goods from the country where they have their headquarters. Thus, whereas domestic firms source all their intermediate goods domestically, multinationals buy only part of them domestically and import the rest from their home country.

As is standard in the literature, we assume that there is monopolistic competition in the market for intermediate goods, with a different firm selling each variety. The equilibrium variety, n, is determined by the zero-profit condition for monopolists selling varieties of intermediate goods. Each firm charges a price equal to $1/\alpha$ (recall that the wage is equal to one), and profits are equal to $x/\theta - 1$, where $\theta \equiv \alpha/(1-\alpha)$.[37] The zero profit condition thus implies $x(j) = \theta$.

Since labor cannot move across manufacturing sectors, we must allow the wage in sector j, w_j, to differ from the wage in other manufacturing sectors. Wages will be determined by the zero profit condition for final goods producers in each manufacturing sector. More importantly, the quantity of each variety of x that final goods producers purchase per unit of labor hired is given by $\alpha v(j) w_j / n$, where $v(j) \equiv [1-\beta(j)]/\beta(j)$. To proceed, imagine first that there were no multinationals. Then the total demand for each variety of x would be

$$\sum_j \frac{\alpha v(j) w_j \bar{L}_j}{n}.$$

Without loss of generality, we choose the values for $A(j)$ in such a way that the minimum unit cost of manufacturing good j is $\alpha^{\beta(j)-1} n^{[\beta(j)-1]/\theta} w_j^{\beta(j)}$.[38] This implies that the equilibrium wages are given by $w_j(n) = p_j^{1/\beta(j)} \alpha^{v(j)} n^{v(j)/\theta}$. The equilibrium condition that determines n is the following:

$$\sum_j \frac{\alpha v(j) w_j(n) \bar{L}_j}{n} = \theta. \tag{3}$$

We assume that $v(j) < \theta$ for all j, which implies that the share of intermediate goods relative to labor in the production of final good j is lower than the (absolute value of) the elasticity of substitution across varieties of

37. Given that the firm sells x units at price $1/\alpha$ and unitary cost, then variable profits are $(1/\alpha - 1)x = x/\theta$. Total profits are variable profits minus the fixed cost, which is simply one.

38. Specifically, we assume that $A(j) = \beta(j)^{-1} v(j)^{\beta(j)-1}$.

intermediate goods. This condition is sufficient to guarantee that the left-hand side of equation 3 is decreasing in n and hence that there is a unique equilibrium value of n.[39]

Our interest now is in understanding the effect of multinationals on the equilibrium n. Imagine that multinationals hire L_{mj} units of labor in manufacturing sector j. As in the case of domestic firms, it is useful to derive the multinationals' demand for each variety of intermediate goods in the host country per unit of labor hired there. This is given by

$$\frac{\gamma(j)\sigma_j(n)^{1/\tilde{\beta}(j)}\alpha\tilde{v}(j)w_j(n)}{n},$$

where $\tilde{v}(j) \equiv \dfrac{1-\tilde{\beta}(j)}{\tilde{\beta}(j)}$.

The term $\gamma(j)$, which is generally strictly lower than one, is the share of inputs sourced domestically by multinationals. As shown in Rodríguez-Clare, $\gamma(j)$ is higher when the variety of intermediate goods available in the home (or source) country is lower and when the transportation cost of intermediate goods is higher, perhaps because the home country is far away from the host country.[40] The term $\sigma_j(n)$ is the ratio of the price of good j and the minimum unit cost for multinationals. Since multinationals have access to intermediate goods from abroad and since $\tilde{\beta}(j) \neq \beta(j)$, their minimum unit cost will be lower than for domestic firms, such that this ratio is higher than one. This term is increasing in n because the wage, w_j, increases as n increases; given that $\tilde{\beta}(j) < \beta(j)$, this increases the unit cost of domestic firms more than that of multinationals.

There are two sources of differences in the purchases of intermediate goods per unit of labor hired between multinationals and domestic firms. The first relates to the share parameter, defined by the share of inputs bought domestically. This is equal to one for domestic firms and $\gamma(j) < 1$ for multinationals. The second is the intensity parameter, defined as the

39. If, on the other hand, the share of intermediate goods in manufacturing is high or the elasticity of substitution across intermediate goods is low (implying a high degree of love of variety), then the wage will be increasing very rapidly in n. This could make the left-hand side of equation 3 increasing in n, in which case there would not be an equilibrium with unitary wage, as we have been assuming.

40. Rodríguez-Clare (1996).

quantity of each variety of the intermediate good bought domestically per unit of labor hired. This is captured by

$$\frac{\alpha v(j) w_j(n)}{n} \text{ and}$$

$$\frac{\sigma_j(n)^{1/\tilde{\beta}(j)} \alpha \tilde{v}(j) w_j(n)}{n}$$

for domestic firms and multinationals, respectively. With $\tilde{\beta}(j) < \beta(j)$, we then have that $\tilde{v}(j) > v(j)$. Together with the fact that $\sigma_j(n) > 1$, this results in a higher intensity parameter for multinationals than for domestic firms.

We assume that entry by multinationals is exogenous. Thus, we simply take a distribution of L_{mj} across manufacturing sectors as given. The equilibrium is determined by

$$(4) \qquad \sum_j \alpha \left[\frac{w_j(n)}{n} \right] \left[v(j)(\bar{L}_j - L_{jm}) + \gamma(j) \sigma_j(n)^{1/\tilde{\beta}(j)} \tilde{v}(j) L_{jm} \right] = \theta.$$

It is important, again, to ensure that the left-hand side of equation 4 is decreasing in n, so that the equilibrium level n determined implicitly by this equation is unique. A sufficient condition for this is that

$$\frac{1 - \tilde{\beta}(j)}{\tilde{\beta}(j)} < \theta \text{ for all } j.$$

(See appendix A). As for domestic firms, this implies that the share of intermediate goods in multinationals' production of manufactures is not too high relative to the elasticity of substitution across inputs.

The impact of changes in L_{mj} depends on the relation between $v(j)$ and

$$\gamma(j) \sigma_j(n)^{1/\tilde{\beta}(j)} \tilde{v}(j).$$

In particular, it is easy to see that the equilibrium level of n is increasing in L_{mj} if and only if

$$\gamma(j) \sigma_j(n)^{1/\tilde{\beta}(j)} \tilde{v}(j) > v(j).$$

We refer to this case as one in which there is a positive linkage effect of multinationals. If

$$\gamma(j)\sigma_j(n)^{1/\tilde{\beta}(j)}\tilde{v}(j) < v(j),$$

then multinationals have a negative linkage effect, and equilibrium n is decreasing in L_{mj}. The intuition for this result is that if

$$\gamma(j)\sigma_j(n)^{1/\tilde{\beta}(j)}\tilde{v}(j) < v(j),$$

then a stronger presence of multinationals reduces the demand for domestic intermediate goods because multinationals' demand for these intermediate goods per unit of labor is lower than that of the domestic firms they displace from the labor market.

The importance of the linkage effect arises from the fact that there is love of variety for inputs. That is, the productivity of final goods producers rises when the variety of intermediate goods produced domestically increases, which is why $w_j(n)$ is increasing in n. This can be seen as capturing the benefits of specialization or the productivity gains from the division of labor. The positive association between the variety of intermediate goods (n) and the productivity of final goods producers implies that a positive (negative) linkage effect has a positive (negative) effect on productivity among domestic firms.

Measuring the Linkage Coefficient

Under the assumptions of the model presented above, the appropriate measure of the linkage coefficient is the value of inputs bought domestically per unit of labor hired. This section considers the different key assumptions for this result and how the violation of these assumptions would affect the validity of our measure for the linkage coefficient.

First, a key assumption is that all the intermediate goods used by domestic firms are nontradable. This is clearly a very extreme assumption and could significantly affect the results of the model. For instance, in a model with two kinds of inputs—nontradable and tradable with no transportation costs—only demand for nontradable inputs generates meaningful linkages. A finding that the linkage coefficient defined above is higher for multinationals than for domestic firms would lead to the conclusion that multinationals have a positive linkage effect. This would be wrong, however, if multinationals buy mostly tradable inputs, whereas domestic firms buy mostly nontradable inputs. Ideally, we would take into account

only the purchases of nontradable inputs, but this is clearly impossible in most cases owing to data constraints. We explore this topic further later in the paper.

Second, another key assumption in our model is that the degree of increasing returns is the same for all intermediate goods. If, however, intermediate goods can exhibit either increasing returns, as in the model above, or constant returns to scale, only demand for intermediate goods of the first kind entails linkages. It is possible in this situation for multinationals to have a higher linkage coefficient than domestic firms and yet the conclusion of a positive linkage effect by multinationals would be incorrect if domestic firms use mostly inputs with increasing returns and multinationals use mostly inputs with constant returns. Given data constraints, again, we can do very little at this stage regarding this issue.

Third, a further concern with the measurement we propose is related to our assumption of a common elasticity of substitution among all intermediate goods. Demand for inputs with a low elasticity of substitution generates linkages with a stronger effect on productivity than is the case with inputs that have good substitutes. Multinationals could thus have a higher linkage coefficient than domestic firms, and yet their linkage effect is negative because they demand mostly inputs with good substitutes, whereas domestic firms demand inputs with bad substitutes.

A final concern has to do with the model's assumptions regarding labor. The simplifying assumption we made is that multinationals and domestic firms employ the same kind of worker. A more realistic scenario is that multinationals hire more skilled workers than domestic firms. We could modify the model to capture this possibility by assuming that production of manufacturing goods is carried out with both skilled labor—which is sector specific—and unskilled labor—which is mobile across sectors and, in particular, is equal to labor used in agriculture. In this case, the relevant linkage coefficient is the ratio of inputs bought domestically to the number of skilled workers employed. Again, one can imagine a situation in which the linkage coefficient defined above is higher for multinationals than for domestic firms while the modified linkage coefficient (in which we divide by the number of skilled workers rather than the total number of workers) is lower for multinationals than domestic firms.[41] Fortunately,

41. Hanson (2001) makes a similar point by noting that positive externalities by multinationals are less likely when there is stronger competition for scarce skilled labor between multinationals and domestic firms.

data for some of our countries allow us to explore the importance of this issue.

Two points emerge from this analysis. First, multinationals' share coefficient as measured by most studies of linkages does not capture the whole story. The share coefficient most likely will be lower for multinationals than for domestic firms. The linkage coefficient, however, is the product of two terms: the share coefficient and the intensity coefficient. Since the intensity coefficient is likely to be higher for multinationals than for domestic firms, conclusions based on comparisons of the share coefficient only are likely to be wrong. Second, a positive backward linkage effect by multinationals leads to a positive effect on TFP for firms in the same industry, rather than for firms in upstream industries. In other words, a positive backward linkage effect leads to a positive horizontal externality, rather than a positive vertical externality as is often assumed.

Evidence in Favor of the Model

The next section explores the quantitative implications of the model. This empirical exercise is meaningful only to the extent that the model captures the essence of the way in which multinationals affect host countries through linkages. In this section, therefore, we examine whether this is the case. The two ways to approach this question are by exploring the reasonableness of the model's critical assumptions and by reviewing the available evidence regarding the model's implications.

As to the first approach, recall that the three key assumptions of the model are that inputs are nontradable, that they are produced with increasing returns, and that there are benefits to specialization. The nontradability of inputs is simply an extreme way to capture transportation costs in the model. Evidence of the importance of transportation costs for inputs can be found in Overman, Redding, and Venables.[42] Four additional references may be useful. First, Hummels provides evidence of costs of international trade (which include tariffs and nontariff barriers, shipping costs, costs of time delays, and other costs associated with marketing and distribution) for a large class of goods and inputs.[43] Second, Steinberg shows that the production of most inputs in Singapore—a small and very open economy where one would think that everything is tradable—behaves as if inputs

42. Overman, Redding, and Venables (2001).
43. Hummels (1999, 2001).

were nontradable.[44] Third, Klenow and Rodríguez-Clare, as well as Hummels and Klenow, show that the variety of imports increases with country size, a result consistent with the existence of fixed costs of importing.[45] Finally, Rodríguez-Clare discusses producer services, which is a class of inputs that fits the model well.[46] Alternatively, one may think of the assumption of nontradability of inputs as capturing the benefits for producers of having local, as opposed to foreign, suppliers. This comes out clearly in interviews with multinationals, as well as in case-study analysis, like that of Porter.[47]

The other two key assumptions of the model (increasing returns and benefits to specialization) are now standard in several fields of economics, such as international trade, growth, development, and economic geography.[48] Moreover, there is good evidence on the importance of increasing returns in the production of producer services, as well as plant-level increasing returns in manufacturing.[49] Finally, recent evidence is consistent with the implications of our three key assumptions working together, namely, agglomeration economies and sector-wide increasing returns in international trade.[50]

An alternative to checking for evidence in support of the model's key assumptions involves testing the model directly. Most of the relevant work to date entails case studies, with almost no rigorous empirical analysis. However, this literature, particularly that analyzing East Asian countries, does provide evidence in support of the view that multinationals establish positive linkages with domestic firms.[51]

The only empirical analysis that we are aware of is by Görg and Strobl, who follow Markusen and Venables in estimating the factors that lead to

44. Steinberg (2002).

45. Klenow and Rodríguez-Clare (1997); Hummels and Klenow (2002).

46. Rodríguez-Clare (1993).

47. Porter (1990).

48. On international trade, see Ethier (1982); Helpman and Krugman (1985). On growth, see Romer (1990); Grossman and Helpman (1993). On development, see Rodrik (1995); Rodríguez-Clare (1996). On economic geography, see Fujita, Krugman, and Venables (1999).

49. Rodríguez-Clare (1993) covers producer services; see Tybout and Westbrook (1995) on plant-level increasing returns in manufacturing.

50. On the former, see Ellison and Glaeser (1997, 1999); Hanson (2000). On the latter, see Antweiler and Trefler (2000).

51. Lall (1980); Pack (1997); UNCTAD (2001).

the entry of domestic firms in the manufacturing sector in the Irish economy.[52] Their findings suggest that multinationals have a positive effect on domestic firm entry. Their work, however, defines the linkage effect as the share of inputs sourced domestically, which might be a misleading indicator of the true linkage potential of a firm.

Measuring Linkage Coefficients for Multinational Corporations and Local Firms in Latin America

In this section we use our proposed measure of the linkage coefficient to explore the model's implied relation between linkages generated by foreign and local firms in the four countries for which we obtained the appropriate data. We then compare our results with the main findings in the literature. The empirical exercise in this section does not involve a test of the model presented in the previous section. Rather, we explore its quantitative implications. The actual testing of the model remains an important issue for future research.

Data

The empirical analysis was performed using manufacturing firm data, distinguished by sector and ownership, from Brazil, Chile, Mexico, and Venezuela. In all cases, a firm or plant was considered foreign if foreigners owned more than 50 percent of equity.

For Brazil, the sample covers 1997 through 2000. The analysis is based on a data set of firms taken from the annual industrial survey conducted by the Brazilian Geographical and Statistical Institute (IBGE). The unbalanced panel has 38,926 observations, of which 3,118 are foreign. The number of observations ranges from 10,767 in 1997 to 8,528 in 2000. For Chile, the sample covers firms in the manufacturing sector for the years 1987 through 1999 and was taken from the annual industrial survey, conducted by the National Institute of Statistics (INE). Our sample includes 65,809 observations, of which 6,223 are foreign. The number of observations ranges from 5,466 in 1996 to 4,394 in 1999. Data for Mexico were

52. Görg and Strobl (2000); Markusen and Venables (1999).

TABLE 2. Average Linkage Coefficient, by Year and Firm Ownership[a]

	Brazil		*Chile*		*Mexico*		*Venezuela*	
Year	*Foreign*	*Local*	*Foreign*	*Local*	*Foreign*	*Local*	*Foreign*	*Local*
1987	…	…	3,569	2,723	…	…	…	…
1988	…	…	12,926	3,117	…	…	…	…
1989	…	…	14,908	3,622	…	…	…	…
1990	…	…	16,864	4,219	…	…	…	…
1991	…	…	19,488	5,387	…	…	…	…
1992	…	…	22,190	5,975	…	…	…	…
1993	…	…	23,892	6,528	101	98	…	…
1994	…	…	28,700	7,012	117	113		
1995	…	…	20,454	8,766	154	202	3,920	3,829
1996	…	…	20,833	9,472	222	264	5,566	5,833
1997	72,541	38,427	22,542	10,564	236	322	10,303	9,085
1998	60,578	43,956	25,441	11,577	257	359	18,805	12,262
1999	41,043	29,012	27,249	15,343	288	336	14,558	10,411
2000	44,405	25,821	…	…	402	351	…	…
Mean	55,320	34,847	15,803	7,263	217	247	9,818	7,900

… Not applicable.

a. The average linkage coefficient is calculated as the average value of domestic inputs to total workers per year for foreign and domestic firms, respectively. Data are in local currency, for Venezuela in thousands. Data are from the respective country annual industrial plant surveys.

taken from the annual industrial survey, collected by Mexico's National Institute of Statistics, Geography, and Information (INEGI). Our sample covers the years 1993 through 2000 and includes 47,914 observations, of which 4,071 are foreign. The number of observations per year ranges from 6,616 in 1993 to 5,330 in 2000. Data for Venezuela are from the annual industrial plant survey, conducted by the Central Statistics and Informatics Office (OCEI). The data cover the years 1995 through 2000. Our sample includes 13,765 observations, of which 1,508 are foreign. The number of observations ranges from 1,785 in 1998 to 3,572 in 1996.

Basic Results for the Linkage Coefficient

We calculated the linkage coefficient as the value of domestic inputs to total workers per year for each firm. Table 2 presents the main descriptive statistics for the linkage coefficient for the countries and years in our sample. The linkage coefficient varies widely across countries and years, and different patterns emerge. For Mexico, the linkage coefficient for foreign firms is lower than for local firms, whereas it is higher for foreign firms than for local ones in Brazil, Chile, and Venezuela.

TABLE 3. Average Share of Domestic Inputs to Total Inputs, by Year and Firm Ownership[a]

	Brazil		*Chile*		*Mexico*		*Venezuela*	
Year	*Foreign*	*Local*	*Foreign*	*Local*	*Foreign*	*Local*	*Foreign*	*Local*
1987	…	…	0.915	0.914	…	…	…	…
1988	…	…	0.882	0.927	…	…	…	…
1989	…	…	0.896	0.933	…	…	…	…
1990	…	…	0.893	0.935	…	…	…	…
1991	…	…	0.894	0.933	…	…	…	…
1992	…	…	0.883	0.923	…	…	…	…
1993	…	…	0.874	0.920	0.560	0.854	…	…
1994	…	…	0.874	0.912	0.551	0.847	…	…
1995	…	…	0.756	0.919	0.534	0.855	0.759	0.851
1996	…	…	0.724	0.921	0.533	0.853	0.830	0.880
1997	0.705	0.933	0.702	0.921	0.520	0.835	0.783	0.861
1998	0.685	0.934	0.759	0.923	0.530	0.842	0.698	0.822
1999	0.671	0.934	0.767	0.936	0.533	0.835	0.824	0.870
2000	0.662	0.933	…	…	0.522	0.820	…	…
Mean	0.682	0.933	0.874	0.923	0.536	0.844	0.792	0.861

… Not applicable.

a. The average share is calculated as the average value of domestic inputs to total inputs per year for foreign and domestic firms, respectively. Data are from the respective country annual industrial plant surveys.

In the interest of comparing our linkage coefficient with those used in the literature, we also calculated the share of inputs sourced domestically per year by each firm. Table 3 shows comparable statistics for this measure. In all cases, we observe a higher share of inputs sourced domestically by local firms relative to foreign ones. For Brazil and Mexico, the share of inputs sourced domestically is fairly constant throughout the period, while it tends to decline in Chile and increase in Venezuela.

Finally, Table 4 reports the intensity coefficient, calculated as total inputs bought by the firm to total employees per firm (that is, the intensity coefficient equals the linkage coefficient times the share). This indicator also varies widely throughout the sample. Overall, however, the intensity coefficient for foreign firms tends to be higher than for local firms for all countries in our sample.

Regression Analysis

We use the ratio of domestic inputs to workers as our linkage coefficient and explore the validity of claims in the literature regarding linkages across different types of firms, in particular comparing the linkage coefficients of local and foreign firms. We estimate the following relation:

TABLE 4. Average Intensity Coefficient, by Year and Firm Ownership[a]

	Brazil		*Chile*		*Mexico*		*Venezuela*	
Year	*Foreign*	*Local*	*Foreign*	*Local*	*Foreign*	*Local*	*Foreign*	*Local*
1987	…	…	4,117	3,202	…	…	…	…
1988	…	…	14,426	3,575	…	…	…	…
1989	…	…	16,435	4,109	…	…	…	…
1990	…	…	19,011	4,752	…	…	…	…
1991	…	…	22,154	6,112	…	…	…	…
1992	…	…	25,410	6,913	…	…	…	…
1993	…	…	27,318	7,643	174	120	…	…
1994	…	…	32,819	8,348	210	138	…	…
1995	…	…	27,809	10,097	319	246	6,146	4,704
1996	…	…	29,035	10,818	464	324	8,700	7,265
1997	100,049	43,838	33,130	11,998	532	405	15,779	11,674
1998	88,433	49,549	33,590	13,117	591	444	28,720	16,445
1999	65,233	33,165	38,820	16,984	652	417	20,164	13,368
2000	70,070	29,853	…	…	811	445	…	…
Mean	81,684	39,700	18,731	8,299	457	305	14,597	10,138

… Not applicable.

a. The average intensity coefficient is calculated as the average value of total inputs to total workers per year for foreign and domestic firms, respectively. Data are in local currency, for Venezuela in thousands. Data are from the respective country annual industrial plant surveys.

$$\text{LINKCOEF}_{ift} = \beta_0 + \beta_1 \text{FOREIGN}_{ift} + \mu_j + \mu_t + \varepsilon_{ift}, \tag{5}$$

where LINKCOEF_{ift} refers to the ratio of domestic inputs to total workers for firm i in sector j at time t; FOREIGN_{ift} is a dummy variable taking the value of one if firm i in sector j at time t is owned by foreigners (50 percent or more foreign equity); μ_j and μ_t capture sector and time specific effects; and ε_{ift} is an independent and identically distributed (i.i.d.) error term.[53]

The first regression in table 5 presents the result of estimating equation 5 excluding the sector dummies. We find that the linkage coefficient of multinational corporations is significantly higher than that of domestic firms in Brazil, Chile, and Venezuela. For Mexico, our estimations imply a lower linkage coefficient for foreign firms than domestic firms, but the coefficient is not significant at conventional levels. These results remain robust when we control for different sectors, as seen in the second regres-

53. We used nine sectors according to the International Standard Industrial Classification (ISIC) revision 2 for Chile, Mexico, and Venezuela. For Brazil, we use fifteen sectors from the ISIC revision 3.

TABLE 5. Foreign Ownership: Linkage, Share, and Intensity Coefficients[a]

Country and explanatory variable	Linkage (1)	Linkage (2)	Share (3)	Intensity (4)
Brazil				
FOREIGN	20,680	15,412	–0.391	32,834
	(3.60)***	(2.67)***	(–56.16)***	(5.01)***
No. observations	38,926	38,926	38,926	38,926
R^2	0.1	0.1	…	0.1
Chile				
FOREIGN	11,442	9,218	–0.274	11,521
	(9.18)***	(7.36)***	(–30.46)***	(8.99)***
No. observations	65,812	65,812	65,720	65,812
R^2	0.1	0.1	…	0.1
Mexico				
FOREIGN	–33.4	8.9	–0.401	181.5
	(–1.28)	(0.42)	(–53.85)***	(6.34)***
No. observations	47,065	47,065	47,575	46,692
R^2	0.1	0.1	…	0.1
Venezuela				
FOREIGN	1,904	1,565	–0.171	3,929
	(2.19)**	(1.84)*	(–9.45)***	(4.08)***
No. observations	13,724	13,724	13,555	13,724
R^2	0.1	0.1	…	0.2

* Statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

a. The dependent variable in regressions 1 and 2 is the share of inputs sourced domestically by firm *i*; in regression 3, the share of inputs sourced domestically by firm *i*; in regression 4, the ratio of total inputs to workers for firm *i*. Regressions 1, 2, and 4 are estimated using White's correction of heteroskedasticity; regression 3 is estimated using a Tobit model. Regressions 2, 3, and 4 control for sectors. All regressions include annual time and industry dummies. FOREIGN is a dummy variable for foreign ownership. For Chile, Mexico, and Venezuela, industry dummies correspond to two-digit ISIC2 classification; for Brazil, they are two-digit ISIC3 classification. *t* statistics are in parentheses.

sion in the table.[54] When we control for sector differences, we find higher and significant linkage coefficients for foreign versus domestic firms in Brazil, Chile, and Venezuela.[55] The estimated effects in these countries are economically significant. An increase from 10 to 11 percent in the pres-

54. Results are also robust to excluding outliers.

55. We further explored for differences in terms of linkage potential for foreign firms at the sector level. We estimated the following relation: $\text{LINKCOEF}_{ijt} = \beta_0 + \beta_1\text{FOREIGN}_{itjt} + \beta_1\text{FOREIGN}_{itjt} \times \mu_j + \mu_j + \mu_t + \varepsilon_{ijt}$, where the term $\text{FOREIGN}_{itjt} \times \mu_j$ captures differences for foreign firms at the sector level. Although we found foreign firms to have significantly different linkage potential across some sectors, these differences seemed to be country specific. The model developed earlier in the paper is silent, however, on the implications of these results.

ence of multinational firms in sector *i* (as measured by the share of employment in multinational firms) implies an average increase in wages ranging from close to 0.2 percent in Venezuela to 0.6 percent in Chile.[56] The coefficient for Mexico in the regression that controls for time and industry effects is now positive, although not significant.

We compare our results to those obtained in the literature by using the percentage of inputs sourced locally, which appears as an indicator of linkage effects in the literature.[57] In particular, we estimated an equation similar to equation 5 but with $SHARECOEF_{ift}$ as the dependent variable, where $SHARECOEF_{ift}$ is the ratio of domestic inputs to total inputs for firm *i* in sector *j* at time *t*. Since the dependent variable can take values between 0 and 1, we estimated this equation using a Tobit regression.[58] The results are presented in table 5 (regression 3).

The share of inputs sourced domestically is lower for foreign firms than for domestic ones in all countries. This is consistent with most of the empirical literature on linkages, in which the usual approach is to consider the share of inputs bought domestically. This generally leads to the finding that the share of local to total inputs is lower for multinationals than for domestic firms, as in works by Forsyth for Scotland and Cohen and Biersteker for Nigeria.[59] The case of Ireland has received particular attention in the literature. McAleese and McDonald and O'Loughlin and O'Farrell both find that foreign subsidiaries in Ireland buy fewer local inputs than national firms; Barry and Bradley similarly report that foreign firms are more likely to import their inputs than local firms; and Görg and Ruane, who study the effect of foreign firms in the Irish electronic sector between 1982 and 1995, indicate that while foreign firms have lower linkages than local firms, their linkages with the local economy tend to become stronger with time.[60]

56. Appendix B explains in detail the derivation of this calculation and the assumptions behind it.

57. See McAleese and McDonald (1978); O'Loughlin and O'Farrell (1980); Görg and Strobl (2002).

58. See Görg and Ruane (2001) for a similar treatment of the Irish case.

59. Forsyth (1972); Cohen (1973); Biersteker (1978).

60. McAleese and McDonald (1978); O'Loughlin and O'Farrell (1980); Barry and Bradley (1997); Görg and Ruane (2001). McAleese and McDonald (1978) define backward linkages as the ratio of current expenditure in Ireland relative to total current expenditure by firms; O'Loughlin and O'Farrell (1980) define it as the percentage of raw materials and components sourced locally.

Our results suggest that some of the common notions in the literature about the linkage effects of multinational corporations may stem from the use of linkage measures that are not properly derived from theory. As discussed before, our proposed indicator provides evidence that foreign firms have significantly higher linkage coefficients than local firms in Brazil, Chile, and Venezuela.[61] We further explored why our results differ from those of the current empirical literature by measuring the intensity coefficient, a concept introduced in the previous section and calculated as the ratio of total inputs used to the number of employees hired (that is, the linkage coefficient equals the source coefficient times the intensity coefficient). We then estimated an equation similar to equation 5 but with $INTENSITYCOEF_{ift}$ as the dependent variable. The main results are reported in the final column of table 5. For all countries, we found significantly higher intensity coefficients for foreign firms vis-à-vis domestic firms. These results suggest that while domestic firms do source a larger percentage of their inputs domestically, they buy fewer inputs in relation to the number of workers they hire. As a result, domestic firms do not necessarily generate stronger linkages than foreign firms.

Mexico is the only country in which the linkage coefficient of multinational corporations is not significantly higher than that of domestic firms. One possible explanation for this finding is that most of Mexico's multinationals have their headquarters in the United States, and they can easily import most of their inputs from there.[62] One would thus expect the multinationals in Mexico to have a much lower share coefficient than domestic firms, and indeed this is what we find. As shown in table 3, the average share coefficient for foreign and domestic firms in Mexico is 54 percent and 84 percent, respectively, whereas the corresponding num-

61. We found that exporting firms have a higher linkage coefficient than those firms whose production is aimed at the domestic market, based on the following regression: $LINKCOEF_{ijt} = \beta_0 + \beta_1 D\_EXP_{itjt} + \mu_j + \mu_t + \varepsilon_{ijt}$, where D_EXP_{itjt} is a dummy variable taking the value of one if firm i in sector j at time t is exporting. In our sample, the number of observations geared to the external market ranges from 30 percent in Mexico to 15 percent in Chile. The results are significant for Chile and Venezuela. Moreover, the share of inputs sourced domestically for exporting firms is lower than that for firms oriented to the domestic market. This last result is significant for all countries. Our evidence suggests that these results are also driven by the higher intensity coefficients of exporting firms relative to those geared to the domestic market. In contrast with the results on multinationals reported in the text, the interpretation of these results regarding exporting firms is not entirely clear. This remains an issue for future research.

62. Rodríguez-Clare (1996).

bers are 68 percent and 93 percent in Brazil, 79 percent and 86 percent in Venezuela, and 87 percent and 92 percent in Chile. We get the same results when we control for sectors, as shown in table 5 (regression 3).

NEW FOREIGN FIRMS AND TIME EFFECTS. Firms might need time to get to know the domestic market and establish relationships with the local economy. This means that the linkage effect may be different for well-established firms and for firms just entering the market. To explore this, we regressed the linkage coefficient on the foreign dummy, time and sector dummies, and an interaction term capturing the effect of new foreign firms. Formally, we estimate the following relation:

$$\text{LINKCOEF}_{ift} = \beta_0 + \beta_1 \text{FOREIGN}_{ift} + \beta_2 \text{FOREIGN}_{ift} \cdot \text{NEWFIRMS}_{ift} + \mu_j + \mu_t + \varepsilon_{ift}, \tag{6}$$

where NEWFIRMS_{ift} is a dummy variable that takes the value of one for firms with less than three years of age. Since the hypothesis under study is relevant only for foreign firms, we interact this variable with the foreign dummy. As shown in the first regression in table 6, new foreign firms tend to have a lower linkage coefficient than established foreign firms. This result is significant only for Venezuela, however.[63] Because our data sets for Brazil and Chile do not include age information, we were not able to perform this exercise for those countries.

This result could reasonably arise because the share coefficient for new multinationals is lower than for older ones, as it takes time for new foreign firms to find reliable local suppliers. Support for this hypothesis is not robust. We ran a regression similar to equation 6 but with the share coefficient as the dependent variable. This yielded a negative and significant coefficient (for the interacted variable) in Mexico, but the results for Venezuela were not significant (see table 6, regression 2).

63. In this case, the coefficient on $\text{FOREIGN}_{ift} \cdot \text{NEWFIRMS}_{ift}$ indicates that the linkage coefficient for these firms is lower than that of well-established foreign firms. To obtain the total estimated linkage coefficient for new foreign firms, one should add to this coefficient the estimated coefficient for foreign firms, the corresponding sector and year dummies, and the constant. For both Mexico and Venezuela, the results imply a positive total linkage coefficient for new foreign firms. For Mexico the estimated coefficient for the constant was 81.39 (1.69), and all year dummies had significant positive values higher than 35.07. For Venezuela, the estimated coefficient for the constant was 1174.3 (3.57), and all year dummies had significant positive values higher than 3987.4. We may, however, be using a linear approximation to estimate a nonlinear relation of age on the linkage coefficient.

TABLE 6. Age of New Foreign Firms, Controlling for Sectors: Linkage and Share Coefficients[a]

Country and explanatory variable	*Linkage (1)*	*Share (2)*
Mexico		
FOREIGN	11.0	–0.396
	(0.49)	(–51.78)***
NEWFIRMS × FOREIGN	–35.0	–0.085
	(–1.29)	(–2.94)***
No. observations	47,065	47,575
R^2	0.1	. . .
Venezuela		
FOREIGN	1,907	–0.183
	(2.07)**	(–9.78)***
NEWFIRMS × FOREIGN	–3,987	0.159
	(–3.13)***	(0.46)
No. observations	13,724	13,555
R^2	0.1	. . .

** Statistically significant at the 5 percent level; *** at the 1 percent level.

a. The dependent variable in regression 1 is the linkage coefficient of firm *i*, defined as the value of inputs bought domestically to total workers; in regression 2 it is the share of inputs sourced domestically by firm *i*. Regression 1 is estimated using OLS with White's correction of heteroskedasticity; regression 2 is estimated using a Tobit model. All regressions include annual time and industry dummies. FOREIGN is a dummy variable for foreign ownership; NEWFIRMS is a dummy variable for firms with less than three years of age. For Chile, Mexico, and Venezuela, industry dummies correspond to two-digit ISIC2 classification; for Brazil, they are two-digit ISIC3 classification. *t* statistics are in parentheses.

To explore this further, we analyzed how the share of inputs bought domestically by foreign firms was likely to evolve through time. We estimated the following relation for foreign firms:

$$\text{SHARECOEF}_{ift} = \delta_0 + \delta_1 t + \mu_{if} + \varepsilon_{ift}, \tag{7}$$

where t stands for time (year) and μ_{if} corresponds to a firm-specific effect. We conjecture that once we control for firm characteristics, we should observe foreign firms buying an increasingly higher percentage of inputs domestically. That is, we should observe a positive coefficient on the time trend variable.

In effect, we find a positive coefficient for all countries in our sample (see table 7). Only in the case of Mexico, however, do we find strong evidence that foreign firms increase the share of inputs sourced domestically as time progresses. The relation is not significant for the other countries, although it is positive. Görg and Ruane similarly find a positive and statistically significant relation between the extent of linkages and a proxy for

TABLE 7. Time Trend for Foreign Firms: Share Coefficient[a]

Explanatory variable	*Brazil*	*Chile*	*Mexico*	*Venezuela*
Time trend	0.001	0.007	0.009	0.007
	(0.65)	(1.84)*	(6.43)***	(1.26)
Summary statistic				
No. observations	3,152	6,223	4,408	1,508
No. groups	852	2,339	551	818

* Statistically significant at the 10 percent level; *** at the 1 percent level.

a. The dependent variable is the share of inputs sourced domestically by foreign firm *i*. All regressions are estimated using a Tobit model with firm-specific random effects. Regressions include foreign firms only; *t* statistics are in parentheses.

firm maturity in Ireland, as indicated by the date at which the firm entered the survey.[64] Their results, which are consistent with our findings, suggest that firms source an increasing share of inputs locally as they get accustomed to local markets.

ROBUSTNESS: LINKAGES MEASURE. As mentioned, one potential problem with the measurement of the linkage coefficient we used above has to do with differences in the types of workers hired by multinationals and domestic firms. The empirical literature finds robust evidence that multinationals pay higher wages per employee than domestic firms, and we strongly confirm this in our data: in all cases, running a regression of the wage (total wages paid over total employees) on a foreign dummy results in a positive and significant coefficient, as shown in table 8.[65] One likely explanation for such higher wages has to do with the payment of efficiency wages by multinationals. Another is that multinationals hire more skilled workers.

Unfortunately, we only have data on the types of workers hired for Mexico and Venezuela. For these countries, we confirm the above conjecture: the share of workers that are skilled is higher for multinationals than for domestic firms.[66] Do the results presented above change when we take

64. Görg and Ruane (2001).

65. We estimate an equation similar to equation 5 but with $AVEWAGE_{ijt}$ as the dependent variable, where $AVEWAGE_{ijt}$ corresponds to total wages per employee in firm *i* in sector *j* at time *t* and the rest is as in the previous equations.

66. Formally, we estimated an equation similar to equation 5 using $SHARESKILLED_{ijt}$ as the dependent variable, where $SHARESKILLED_{ijt}$ corresponds to the ratio of nonproduction workers to total workers in firm *i* in sector *j* at time *t* and the rest is as in the previous equations.

TABLE 8. Average Wages[a]

Explanatory variable	*Brazil*	*Chile*	*Mexico*	*Venezuela*
FOREIGN	7,258	1,083	47.8	277
	(66.48)***	(37.56)***	(46.16)***	(2.74)***
Summary statistic				
No. observations	38,926	65,812	47,108	13,724
R^2	0.4	0.4	0.3	0.2

*** Statistically significant at the 1 percent level.

a. The dependent variable is total wages to total number of workers in firm *i*. All regressions are estimated using OLS with White's correction of heteroskedasticity and include time and industry dummies. FOREIGN is a dummy variable for foreign ownership. For Chile, Mexico, and Venezuela, industry dummies correspond to two-digit ISIC2 classification; for Brazil, they are two-digit ISIC3 classification. Data are in local currency (for Venezuela in thousands); *t* statistics are in parentheses.

this into account? Following the discussion in the previous section, we calculated the linkage coefficient as the ratio of domestic inputs to qualified employees and revisited our estimations with this new measure. The main results are reported in the first regression of table 9. After controlling for time and sector dummies, we still cannot reject the claim that foreign and local firms have similar effects in terms of linkages. We then compared the results with those previously obtained using total inputs to total workers as defined in equation 1. In the case of Mexico, we find that foreign firms have a higher linkage potential than domestic firms for both indicators. In neither case, however, are the results significant at conventional signifi-

TABLE 9. Qualified Workers: Linkage and Intensity Coefficients[a]

Country and explanatory variable	*Linkage (1)*	*Intensity (2)*
Mexico		
FOREIGN	14.8	768.6
	(1.10)	(4.98)***
No. observations	46,386	46,018
R^2	0.1	0.1
Venezuela		
FOREIGN	1,874	7,614
	(0.43)	(1.25)
No. observations	10,439	10,439
R^2	0.1	0.1

*** Statistically significant at the 1 percent level.

a. The dependent variable in regression 1 is the linkage coefficient of firm *i*, defined as the value of inputs bought domestically to qualified (or nonproduction) workers; in regression 2 it is the ratio of total inputs bought to qualified (or nonproduction) workers for firm *i*. All regressions are estimated using OLS with White's correction of heteroskedasticity and include annual time and industry dummies. FOREIGN is a dummy variable for foreign ownership. Data are in local currency; *t* statistics are in parentheses.

cance levels. For Venezuela, our results remain positive, but the results are not significant at 10 percent, unlike the previously obtained results.

The second regression of table 9 presents the results of running our alternative intensity measure defined as the ratio of domestic inputs to qualified employees on the foreign dummy and on the time and sector dummies. For both Mexico and Venezuela, the intensity coefficient remains significantly higher for foreign than domestic firms. In relation to previous findings reported in table 5 (regression 3), the results remain robust only for Mexico.

SUMMARY. Consistent with the literature, we find that foreign firms in Brazil, Chile, Mexico, and Venezuela source a lower percentage of their inputs domestically than local firms. When we use our proposed measure of a firm's (backward) linkage potential, however, we do not find evidence that multinational corporations have a lower linkage potential. In fact, when we use domestic inputs to total workers as the linkage coefficient, we find that the linkage potential of multinationals in Brazil, Chile, and Venezuela is higher than that of domestic firms. For Mexico, the coefficient is positive, but not significant. In contrast, using domestic inputs to skilled workers allows us to conclude that foreign and local firms have similar linkage potential in Mexico and Venezuela.

An important caveat of our analysis is that for linkages to be meaningful, inputs must be nontradable (or, more generally, have high costs associated with importing them, relative to domestic procurement) and must be produced with increasing returns to scale. Unfortunately, data limitations do not allow us to control for nontradability and the degree of increasing returns. The approach we follow so far can be interpreted as establishing upper bounds on the linkages that can be generated by different firms. A more rigorous analysis of this question requires considering only the purchases of nontradable inputs and inputs produced with increasing returns to scale.

The Case of Costa Rica

Although Costa Rica does not have good plant-level data, the country collects detailed information on all firms under the export processing zone (EPZ) regime.[67] One advantage of this data set is that it contains detailed

67. In particular, we have firm data by nationality and sector from the EPZ regime for 1995 and 2000. We have an unbalanced panel with only 118 observations (57 for 1995 and

information on the inputs used by each firm. This allows us to explore an issue mentioned above, namely the possibility that the tradability of inputs may vary across foreign and domestic firms. We briefly report on the findings, although any generalization must take into account the limited nature of our data.

One robust finding, even in this small sample, is that domestic firms source a higher percentage of inputs locally than foreign firms. Moreover, consistent with previous results, we do not find evidence that foreign firms have a different linkage potential than domestic firms, although this could be due to the small size of the sample.

As mentioned, the data set allows us to investigate the tradability of the inputs used by different firms. For each input, we construct a tradability index as world trade (exports plus imports) to world production:

$$\text{TRADINDEX}_t = \frac{\text{WORLDEXP}_t + \text{WORLDIMP}_t}{\text{WORLDPROD}_t}.$$

We then calculated the average tradability of inputs bought domestically by each firm according to

$$\text{INPUTTRAD}_I = \sum_l \left(\frac{x(l,i)}{\sum_l x(l,i)} \right) \text{TRADINDEX}_l,$$

where $x(l, i)$ denotes spending by firm i on input l.

We used data from the Industrial Demand-Supply Balance Database published by the United Nations Industrial Development Organization (UNIDO) to construct the tradability index; we then ran a regression of INPUTTRAD_i on a foreign dummy with year and sector dummies and verified that multinationals are using domestic inputs that are more tradable.[68] This suggests caution in interpreting the above results since higher tradability implies less room for meaningful linkages.

Of course, our results are derived from a very particular case. Any conclusion or generalization must consider that the small sample of firms

61 for 2000); 70 percent of the firms are foreign ones. In this case, firms are either foreign or local.

68. UNIDO (2002). The sectors into which we classified firms are *maquila*, high tech, and other, following the EPZ's internal classification system. The estimated coefficient for the foreign dummy is 14.4, with standard error 8.23 ($t = 1.75$). For our small sample size, the estimates are significant at 10 percent.

located in the export processing zone might not necessarily reflect the characteristics of firms in the country. Even so, the case suggests that further research should explore the role of the tradability of inputs, as it might be an important determinant in the linkage potential of foreign firms.

Linkages versus the Empirical Literature on Multinationals and Externalities

The previous section shows that multinational corporations have a higher linkage coefficient than domestic firms in Brazil, Chile, and Venezuela (at least when we use the linkage coefficient with the total number of employees rather than the number of skilled employees in the denominator). This should lead to a positive backward linkage effect, which does not necessarily imply a positive externality from multinationals to suppliers. In fact, such a positive linkage effect should lead to a positive externality from multinationals to other firms in the same industry (that is, a positive horizontal externality). There is thus a puzzle, in that the empirical literature on FDI externalities finds exactly the opposite: a negative or zero horizontal externality and a positive vertical externality. This section discusses this apparent contradiction between the implication of our findings and the general conclusions of the recent empirical literature on FDI externalities.

Could positive backward linkages lead to higher productivity for suppliers? In the model presented above, the Dixit-Stiglitz-Ethier specification implies that when demand for intermediate goods increases, new suppliers enter the market and variety expands, conferring advantages of specialization on downstream producers. Suppliers would not be able to expand production, so they would not benefit from economies of scale. We can generalize beyond the Dixit-Stiglitz-Ethier specification by considering the case in which the elasticity of substitution is not constant or there is an endogenous markup.[69] As the demand for inputs increases, then both the variety of inputs and the scale of production for suppliers may increase, allowing suppliers to reap productivity gains as they move down their average cost curve. These productivity gains, however, would not show up as increases in total factor productivity in most recent empirical studies, since they allow for the existence of increasing returns to scale.

69. Eckel (2003).

The falling average cost caused by a higher scale of production would be captured as gains from economies of scale, rather than showing up in the residual.

This reasoning leads us to look for an alternative interpretation of the recent empirical finding of a positive externality from multinational corporations to suppliers. This could point to the existence of positive knowledge spillovers, which would clearly lead to higher TFP among suppliers. There is plenty of anecdotal evidence for such knowledge spillovers.[70] However, interviews we conducted with suppliers and multinationals in Costa Rica revealed few clear cases of a positive technology transfer from the multinational to its suppliers.[71] According to one of the multinationals we interviewed, this is because multinationals often do not have technical knowledge about the production process of the *inputs* they use. The cases in which they do have such knowledge are usually related to sophisticated inputs that are physically integrated in the good being produced by the multinational. It is unlikely that local firms will be able to supply these inputs, which the multinationals usually obtain from specialized international suppliers.

The interviews we conducted revealed many cases in which suppliers had improved their technologies because of the pressures exerted on them by the multinational corporations.[72] That is, instead of stories of multinationals helping suppliers to improve their productivity through the transfer of technology, we found stories of how local firms had decided to upgrade the quality of their production process in order to become suppliers to the multinationals. This suggests a different kind of linkage than the one we modeled above. Imagine that suppliers can choose to become high-quality suppliers, but that this entails some investment. They will make this investment only if the demand for high-quality inputs is sufficiently large. If we modify the model by defining the quality-linkage coefficient as the usage of high-quality inputs per employee, then multinationals have

70. Lateef (1997); Cyhn (1999).

71. Rhee, Ross-Larson, and Pursell (1984) report considerable knowledge transfer from foreign firms to Korean firms: visits to foreign plants by local staff and by foreign buyers to their plants; provision of blueprints and specifications; and feedback on designs, quality, and technical performance of their products. For example, Daewoo Electronics entered an original equipment manufacturing arrangement with Japan's NEC in 1981. NEC enhanced Daewoo's capability by providing technological help; see Cyhn (1999).

72. This is consistent with the findings in the literature on industry upgrading in manufacturing value chains; see Humphrey and Schmitz (2002).

a higher quality-linkage coefficient than domestic firms, and a stronger multinational presence would lead to a positive quality-linkage effect. Such an effect would imply an increase in the variety of high-quality inputs produced locally, which would lead to an increase in the productivity of domestic firms in downstream sectors. The quality upgrading by suppliers would probably be captured as an increase in their measured TFP, providing an explanation for the observed positive productivity externality from multinationals to suppliers.

The question that remains is why we do not observe a positive externality from multinationals to other firms in the same industry. This is a problem not only for the two types of linkage effects we have described (one affecting the variety of inputs and the other affecting their quality), but also for any other type of positive externality from multinationals to suppliers. For instance, if multinationals generate knowledge spillovers to suppliers, one would expect this to lead to improvements in the quality of the inputs they produce, which in turn should show up as increases in TFP for downstream firms.[73] In other words, the joint finding in the recent empirical literature of positive vertical externalities and negative horizontal externalities poses a puzzle, independently of the interpretations we suggest in this paper.

The natural answer to this puzzle is that a negative horizontal externality more than compensates for the positive effect that multinationals have on other firms in the same industry through the increases in the variety and quality of domestic inputs they help to bring about. Such a negative horizontal productivity externality could be the result of a competition effect caused by the entry of multinational corporations, as argued by Aitken and Harrison.[74] If the entry of multinationals shrinks the market for domestic firms, this would most likely show up as a reduction in measured TFP because of the inability of the econometrician to adjust the measured capital stock for the reduction in its usage. Another mechanism through which

73. The case could be made that the knowledge spillover from multinationals to suppliers leads to a decrease in input prices. This would benefit downstream producers, but it would be captured as increases in materials usage, which would not show up as TFP growth. Still, one would expect an important part of spillovers to be improvements in quality rather than price reductions. Such quality improvements on the part of suppliers would most likely imply increases in the measured TFP of downstream firms.

74. Aitken and Harrison (1999).

negative horizontal productivity externalities could materialize is that multinationals could steal away the best workers from domestic firms. The problem here is that there is no formal theory showing how this may take place.[75]

Conclusion

In recent years the profession has seen a surge of empirical studies exploring the existence of productivity externalities from multinationals to other firms in their host countries. This research suggests that firms producing similar goods as multinationals are less likely to benefit from these externalities than firms in upstream industries. In fact, one of the most surprising conclusions to emerge from this literature is that multinationals may generate negative horizontal externalities, although one would expect the existence of positive externalities benefiting upstream industries to somehow have a ripple effect and benefit local firms using the same inputs as multinationals.

In this paper, we have focused on backward linkages as one particular mechanism through which externalities from multinationals may materialize. We have shown that because the current literature uses the local sourcing coefficient as a measure of a firm's linkage potential, it may be incorrect in implying that multinationals are likely to have a negative backward linkage effect. Our alternative indicator of a firm's linkage potential takes into account the fact that multinationals are likely to use more inputs per unit of labor than domestic firms; this measure shows that the opposite is true: multinationals are likely to have a positive linkage effect.

As we have stressed in the paper, however, this result must be interpreted with caution, for several reasons. First, taking into account differences in the skill mix of workers hired by multinational corporations and domestic firms leads to weaker results, from which all we can say is that there is no evidence that the linkage effect of multinationals is negative. Second, very preliminary results using data from the export processing

75. Hanson (2001) shows how competition for skilled workers may negatively affect domestic firms, but he does not show how this would affect their measured productivity.

zone in Costa Rica suggest that the inputs bought locally by multinationals are more tradable than those bought by domestic firms. This would imply that the benefits of the linkages generated by multinationals are weaker than for domestic firms. Finally, data constraints prevent us from exploring the role of other key assumptions of the model (for example, increasing returns and the elasticity of substitution) with regard to the difference between the implied linkage coefficient of multinationals and local firms. Clearly, much more research is required into these and other matters to clarify the impact of multinational corporations on host countries through linkages.

Even if we take our results as convincing at this stage, incentives for multinationals are not necessarily warranted. Perhaps a more sensible policy is to eliminate the barriers that prevent local firms from establishing adequate linkages. This includes improving local firms' access to inputs, technology, and financing and streamlining the procedures associated with selling inputs to firms in export processing zones.

A final comment relates to the observation that a strict interpretation of our model leads to the conclusion that multinationals' positive linkage effects should be reflected in a positive horizontal externality rather than the commonly found externality from multinationals to suppliers. This stands in direct contradiction with the results of the recent empirical literature. We argued that a different interpretation of the model, in which backward linkages lead to quality improvements rather than variety expansion in upstream industries, should make the model consistent with the finding of positive vertical externalities. The implication of a positive horizontal externality remains a puzzle for both interpretations of the model, however, as well as for theories in which vertical externalities occur through knowledge spillovers.

One explanation for this puzzle is that the empirical finding of a negative productivity externality from multinationals to firms in the same industry may result from problems with the measurement of productivity or with the econometrics for dealing with the endogeneity of the presence of multinationals. Another possibility is that some other source of negative productivity externality compensates for any positive ripple effect from the positive vertical externalities associated with multinationals. Exploring these two possibilities further is an important topic for future research.

Appendix A: Sufficiency Condition for Uniqueness in the Equilibrium of the Model

In this appendix, we derive a sufficient condition for the left-hand side of equation 4 to be decreasing in n. First, we expand this term into two components:

$$\frac{\alpha}{n}\sum_j w_j(n)\left[v(j)(\bar{L}_j - L_{jm}) + \gamma(j)\sigma_j(n)^{1/\tilde{\beta}(j)}\tilde{v}(j)L_{jm}\right]$$

$$= \sum_j v(j)(\bar{L}_j - L_{jm})\left(\frac{\alpha}{n}\right)w_j(n) + \sum_j \gamma(j)\sigma_j(n)^{1/\tilde{\beta}(j)}\tilde{v}(j)L_{jm}\left(\frac{\alpha}{n}\right)w_j(n).$$

The first component is decreasing by our assumption that $v(j) < \theta$ for all j. As to the second term, $\sigma_j(n)$ is the ratio of the price of good j to the minimum unit cost of multinationals. Using the fact that domestic firms producing good j make zero profits in equilibrium, we have that

$$\sigma_j(n) = \psi_j\left[\frac{P_x(n)}{P_{xm}(n)}\right]^{1-\beta(j)}\left[\frac{w_j(n)}{P_{xm}(n)}\right]^{\beta(j)-\tilde{\beta}(j)},$$

where ψ is some constant dependent on $\beta(j)$ and $\tilde{\beta}(j)$ and where $P_x(n) = \alpha^{-1}n^{-1/\theta}$ and $P_x(n) = [C + P_x(n)^{-\theta}]^{-1/\theta}$ are the shadow prices of the composite intermediate good, X, for domestic firms and multinationals, respectively. Since $P_x(n)/P_{xm}(n)$ is clearly decreasing in n, all we need is a sufficient condition for the term,

$$\frac{w_j(n)}{n}\left[\frac{w_j(n)}{P_{xm}(n)}\right]^{\beta(j)-\tilde{\beta}(j)},$$

to be decreasing in n. Since, again, $P_x(n)/P_{xm}(n)$ is decreasing in n, it is sufficient to find a condition for the term,

$$\frac{w_j(n)}{n}\left[\frac{w_j(n)}{P_x(n)}\right]^{\beta(j)-\tilde{\beta}(j)},$$

to be decreasing. However, given that $P_x(n) = \alpha^{-1}n^{-1/\theta}$, then

$$\left(p_j^{1/\beta(j)}\alpha^{v(j)}n^{v(j)/\theta-1}\right)\left(p_j^{1/\beta(j)}\alpha^{v(j)+1}n^{[v(j)+1]/\theta}\right)^{\beta(j)-\tilde{\beta}(j)}$$

$$=\xi n^{[v(j)/\theta-1]+[\beta(j)-\tilde{\beta}(j)][v(j)+1]/\theta},$$

where ξ is a constant. Some manipulation shows that

$$\frac{v(j)}{\theta}-1+\frac{[\beta(j)-\tilde{\beta}(j)][v(j)+1]}{\theta}=\frac{1}{\theta}\left[\frac{1-\tilde{\beta}(j)}{\beta(j)}\right]-1.$$

Hence, if

$$\frac{1-\tilde{\beta}(j)}{\beta(j)}<\theta \text{ for all } j,$$

then the left-hand side of equation 4 is decreasing in n. Given that

$$\frac{1-\tilde{\beta}(j)}{\beta(j)}<\frac{1-\tilde{\beta}(j)}{\tilde{\beta}(j)},$$

we finally obtain the sufficient condition in the text.

Appendix B: Quantitative Significance of Regression Results

This appendix outlines the procedure we follow to derive the quantitative significance of the regression results presented in the paper. We need to derive an expression for $\partial \ln w_s/\partial \ln L_{im}$, where s is some sector possibly different from i. Since we are interested only in gauging the order of magnitude of this term, we assume that $\beta(j)=\beta$ (and hence $v(j)=v$) for all j and also that $L_{jm}=\eta L_j$ for all j in the initial situation. Moreover, we ignore the second-order element associated with the impact of changing variety on the intensity coefficient of multinationals. This entails disregarding the derivative of $\sigma_j(n)$ with respect to n. In equation 4, therefore, we can substitute $\lambda(j)$ for

$$\gamma(j)\sigma_j(n)^{1/\tilde{\beta}(j)}\tilde{v}(j)>v(j).$$

Using $w_j(n)=p_j^{1/\beta(j)}\alpha^{v(j)}n^{v(j)/\theta}$ we then arrive at the following equation, which determines equilibrium n:

$$\sum_j \alpha p_j^{1/\beta} \alpha^{v} n^{v/\theta-1}\left[v(\bar{L}_j - L_{jm}) + \lambda(j) L_{jm}\right] = \theta.$$

This implies that

$$n = \left\{ \frac{\theta}{\sum_j p_j^{1/\beta} \alpha^{v+1} n^{v/\theta-1}\left[v(\bar{L}_j - L_{jm}) + \lambda(j) L_{jm}\right]} \right\}^{\frac{1}{v/\theta-1}}.$$

Differentiating and simplifying yields

$$\frac{\partial \ln n}{\partial L_{im}} = \left(\frac{\theta}{\theta - v}\right)\left\{ \frac{\alpha w_i \lambda(i) - \alpha w_i v}{\sum_j \left[\alpha w_j v(\bar{L}_j - L_{jm}) + \alpha w_j \lambda(j) L_{jm}\right]} \right\}.$$

We then use our assumption that $L_{jm} = \eta L_j$ for all j and manipulate the resulting expression to obtain the following:

$$\frac{\partial \ln n}{\partial L_{im}} = \left(\frac{\theta}{\theta - v}\right)\left\{ \frac{\alpha w_i \lambda(i) - \alpha w_i v}{\left(\bar{L}/\eta \bar{L}_i\right)\sum_j \left[\alpha w_j v(1-\eta)(\bar{L}_j/\bar{L}) + \alpha w_j \lambda(j)\eta(\bar{L}_j/\bar{L})\right]} \right\},$$

where $\bar{L} \equiv \Sigma_j \bar{L}_j$. If $\omega \equiv \bar{L}_j / \bar{L}$, then

$$\frac{\partial \ln n}{\partial \ln L_{im}} = \left(\frac{\theta}{\theta - v}\right)\eta \omega_i \left\{ \frac{\alpha w_i \lambda(i) - \alpha w_i v}{\sum_j \alpha w_j v \omega_j + \eta \sum_j \omega_j [\alpha w_j \lambda(j) - \alpha w_j v]} \right\}.$$

If $l \equiv \alpha w_i \lambda(i) - \alpha w_i v$, which in the empirical analysis is implicitly assumed common across sectors, then

$$\frac{\partial \ln n}{\partial \ln L_{im}} = \left(\frac{\theta}{\theta - v}\right)\eta \omega_i \left\{ \frac{l}{\sum_j \alpha w_j v \omega_j + \eta l} \right\}.$$

It is actually more instructive and useful to express this as follows:

$$\frac{\partial \ln n}{\partial \left(L_{im}/L_i\right)} = \left(\frac{\theta}{\theta - v}\right)\omega_i \left\{ \frac{l}{\sum_j \alpha w_j v \omega_j + \eta l} \right\}.$$

To proceed, empirical estimates of the elasticity of substitution among intermediate goods revolve around equation 4 (see Feenstra, 1994),

which implies that $\alpha = 1 - 1/4 = 3/4$. This, in turn, implies that $\theta = \alpha/(1 - \alpha) = 3$.

We obtain η directly from the data. For v, we experimented with two values. We first assumed $\beta = 1/2$, which implies $v = (1 - \beta)/\beta = 1$. Alternatively, for each domestic firm, we have data on the wages paid and also on the linkage coefficient for domestic firms (the total value of inputs bought domestically per unit of labor hired), which corresponds to $\alpha w_i v$. To obtain an average parameter value for v, we estimated the following relation: $\text{LINKCOEF}_{ijt} = A_0 + A_1 \text{AVEWAGE}_{ijt} + \varepsilon_{ift}$. We use the resulting estimate for A_1 to obtain v from $v = A_1/\alpha$. Given $\alpha = 0.75$, the estimated value of v is 2.3 for the case of Venezuela, for example, which implies $\beta = 0.3$.

The parameter η corresponds to the share of workers hired by multinationals, and ϖ_i is the share of workers in sector i. Employment data were taken from each country's annual industry survey.

The expression $l = \alpha w_i \lambda(i) - \alpha w_i v$ represents the difference between the total value of inputs bought domestically per unit of labor hired by multinationals and domestic firms, respectively; it corresponds to the estimated coefficient for the foreign dummy in equation 5.

For the value of inputs bought domestically per unit of labor hired by the domestic firm in sector i, $\alpha w_i v$, we used the corresponding estimated value of the sector dummies plus the effect for the base year (the first year in each of the data sets) in equation 5. The estimated elasticities thus correspond to the first year in each data set. We multiplied the value $\alpha w_i v$ by the share of workers in each sector i, ϖ_i. We finally added the terms across all sectors and added ηl to obtain the term in the denominator, $\sum_j \alpha w_j v \varpi_j + \eta l$.

Finally, the corresponding elasticity for wages is given by

$$\frac{\partial \ln w_s}{\partial (L_{im}/L_i)} = \left(\frac{\theta}{v}\right) \frac{\partial \ln n}{\partial (L_{im}/L_i)}.$$

In the text, we report average results for $v = 1$. In the case of Venezuela, for example, the estimated values for $\partial \ln w_s / \partial (L_{im}/L_i)$ in 1995 for each of the nine manufacturing sectors (according to two-digit ISIC2 classification) correspond to 0.60 percent, 0.27 percent, 0.05 percent, 0.15 percent, 0.47 percent, 0.18 percent, 0.26 percent, 0.43 percent, and 0.03 percent.