POLICY RESEARCH WORKING PAPER 1248

Do Domestic Firms Benefit from Foreign Direct Investment?

Evidence from Panel Data

Brian Aitken
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The World Bank
Policy Research Department
Trade Policy Division
February 1994

POLICY RESEARCH WORKING PAPER 1248

Summary findings

Many developing countries now actively solicit foreign investment, offering foreign firms subsidies, tax holidays, and exemptions from import duties. One justification for subsidizing these firms is the so-called spillover of technology from foreign to domestic firms.

Using panel data — following more than 4,000 Venezuelan firms from 1975 through 1989 — Aitken and Harrison explore two aspects of the effect of foreign direct investment.

First, they examine the relative performance of joint ventures and domestic firms. They find that increases in foreign equity participation are strongly correlated with increases in plant productivity.

Second, they measure the impact of joint ventures and foreign subsidiaries on plants with no foreign investment. Facing fewer data limitations than in previous studies, they find that foreign investment negatively affects the productivity of domestically owned plants.

These results suggest that whatever technology gains occur through foreign investment are captured entirely by joint ventures.

This paper — a product of the Trade Policy Division, Policy Research Department — is part of a larger effort in the departme to examine the determinants and consequences of foreign investment at the micro level. Copies of the paper are available free fro the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Dawn Ballantyne, room N10-023, extension 37947 (42 pages). February 1994.

Do Domestic Firms Benefit from Foreign Direct Investment?

Evidence from Panel Data

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*The authors would like to thank Susan Collins, Rudi Dornbusch, Stan Fischer, David Genesove, Rob Porter, Ed Wolff, Mayra Zermeno, and seminar participants at Boston University, Brandeis, Fletcher, MIT, Princeton, the Winter 1992 AEA Meetings, the NBER International and Productivity lunches, and the NBER Summer Institute for useful comments and discussion.

1 Background

In the 1980s, the disappearance of non-equity sources of foreign capital created a resurgence of interest in direct foreign investment (DFI). The need for alternative sources of capital, combined with an increasing skepticism about import substituting trade strategies, led many developing countries to liberalize restrictions on incoming foreign investment. Some countries actually tilted the balance towards foreign firms by offering special incentives: in Mexico, the maquiladora firms pay no income taxes; in much of the Caribbean, foreign firms receive income tax holidays, import duty exemptions, and subsidies for infrastructure. The expectation that foreign investment serves as a catalyst for domestic production has led countries such as Taiwan and Bulgaria to offer special treatment for foreign firms in high technology sectors.

Can these subsidies be justified? Apart from the employment and capital inflows which accompany foreign investment, multinational activity may generate knowledge transfers or new technology to domestic firms.[1] If foreign firms introduce new products or processes to the domestic market, domestic firms may benefit from the accelerated diffusion of new technology (Teece, 1977; Davies, 1977). In some cases, domestic firms may increase productivity simply by observing nearby foreign firms. In other cases, diffusion may occur from labor turnover as domestic employees move from foreign to domestic firms. Several studies have shown that foreign firms initiate more on-the-job training programs than their domestic counterparts (Edfelt, 1975; Gonclaves, 1986; Watson, 1972). If these benefits from foreign investment are not completely internalized by the incoming firm, some type of subsidy could be justified.

Case studies present mixed evidence on the role of foreign investment in generating technology transfer to domestic firms. In Mauritius and Bangladesh, studies suggest that the entry of several foreign

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[1]See Caves (1982), and Helleiner (1989) for surveys of technology transfer and foreign direct investment.

firms led to the creation of a booming, domestically-owned export industry for textiles (Rhee and Belot (1990)). Mansfield and Romeo (1980), however, found in a survey of 15 multinationals that only a small share had accelerated access to process technology for local competitors. A 1970s study commissioned by the OECD of 65 subsidiaries in twelve developing countries found almost no evidence of technology transferred to local competitors (see Germidis (1977)). The lack of spillovers to domestic firms was attributed to a number of factors, including limited hiring of domestic employees in higher level positions, very little labor mobility between domestic firms and foreign subsidiaries, limited subcontracting to local firms, no research and development by the subsidiaries, and few incentives by multinationals to diffuse their knowledge to local competitors.

Few researchers have attempted to go beyond qualitative case study evidence. In a pioneering paper, Caves (1974) tested for the impact of foreign presence on value-added per worker in Australian domestically-owned manufacturing sectors. Caves found that the positive disparity between foreign and domestic value-added per worker disappears as foreign firms employed an increasing share of the labor in the sector, which is consistent with the spillover hypothesis. Globerman (1979) replicated Caves (1974) using sectoral, cross-section data for Canadian manufacturing industries in 1972. The results are consistent with a weak spillover effect.

Yet spillovers from foreign investment are likely to be much larger in industrializing countries, where the gap between domestic and foreign productivity may be significant. Most of the empirical work on technology spillovers from foreign investment in developing countries has focused on Mexico. Blomstrom and Persson (1983), Blomstrom (1986), and Blomstrom and Wolff (1989) generally find that sectors with higher foreign ownership exhibited higher levels of productivity, faster productivity growth and faster convergence of productivity levels to US norms.[2]

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[2]Blomstrom (1989) provides a synthesis of his previous work on the impact of foreign investment in Mexico.

None of the previous studies use firm-level data, restricting the authors' ability to examine domestic and foreign firm behavior separately. In this paper, we use annual census data on Venezuelan firms, averaging over 4,000 firms annually, to examine two related issues. First, to what extent do joint ventures or wholly owned foreign subsidiaries exhibit higher levels of productivity than their domestic counterparts? Second, can we identify any technology "spillovers" from these foreign entrants to domestically owned firms?

All previous attempts to measure spillover effects from foreign investment face a critical identification problem: if foreign investment gravitates towards more productive industries, then the positive impact of foreign presence on domestic firm productivity will be over-estimated. As a result, one could find a positive spillover from foreign investment where no spillover occurs. This paper differs from previous studies by using the differences in foreign investment across regions and over time to identify technology spillovers within each industry. Unlike previous studies, we observe the behavior of each plant over time, which allows us to control for fixed differences in productivity levels across industries.

We find a strong relationship between increased foreign equity participation and plant performance, suggesting that individual plants do benefit from foreign investment. We also find, however, that productivity across domestic plants falls when foreign investment increases. Section 2 presents a theoretical framework which takes into account the possible benefits as well as the costs of foreign investment. Section 3 describes the policy environment and compares the behavior of domestic and foreign plants. Section 4 presents the results from testing for technology spillovers from foreign plants, while Section 5 concludes.

2 Foreign Investment, Competition and Technology Spillovers: The Framework

The so-called "industrial organization" approach to DFI in manufacturing suggests that multinationals can compete locally with more informed domestic firms because multinationals possess a nontangible productive asset, such as technological knowhow, marketing and managing skills, export contacts, coordinated relationships with suppliers and customers, and reputation.[3] Since the assets are almost always gained through experience, they cannot be easily licensed to host country firms, but can be costlessly transferred to subsidiaries who locate in host countries either to circumvent trade barriers or produce with cheap local labor (Teece, 1977).

Although the intangible firm-specific asset may not be licensed, domestic industry might nonetheless benefit from the presence of foreign firms. As workers employed by foreign firms or participating in joint ventures gain experience, for example, they may accumulate knowledge which is valued outside the firm; foreign firms exert an externality by increasing the domestic stock of human capital. As experienced workers leave the foreign firms, this human capital becomes available to domestic firms, raising their measured productivity. Likewise, some firm-specific knowledge of foreign firms might "spill over" to domestic industry as domestic firms are exposed to new products, production and marketing techniques, or receive technical support from upstream or downstream foreign firms. In addition, foreign firms may act as a stable source of demand for inputs in an industry, which can benefit upstream domestic firms by allowing them to train and maintain relationships with experienced employees. In all these cases, foreign presence would raise the productivity of domestically-owned firms.

But foreign presence can also *reduce* total factor productivity of domestically-owned firms. In an environment in which imperfectly competitive domestic firms face fixed costs of production, foreign

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[3]See Hymer (1960) Caves (1971), and more recently Horstman and Markusen (1989), Helpman (1984), and Krugman (1983). For Surveys, see Rugman (1986), Grieco (1986).

firms producing for the local market can steal demand from domestic firms, causing them to cut production. The productivity of domestic firms would fall as they spread their fixed costs over a smaller market, forcing them back up their average costs curves. If the productivity decline from this demand effect is large enough, as shown in Figure 1, net domestic productivity can decline even if some of the firm-specific asset spills over.

We formalize these two effects of foreign activity on domestic plants in a simple theoretical framework. We begin with a Cobb-Douglas production function characterized by constant returns to scale with respect to the variable input. Each firm employs a single input (x), and faces an identical fixed cost F expressed in units of output. For each firm i in sector j producing output q this can be captured through the following specification:

$$q_i = Ax_i - F \quad for \quad Ax_i > F \tag{1}$$

$$q_i = 0 \; for \; Ax_i \leq F$$

From the production function, domestic firm i's cost function will be

$$C_i = wx_i = \frac{w}{A}(q_i + F) \tag{2}$$

where w is the wage paid to input x. Defining marginal cost $m = \frac{w}{A}$, total costs can be expressed as

$$C_i = m\ (q_i + F) \tag{3}$$

The price firms receive for the good (P) varies with the sum of output produced by

domestically-owned firms Q and output by foreign-owned firms Q^*

$$P = \beta - Q - Q^* \tag{4}$$

Foreign-owned output Q^* is assumed to be exogenous. This assumption is based on the belief that foreign entry and expansion in developing countries is typically determined by outside factors, such as political risk, domestic resource endowments, technological superiority, lower labor costs, transport costs, and infrastructure.

If domestic firms maximize profits in a Cournot competitive manner, we can solve (3) for q_i and combine with (4) to yield the standard Cournot reaction function

$$q_i = \frac{\beta - Q^* - m}{n+1} \tag{5}$$

where n is the number of domestic firms in the industry. An increases in foreign investment is represented as an increase in Q^*, and causes a fall in output by domestically-owned firms.[4]

To model the technology transfer from foreign-owned firms to domestic firms, we assume domestic productivity is given by

$$A_i = \eta_i e^{\alpha Q^*} \tag{6}$$

If α is positive, domestic firms receive positive spillovers from foreign investment. We now combine equation (6) with the reaction function in equation (5) to derive our estimating equation giving the domestic firm's output as a function of inputs and foreign investment. The production function for domestic firms in a given industry can be rewritten from (1) as

[4]A more extensive version of the theoretical model, which allows for endogenous entry and exit by domestic firms, is derived in the appendix.

$$q_i = A_i x_i (1 - \frac{F}{A_i x_i}) \tag{7}$$

Rearranging, this is equal to

$$q_i = A_i x_i (1 + \frac{F}{q_i})^{-1} \tag{8}$$

Taking logs and substituting firm output q_i (Q^*) from (7) together with (6), equation (8) becomes

$$\log q_i = \log \eta_i + \alpha Q^* + \log x_i - \frac{F}{q(Q^*)} \tag{9}$$

To determine the nature of the last term in equation (9), we replace $q(Q^*)$ with the relationship in (5) and linearize $\frac{-F}{q(Q^*)}$ at $Q^* = 0$ to get

$$-\frac{F}{q(Q^*)} = -F\frac{(n+1)}{\beta - m} + \gamma Q^* = C + \gamma Q^* \tag{10A}$$

where

$$\gamma = \frac{F}{q^2(0)} \frac{dq}{dQ^*} = -F\frac{(n+1)}{(\beta - m)^2} \tag{10B}$$

$$C=-F\frac{(n+1)}{\beta \cdot m}$$

The coefficient γ will be negative when increases in Q^* cause domestic firm output to contract since, from (5), $\frac{dq}{dQ^*}<0$.

Substituting equation 10A into equation 9 gives domestic firm output as a function of inputs and foreign investment

$$\log q_i = \log \eta_i + \alpha Q^* + \log x_i + C + \gamma Q^* \qquad (11)$$

$$= C + \log x_i + (\alpha+\gamma)Q^* + \log \eta_i$$

Foreign presence affects domestic total factor productivity through two distinct channels. First, foreign presence can raise domestic plant productivity through technology spillovers, captured in the model by the coefficient alpha. The term γ captures the negative impact of foreign presence on domestic productivity when increases in foreign activity lower the level of output optimally chosen by each domestic firm. The value of γ will be negative if an increase in foreign presence reduces domestic total factor productivity by causing domestic output to contract.[5] Since these two effects move in opposite

[5] We have also considered the possibility that foreign investment could affect domestic returns to scale when there are no fixed costs. If there are fixed costs with constant returns to scale in factor inputs, then the negative scale effects of Q on TFP is correctly estimated by a log linear specification; variations in inputs will properly estimate input coefficients, and the Q* variable will capture the fixed cost component. To the extent, however, that there are increasing returns to scale on inputs and no fixed costs (ie a Cobb-

directions, estimation of quation (11) is required to determine the net effect of foreign presence on domestic productivity.

3. Foreign and Domestic Firms in Venezuela

Foreign ownership in Venezuela is restricted to minority participation only in some areas of manufacturing, such as basic industries (iron, steel, and aluminum) and is only excluded from investing in manufacturing enterprises in the petroleum sector. Although foreign investment in Venezuela has generally averaged less than 10 percent of total assets in Venezuela's manufacturing sector (Table 1), reforms initiated in 1986 and extended in 1990 are likely to increase its role.[6]

The dataset employed in this paper is taken from the Venezuelan industrial survey (*Enquesta*

Douglas specification with the sum of the coefficients greater than unity), then the negative impact of an increase in Q* will be underestimated by a log linear specification: variations in productivity associated with changes in scale will be reflected by variations in inputs. In Venezuela, the degree of bias is likely to be small since the estimates reported in the paper suggest constant returns to scale in factor inputs.

[6]Venezuelan firms are classified by degree of foreign ownership into three types: national, with less than 20 percent foreign ownership; mixed with 20 to 49.9 percent foreign ownership; and foreign firms, with majority foreign control. Until 1989, the Superintendencia de Inversiones Extranjeras (SIEX) exercised substantial discretion in regulating the inflow of foreign investment. Profit remittances were limited to 20 percent (plus LABOR) of the investment (based on book value). Since purchasing equity in existing firms was prohibited, foreign investment could only be in the form of direct investment registered with SIEX. Payments by a firm for its foreign partner's technology were prohibited, and contracts that called for royalty or patent payments needed SIEX approval.

During the period from 1975 to 1989, foreign firms were discriminated against in a number of different ways. First, they faced higher tax rates on corporate income--50 percent versus 35 percent for domestic firms. They were also restricted from imposing confidentiality and exclusive use of trade secrets in joint ventures. Finally, foreign firms were obliged to buy bolivares at the official exchange rate rather than the free market rate.

In 1989, the restriction on profit repatriation was eliminated. Bureaucratic discretion was eliminated and SIEX was authorized to reject foreign investment applications only if they did not comply with the sectoral restrictions discussed above. When exchange rates were unified following reforms, the discrepancy between official and free market exchange rates were eliminated. The restrictions on use of confidentiality and trade secret requirements are currently being negotiated as part of agreements on property rights, and the differential tax rates between foreign and domestic firms is addressed in pending tax legislation.

Industrial), which is conducted annually by the National Statistical Bureau (Oficina Central de Estadistica e Informatica, OCEI). The years covered include 1976 through 1989, with the exception of 1980 (the industrial survey is not taken in census years). The Enquesta Industrial covers all plants in the formal sector with more than 50 workers, as well as a large sample of smaller plants. For the smaller plants, OCEI calculates the sample weights, permitting aggregation of output and other variables to estimate the total value for the entire manufacturing sector. The number of plants ranges from a low of 3,955 plants in 1982 to a high of 6,044 plants in 1978. The data contain information on foreign ownership, assets, employment, detailed cost information, location, and product destination. Respondents are guaranteed anonymity in responding to the survey. Since the industrial census gives the percentage of subscribed capital owned by domestic investors, it is possible to derive the mean share of foreign investment by year, location, and sector. Table 1 shows the mean weighted share of the stock of FDI in manufacturing for selected years, using number of employees as the weight.[7] Table 2 shows that the majority of the stock of foreign investment over 1975-89 has been in autos (machinery, transport and metal products), basic metals (iron, steel, and aluminum), chemicals, and food and beverages.

Table 3 compares the performance of foreign and domestic firms in terms of their labor productivity, export and import behavior, and wages. On average, foreign owned firms exhibited higher labor productivity, a higher propensity to import as well as export, and paid higher wages than their domestic counterparts. The net contribution of foreign firms to foreign exchange earnings, defined as export sales less expenditures on imported inputs, is also higher than for domestic firms. The comparative results are robust to corrections for size, capital intensity, and skill composition of foreign versus domestic firms.

The magnitude of technology transfer from foreign to domestic firms is likely to depend on the

[7]Since foreign firms tend to be more capital intensive than domestic firms, the share of foreign firms is significantly higher if weighted by physical capital.

magnitude of the productivity advantages exhibited by joint ventures. Although labor productivity provides one measure of technology advantage, it is an imperfect measure since it varies with capital intensity as well as with the level of other factor inputs. Therefore, we compared the total factor productivity of the two sets of plants.

To compare the levels of total factor productivity between domestic plants and plants with foreign equity participation, output is regressed on the type of ownership (foreign/domestic) of the plant, as well as the plant's capital, materials, skilled labor, unskilled labor, and industry (at the four digit level). Output is calculated as the value of sales less the change in inventories, deflated by a four-digit level production price deflator. Skilled and unskilled labor are measured as the number of skilled and unskilled employees. Although an ideal measure of labor input would be the number of hours worked, this information is only available for selected years. Material costs are adjusted for changes in inventories, then deflated by a production price deflator. Capital stock is the stock of capital reported by each firm at the beginning of the year, deflated by the GDP deflator.

The results are presented in Table 4. In the first column of Table 4, foreign investment is measured as a zero-one dummy variable. A firm is defined as "foreign" if at least some of its equity is foreign-owned. After controlling for differences in inputs, the results show that firms with some foreign equity (either joint ventures of foreign subsidiaries) had an 8.5 percent increase in output over domestic firms in the same industry. Since we already control for input differences, this 8.5 % is a pure productivity gain. In the second column of Table 4, foreign ownership is modelled as a continuous variable which varies from 0 to 100 percent of the plant's total equity. These results show that a 10 percent increase in foreign ownership raises a firm's productivity by 1.36 percent. A 100 percent increase in foreign ownership would raise productivity by 13.6 percent, which is approximately consistent with the 8.5 % increase we estimate using the dummy variable approach in the first column of Table 4.

If foreign owners purchase shares in only the most productive domestic firms, the foreign

ownership variable could simply act as a proxy for an unobserved productivity advantage unrelated to ownership. By transforming the estimating equation into differences, we eliminate this unobserved fixed effect, isolating the productivity impact of a change in ownership on a given plant. Table 5 presents the results of regressing changes in the level of total factor productivity on changes in ownership, controlling for changes in inputs. In column 1 foreign investment is modeled as a dummy variable, while in column 2 it is modeled as continuous variable. The fourth row in column 1 indicates that joint ventures exhibited a level of total factor productivity which was 7.0 percent higher after 5 years than domestic firms which remained domestically-owned. Since changes in capital are included, this increase in productivity is independent of the increase in productivity from new investment which might accompany increases in foreign ownership. The second column in Table 5 suggests that firms experiencing an increase in foreign ownership of ten percentage points were 1.1 percent more productive after 5 years than firms which did not change ownership.

One possible explanation for the productivity advantage accompanying foreign ownership is that foreign firms are able to pick out future high performers and invest their capital in those plants. Yet it seems doubtful that foreign investors would possess better information than domestic investors, or that firms expecting higher future productivity performance would be biased towards foreign sources of capital. The observed productivity advantage of firms with foreign equity participation is consistent with the hypothesis that joint ventures possess a technological superiority over their domestic counterparts. The next section examines whether any of this technological advantage "spills over" to domestic firms.

4. Testing for Spillovers: Empirical Results

In the theoretical framework outlined above, we derived output q, denoted as $Y_{it}(j)$ for plant i in sector j at time t, as a function of input x and foreign presence. Input x consists of plant i's unskilled

labor ($UNSKL_{it}$), skilled labor (SKL_{it}), materials (M_{it}) and capital (K_{it}). We measure foreign presence Q* as the share of foreign investment in a particular sector j.[8]

We assume the error term η_i in (11) is composed of a random component which varies across plants ϵ_{it} and a time-varying component D_t. To allow for the existence of industry fixed effects, we also include in the error term an industry component $f(j)$ which is fixed over time. This yields the following estimating equation:

$$\log Y_{it}(j) = C + \alpha_1 \log SKL_{it} + \alpha_2 \log UNSKL_{it} + \alpha_3 \log K_{it} + \alpha_4 \log M_{it} + \alpha_5 FS_t(j) + \alpha_6 D_t + f(j) + \epsilon_{it} \quad (12)$$

We estimate (12) for a panel of domestic plants for the years 1976 through 1989. Plants are defined as domestically owned if the plant is 100 percent domestically owned over the entire sample period. The foreign share $FS(j)_t$ is calculated annually as the share of the labor force employed by foreign owned firms in four-digit sector j.[9] As in (11), the coefficient on foreign share (α_5) is interpreted as the net impact of foreign presence on domestic plants. This effect, as outlined in Section 2, can be either positive (due to technology spillovers) or negative, as foreign competition drives domestic firms back up their average cost curves. To allow for imperfect competition, we do not impose the restriction that the coefficients on the inputs are equal to their factor shares, nor do we impose constant returns to scale.

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[8] The share of foreign investment in the industry is defined more precisely below. Specifying foreign investment as a share rather than an absolute quantity allows us to normalize the magnitude of foreign presence for differences in the volume of production across sectors. Later, we show that using the absolute quantity of foreign investment does not affect the robustness of our results.

[9] The variable FS(j) can be measured using the share of output, capital, or labor employed by foreign firms in a given sector; since all three variables gave similar results, we only present the regressions for which FS(j) is defined to be the share of workers in sector j employed by foreign-owned firms, weighted by the share of capital in those firms which are foreign-owned.

4.1 The Impact of Foreign Investment: Reproducing Earlier Results

Previous tests for spillovers were performed by Globerman (1978) for Canadian data and Blomstrom and Persson (1983) for Mexican data. These researchers used cross-section industry data to estimate some variation of (12) at the sectoral level, where the coefficient on foreign share was interpreted as a measure of spillovers from foreign presence to domestic firms. Past studies generally estimated a positive value for this coefficient, although it was not always statistically significant. Since previous researchers relied primarily on cross-section estimation, they were forced to ignore any sector-specific fixed effect, which is captured by f(j) in (12). If foreign investors tend to gravitate towards industries which have a higher level of total factor productivity, then the variable *FS(j)* will be positively correlated with the error term, and the OLS estimate of the impact of foreign presence will be biased upwards. Indeed, evidence from Venezuelan manufacturing firms suggests this is the case.

To illustrate, the first row of table 6 estimates (12) without controlling for the fixed effect f(j). The coefficients on the inputs are all positive and statistically significant, as expected. The coefficient on unskilled labor is three times as high as for skilled labor, indicating the higher share of unskilled labor in total labor payments in Venezuela. The coefficient on *FS(j)*, is positive and statistically significant, and the point estimate is in the same range as the results obtained in earlier work. The point estimate, 0.061, suggests that if the share of labor employed by foreign-owned firms rose from 0 to 10 percent of the manufacturing sector, output would increase by 0.6 percent. Since the estimation controls for increases in inputs, this 0.6 increase is a pure (total factor) productivity gain.

One way to correct for the bias caused by an industry fixed effect is to introduce sector dummy variables to control for f(j) in (12). This would allow for fixed productivity differences across industries caused by unobserved factors, exploiting the time series and within-industry variation in productivity to isolate the impact of foreign investment. The second row in Table 6 reports the estimation results including industry dummies at the two-digit level. Including industry dummies causes the coefficient on

foreign investment to switch from positive to negative and statistically insignificant. Introducing four-digit industry dummy variables changes the estimate even more dramatically. Controlling for productivity differences at the four-digit level, industries with greater foreign presence are significantly less productive than those with no foreign presence. The negative impact is large and statistically significant. The results in the third row of Table 6 imply that an increase in the share of foreign investment from 0 to 10 percent is accompanied by a decline in total factor productivity of 2.2 percent for domestic plants.[10]

This evidence suggests that previous findings of a positive impact of foreign investment of domestic productivity are not robust to the inclusion of industry, but reflect the tendency of foreign investment to take place in more productive industries. If we interpret the coefficient in the context of the theoretical equation (11), the negative coefficient we observe in table 6 is consistent with a large detrimental impact of foreign presence on the scale of domestically-owned production.

4.2 Separating Technology from Demand Effects

A negative coefficient on foreign share does not preclude the possibility that some technology transfer from joint ventures to domestic firms does occur. For example, foreign investment could be associated with declining productivity on aggregate and at the same time convey substantial benefits to those few plants located nearby. In this section we attempt to disentangle the possible technology spillovers from the demand effects using the dispersion of foreign investment across regions.

In many theories of technology transfer, where technology is broadly defined to include anything which allows the firm to produce more efficiently, the transfer of technology takes place at a local level.

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[10] The results are almost equivalent when we estimate (12) using "within" estimates, which are computed by subtracting from each variable its sector mean and running OLS on the transformed variables. The reason why the two sets of estimates are not exactly equivalent is because we include time-dummy variables, and the within estimates capture the interaction between the time and industry effects.

Whether trained workers leave the joint venture to work at nearby domestic firms, or whether the joint venture demonstrates a product, process or market previously unknown to domestic owners, the benefits are likely to be received by neighboring domestic firms first before they diffuse to other, more distant domestic firms. To the extent that technology is transferred locally, estimation of (12) should include a variable which measures foreign presence within each region. It is also likely that the negative effect of foreign investment is more likely to occur at the aggregate level, as domestic firms compete with joint ventures in national markets. To test for the possibility that technology is transferred at the local level, we broaden the analysis to include both regional and sectoral foreign share variables in the same regression. We modify equation (6) to assume that a domestic firm's technology is a function of foreign presence in its region s, as well as regional fixed factors a_s:

$$A_i = \eta_i a_s e^{\alpha Q_s^*} \tag{13}$$

Equation (11) now becomes

$$\log q_i = C + \log x_i + \alpha Q_s^* + \gamma Q^* + \log a_s + \log \eta_i \tag{14}$$

The coefficient α determines the impact of regional foreign presence, while the coefficient γ captures the effect of national foreign investment. To estimate α, we include in the regression FS(j,s), defined as the share of industry j's workers in region s employed by foreign firms located in the industry and region. The "unadjusted" estimation is given by

$$\begin{aligned} \log Y_{it} = {} & Constant + \alpha_1 \log SKL_{it} + \alpha_2 \log UNSKL_{it} + \alpha_3 \log M_{it} \\ & + \alpha_4 \log K_{it} + \alpha_5 FS(j)_t + \alpha_6 FS(s,j)_t + \alpha_7 D_t + f(j) + a(s) + \varepsilon_{it} \end{aligned} \tag{15}$$

where $f(j)$ is captured by a dummy variable indicating the firm's four-digit industry, and is included to control for any industry-level factors.

If the location-specific productivity term $a(s)_t$ is positively correlated with foreign share, $FS(s,j)_t$ over-estimates the impact of location-specific foreign investment on productivity. For example, foreign firms may be more attracted to regions which benefit from agglomeration economies or better infrastructure; we could observe a correlation between domestic productivity and foreign share in a location even in the absence of spillovers. Variations in productivity due to agglomeration economies or other region-specific effects may be captured by levels in the real skilled wage. For the United States, Rauch (1991) also provides empirical evidence that variations in human capital accumulation across cities is reflected in higher wages for individuals. Another factor which can be used to capture exogenous differences in productivity across regions in Venezuela is the price of energy. The government encouraged relocation to some regions by implementing uneven energy subsidies across regions. Differences in electricity prices could have affected both productivity as well as foreign relocation across regions.

Including the log of the skilled wage for *all* industries in region s (log Wage(s)$_t$) and the log of electricity prices (log Elecp(s)$_t$) can be used to control for these location-specific productivity effects. The resulting "adjusted" estimation equation is given by

$$\begin{aligned} \log Y_{it} = {} & Constant + \alpha_1 \log SKL_{it} + \alpha_2 \log UNSKL_{it} + \alpha_3 \log M_{it} + \alpha_4 \log K_{it} \\ & + \alpha_5 FS(j)_t + \alpha_6 FS(s,j)_t + \alpha_7 D_t + \alpha_8 \log Wage(s)_t + \alpha_9 \log Elecp(s)_t + f(j) + \varepsilon_{it} \end{aligned} \tag{16}$$

Since foreign investment in any one four-digit industry is unlikely to significantly affect the skilled wage for all industries in the region, the skilled wage will be independent of $FS(s,j)_t$.

Foreign share, electricity prices, and the skilled wage are calculated at the district level. Venezuela

is divided into 23 regions, which in turn are subdivided into districts. Regions may have several or as many as 20 districts. In all, the total number of region-district locations adds up to 220 separate locations. In a country one-third larger than the state of Texas, this indicates that the average district size is 40 miles wide by 40 miles long (1600 square miles). Appendix Table A.1 shows the average share of labor employed at foreign owned firms and the standard deviation of this measure across region-districts. The size of the standard deviations in Table A.1 indicates that foreign presence is not uniformly distributed across industries and across regions.[11]

Estimates of the impact of regional foreign share on domestic firm productivity are given in Table 7. The coefficients on sectoral foreign investment are negative and significant as before. For both the adjusted and unadjusted estimates, the coefficient on regional foreign investment is statistically insignificant, and when the real skilled wage and electricity prices are included, the coefficient on foreign investment falls to zero. We find a consistently positive and large association between the real skilled wage and individual firm productivity. The association with electricity prices (although much smaller) is also statistically significant and negative as expected. This suggests that foreign investment is likely to locate in areas with highly productive skilled workers or lower energy prices, biasing the unadjusted estimates upwards. We also experimented with other measures which might reflect location-specific productivity differences, such as the number of firms in each location, rent prices, and the industry-specific skilled wage in the location, but the results were unchanged.

The within estimates are reported in the last row of Table 7. These estimates were computed by subtracting from each variable its region-sector mean over time. This formulation allows us to control for any unobserved differences across regions and sectors. It would be equivalent to including both sector and region dummies in the estimation, as well as sector-region interactive terms. The within estimates

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[11]Although the table shows industry values at the two-digit level, the regressions were estimated with all industry variables calculated at the four-digit level.

support the results in the first and second rows, indicating no statistically significant impact of region-specific foreign investment on domestic firm productivity growth.

Two conclusions can be drawn from the results presented in the previous two sections. The first is that if technology transfer indeed takes place, it is overwhelmed by the negative productivity effects of joint ventures on domestically-owned firms. The second is to the extent that domestic and foreign firms compete on national (and not local) markets, there is no evidence to support the hypothesis that technology is transferred locally from joint ventures to domestically-owned firms. It is interesting to note that the empirical results confirm case study evidence for Venezuela claiming very little cases of technology transfer from multinationals to domestically-owned firms (Matos(1977)). In the next section, we explore the robustness of our results.

4.3 Alternative Specifications

One possible explanation for the insignificant coefficient on regional foreign presence is the fact that new technology may only slowly filter through to domestic firms. Consequently, the positive impact of foreign investment on observed productivity may not appear for several years. It is also likely that the negative effects of foreign investment would dissipate over time as the adverse impact of competition disappeared.

One simple test for this is to examine the impact of foreign investment on domestic firm productivity growth over a longer time horizon. Table 8 presents a "long difference" version of Table 7, using one-year, two-year, three-year and four-year differences of all the dependent and independent variables instead of deviations from sector-region means. Our previous results are generally maintained in this dynamic specification, although some interesting differences emerge. We continue to see a strong negative impact of sectoral foreign share and a generally insignificant (but positive) impact of regional

foreign share on productivity. The trends in the point estimates, however, are quite interesting. The negative impact of sectoral foreign presence diminishes slightly over time. At the same time, the point estimates on regional foreign presence become more positive and increase in magnitude over time. The coefficient on the three year lag for foreign share is positive and statistically significant, but the estimate is smaller and insignificant for the fourth lag. These results on local foreign presence provide some weak evidence of technology spillovers.

Another possibility is that foreign investment is specified incorrectly. The specification used earlier in the paper is a weighted average of foreign investment in each sector, where foreign investment is defined as the share of the plant's assets which are foreign owned and the weights are given by the number of employees in the plant. Table 9 reports the coefficient on foreign share using three alternative definitions. First, foreign share was redefined as the total number of employees in plants where at least 5 percent of assets are foreign owned, divided by the total number of employees in all plants in that sector. This is described in Table 9 as "unweighted". Second, foreign share was redefined as a zero-one variable, equal to one if there is any foreign investment at all in a region. This specification could only be applied to the regional estimates, since there is some foreign investment in all sectors in Venezuela. The rationale for this specification is that the impact of foreign investment may be nonlinear. One foreign plant in a sector could potentially have as much impact on technology transfer as several foreign firms. Finally, instead of defining foreign presence as a share, we redefined it as the number of employees employed by foreign firms. We also included total employment in the regression to control for aggregate employment changes. This specification is the closest to the theoretical model developed earlier. This specification provides a test of whether the negative coefficient on foreign share could be due to the possibility that foreign firms do not adjust quickly to economic downturns, while domestic firms react immediately. This would lead us to observe a rising foreign share during periods of economic decline.

The results presented in Table 9 suggest that the impact of sectoral foreign investment on

domestic plant productivity is robust to alternative specifications for foreign presence. The coefficient on "unweighted" foreign presence, at both the sector and regional level is statistically significant and negative. If we define foreign investment as a zero-one dummy variable in each region, the results are mixed. The levels estimates give a positive and statistically significant coefficient on regional DFI, but the coefficient in the within estimates is significantly negative. The within estimates are more likely to be unbiased, since the levels estimation captures the fact that foreign investment is attracted to regions with higher productive capacity. Finally, we present separate estimates for the numerator (number of employees in plants with foreign equity) and the denominator (total sectoral employment) used to calculate the foreign share variable. The results confirm that defining foreign investment as a share variable does not lead to spurious results. The coefficient on foreign investment continues to be statistically significant and negative at both the sector and region level. Total employment within a sector has a positive but insignificant impact on domestic plant productivity.

These results point to two robust, but quite different conclusions about the impact of foreign investment on productivity in Venezuela's manufacturing sector. On the one hand, plants with rising foreign participation exhibit significant and positive productivity gains over time. On the other hand, plants which do not receive foreign investment appear to suffer as a result of increases in joint venture activity. One natural question to ask is what is the net impact of these two offsetting forces? Table 10 combines all plants to estimate the impact of foreign investment using aggregate data. Although the results are not directly comparable to the plant-level estimation, they do provide evidence regarding the aggregate effects of foreign investment on productivity. The results show that the positive effects far outweigh the negative impact, in part because the estimates at the aggregate level give much greater weight to larger plants. The within estimates suggest that an increase in foreign investment from 10 to

20 percent of the manufacturing sector would increase aggregate productivity by 5.1 percent.[12]

5. Conclusion

Many developing countries now actively solicit foreign investment, offering income tax holidays, import duty exemptions, and subsidies to foreign firms. One justification for subsidizing these firms is the so-called "spillover" of technology from foreign to domestic firms. Despite the significant interest in the possibility of such spillovers, there have been no empirical tests using micro data. Using a panel of more than 4000 Venezuelan plants between 1975 and 1989, this paper tests for the existence of technology transfer via foreign firms.

First, we examine the relative performance of joint ventures and domestic firms. We find that plants with some foreign investment consistently outperform domestic plants. We also find that increases in foreign equity participation are strongly correlated with increases in plant productivity. This suggests that the host country does benefit from foreign equity participation through the improved performance of joint ventures.

Second, we measure the impact of joint venture activity and wholly owned foreign subsidiaries on the productivity of plants who receive no foreign investment. Facing fewer data limitations than any of the previous studies, we find that foreign investment negatively affects productivity of domestic firms. These negative effects are large and robust to alternative specifications of the model. Although previous studies generally found positive effects, we show that these results can be explained by the tendency for multinationals to locate in the more productive sectors.

We conclude that there do exist benefits from foreign investment, but that such benefits are internalized by joint ventures. In other words, foreign investment provides direct benefits to those firms

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[12] The within estimates differ from the dummy variable estimates presented in the second row because the dummy variable specification does not include time-industry interactive terms.

receiving the investment, but there are no "spillovers" to other plants. This suggests that industrializing countries such as Venezuela are correct in emphasizing the benefits from foreign investment to the recipients. However, we also conclude that less emphasis should be placed on any externalities or "spillovers" to other local firms.

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Table 1: The Share of Foreign Direct Investment in Manufacturing
(percent weighted by number of employees)

Sector	1976	1981	1989
Food Products	8	5	6
Textiles & Clothing	6	6	3
Wood Products	0	0	2
Paper & Publishing	10	11	9
Chemicals, Petrol	6	8	7
Pottery, Glass	6	8	7
Basic Metals	7	6	12
Machinery	9	9	13
Professional Equipment	8	10	4

Table 2: Distribution of Foreign Ownership Across Sectors
(percent weighted by number of employees)

Sector	1976	1981	1989
Food Products	24	15	19
Textiles & Clothing	16	14	6
Wood Products	0	0	1
Paper & Publishing	9	12	8
Chemicals, Petrol	11	17	14
Pottery, Glass	6	7	6
Basic Metals	6	7	15
Machinery	26	28	31
Professional Equipment	1	1	
Total	100	100	100

Table 3: Comparison of productivity, export performance, and wages between domestic and foreign-owned enterprises in Manufacturing[1/]

	Output per worker	Real wages	Exports as percent of sales	Imported Inputs as percent of sales	Net exports as percent of sales
Venezuela					
Food, beverages	2.0*	2.0*	0.7	4.4*	10.2*
Textiles, apparel, leather	1.4*	1.2*	3.5	1.6	-0.2*
Wood products	1.4*	1.7*	0.0	1.7	-0.2*
Paper products	2.2*	1.4*	5.5*	1.2	-7.1*
Chemicals	1.4*	1.4*	3.5*	1.6	-7.1*
Nonmetallic minerals	1.7*	1.7*	7.0*	4.3*	-2.6*
Basic metals	1.6*	1.3	8.3*	2.6*	18.8*
Machinery, metal products	1.7*	1.4*	10.9*	3.2*	-10.3*
Other manufacturing	1.6*	1.4*	0.6	3.6*	-13.5*
All sectors	1.7*	1.6	8.4*	2.9*	6.9*

1/ Ratio of enterprise performance for firms with foreign ownership to domestically owned firms. A firm is defined as foreign if more than 5 percent of total assets are foreign-owned. An "*" indicates that the difference is statistically significant at the 5 percent level.

Table 4: Comparing the Level of Total Factor Productivity (TFP)
Between Foreign and Domestically-Owned Firms
Coefficient on Foreign Ownership 1/

Sector	0-1 Dummy Variable 2/	Continuous Variable 3/
Food Products	0.091 (4.1)	0.113 (3.2)
Textiles and Clothing	0.099 (3.3)	0.248 (3.9)
Wood Products	0.095 (1.8)	0.068 (0.8)
Paper and Publishing	0.080 (2.9)	0.188 (4.1)
Pottery and Glass	0.147 (5.5)	0.282 (5.2)
Basic Metals	-0.001 (0.0)	-0.046 (0.6)
Machinery and Equipment	0.077 (4.7)	0.104 (3.5)
All Industries	0.085 (6.6)	0.136 (6.4)

1/ Coefficients are estimated from a regression of log output regressed on (log) materials, skilled labor, unskilled labor, annual time dummies, four-digit SIC industry dummies and one of 2 measures of foreign ownership. T-statistics are given in ().

2/ Firms are considered foreign-owned if the share of foreign ownership of the firm's capital is greater than zero.

3/ The share of firm equity which is foreign owned, varies between 0 and 100%.

Table 5: Comparing Total Factor Productivity Growth (TFP)
Between Foreign and Domestically-Owned Firms
Coefficient on Foreign Ownership 1/

Long Differences	0-1 Dummy Variable 2/	Continuous Variable 3/
Two-year differences	0.015 (1.7)	0.027 (1.6)
Three-year Differences	0.026 (2.4)	0.042 (2.1)
Four-year differences	0.045 (3.7)	0.071 (2.8)
Five-year Differences	0.070 (4.4)	0.112 (3.7)

1/ Coefficient are estimated from a regression of log changes in (log) output regressed on changes in (log) materials, skilled labor, unskilled labor and annual time dummy variables. T-statistics in parentheses.

2/ Coefficient on changes in foreign ownership dummy variable, equal to 1 if foreign ownership is greater than zero.

3/ Coefficient on changes in the firm's share of capital which is foreign owned.

Table 6: Impact of Sectoral Foreign Investment on Productivity of Domestic Firms
Dependent Variable - Log Output Produced by Domestically-Owned Firms

Sample	Independent Variables				
	Materials	Capital	Unskl Labor	Skl Labor	Foreign Presence
Without Industry Dummies	0.569	0.084	0.296	0.110	0.061
obs=35514	(327.0)	(59.2)	(103.7)	(44.7)	(1.9)
With 2-digit Dummies	0.573	0.076	0.293	0.114	-0.028
obs=35514	(272.9)	(44.7)	(84.8)	(39.4)	(0.9)
With 4-digit Dummies	0.585	0.060	0.293	0.108	-0.223
obs=35514	(280.2)	(36.8)	(87.7)	(39.0)	(3.8)

T-statistics in parentheses. Domestically-owned firms defined as firms which had no foreign ownership over the entire sample period. All regressions include annual time dummy variables.

Table 7: Impact of Sectoral and Regional Foreign Investment on Productivity of Domestic Firms
Dependent Variable - Log Output Produced by Domestically-Owned Firms

Sample	Independent Variables							
	Materials	Capital	Unskl Labor	Skl Labor	Wage	Elec Price	Regional Foreign Presence	Sectoral Foreign Presence
Adjusted	0.585	0.060	0.290	0.106	0.111	-0.019	-0.001	-0.224
obs=34236	(275.4)	(36.2)	(85.8)	(37.9)	(16.2)	(4.8)	(0.0)	(4.1)
Within Estimation	0.572	0.060	0.294	0.103	-0.013	0.002	-0.014	-0.217
obs=34236	(250.1)	(35.2)	(83.3)	(35.5)	(1.3)	(0.4)	(0.3)	(3.5)

T-statistics in parentheses. Domestically-owned firms defined as firms which had no foreign ownership over the entire sample period. All regressions include annual time dummy variables. Adjusted and Within regressions include the overall skilled wage in the region and electricity prices. Adjusted regressions include 4-digit industry dummy variables.

Table 8: Long Run Impact of Foreign Investment on Domestic Productivity: Long Differences

	Sectoral DFI	Regional DFI
One Period Obs=25766	-0.165 (2.5)	-0.006 (0.1)
Two Periods Obs=17691	-0.184 (2.7)	-.001 (0.0)
Three Periods Obs=11901	-0.184 (2.3)	0.118 (2.0)
Four Periods Obs=7873	-0.158 (1.7)	0.062 (0.9)

Table 9: Alternate Specifications for DFI

Specification	Sectoral DFI	Regional DFI
Unweighted Levels 1/	-0.146 (5.3)	-0.029 (1.9)
Unweighted Within 1/	-0.145 (1.2)	-0.029 (5.0)
Zero-One Levels 2/	-0.196 (3.5)	0.030 (6.0)
Zero-One Within 2/	-0.112 (1.9)	-0.023 (3.4)

Separate Estimates for Numerator (foreign employment) and Denominator (total employment)

Employees in Foreign Plants 3/	-22.0 (3.1)	-69.8 (2.5)
Employees in All Plants 3/	0.8 (0.7)	2.2 (0.7)

1/ DFI is defined as the total number of employees in plants with at least 5% of assets foreign owned, divided by the total number of employees in all plants in that sector.

2/ DFI at the regional level defined as a zero-one variable, equal to 1 if there is any DFI in the region.

3/ DFI defined as the total number of employees in foreign plants. Total employment in the sector included as a control variable.

Table 10: Impact of foreign investment on total factor productivity using aggregate data[1/]

Plant-level date aggregated to industry-level	Coefficient on Foreign Share[2/]
All plants: foreign and domestic	
No industry dummy Variables	0.567 (6.0)
Industry dummy Variables included	0.357 (3.4)
Within estimates	0.505 (4.8)
Only wholly domestically-owned plants[3/]	
No industry dummy Variables	0.111 (1.2)
Industry dummy Variables included	-0.468 (4.5)
Within estimates	-0.487 (4.8)

1/ Log total output in the four-digit sector is regressed on the foreign share of the sector, the logs of sectoral materials, skilled labor, unskilled labor, and annual time dummies. T-statistics are given in ( ).

2/ Coefficients correspond to total labor employed in foreign-owned firms in a 4-digit sector divided by the total labor force in that sector.

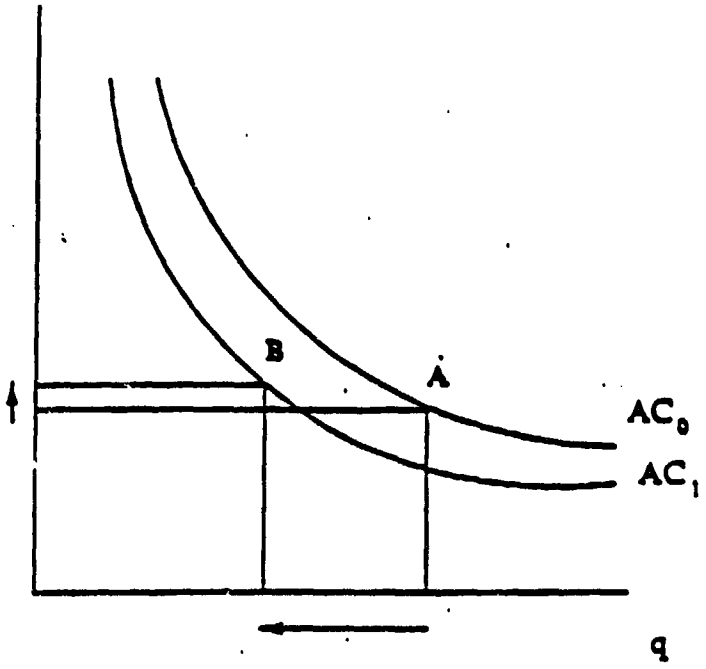
3/ Firms are defined as wholly domestically-owned if they retain 100 percent domestic ownership throughout the sample period.

Appendix Table A.1: The Share of Labor employed at Foreign-owned Firms - Means and Standard Deviations across Region-Districts

Sector	Average Foreign Share		
	1975-77	1982-84	1986-88
Food Products	2.8% (10.5%)	2.7% (10.5%)	3.6% (13.8%)
Textiles & Clothing	1.1 (5.5)	1.4 (4.5)	0.9 (6.3)
Wood Products	0.2 (2.2)	0.4 (3.2)	1.0 (7.1)
Paper & Publishing	6.8 (11.8)	8.6 (16.7)	7.2 (16.7)
Pottery and Glass	2.8 (8.4)	3.8 (13.8)	4.4 (14.5)
Basic Metals	5.0 (12.6)	4.8 (12.6)	5.9 (13.8)
Machines and Equipment	3.1 (10.0)	3.2 (10.5)	3.7 (11.8)

Standard deviations in parentheses

Figure 1: Output Response of Domestic Firms to Foreign Entry



APPENDIX

This appendix extends the model presented in the paper to allow for entry and exit of domestic firms.

Zero Profits and Free Entry

We extend the model to allow for the impact of foreign investment on entry and exit of domestically-owned firms, accounting for the optimal firm behavior given in (5). We show the estimation in equation 11 remains unchanged with entry and exit, provided the least efficient domestic firms are the first to be driven out by foreign competition.

Domestically-owned firms enter or exit until the marginal firm earns zero profits. Firm i earns profits according to

$$\Pi_i=(P-m)q_i-F_i \tag{A1}$$

Substituting into this expression the first order condition for profit maximization under Cournot competition, profits become

$$\Pi_i=q_i^2-F_i \tag{A2}$$

We allow for the possibility that not all firms have the same fixed costs, and we assume that as firms enter, each new firm faces a higher fixed cost than the previous entrant; firms continue to enter until the marginal firm receives zero profits. To capture this fixed cost relationship, we assume fixed costs for the ith firm are given by

$$F_i = F(i) \qquad F' > 0 \tag{A3}$$

Combining equation (A2) and (A3)

$$\Pi_i = q^2 - F(i) \tag{A4}$$

There exists a marginal firm n such that profits in (A4) are zero. This firm produces q_n according to (A5):

$$q_n = F(n)^{\frac{1}{2}} \tag{A5}$$

Firm symmetry guarantees the level of output in (A5) will be produced by all firms:

$$q_i = F(n)^{\frac{1}{2}} \tag{A6}$$

Equations (5) and (A6) jointly determine the level of output and the number of firms which satisfy both the profit maximization and the zero profit conditions. To solve for the level of output explicitly, we rewrite (A6) in terms of n:

$$n = F^{-1}(q_i^2)) \tag{A7}$$

Combining (A7) with the reaction function in (5) gives

$$q_i = \frac{\beta - Q^* - m}{F^{-1}(q_i^2)} \tag{A8}$$

Equation (A8) implicitly defines equilibrium domestic firm output $q_i(Q^*)$ as a function of foreign output. Applying the implicit function theorem to (A8) gives

$$\frac{dq_i}{dQ^*}=[\frac{1}{n+1}(1+2q_i\frac{\beta-Q^*-m}{(n+1)^2}F^{-1'}(Q_i))^{-1}]<0 \qquad (A9)$$

which is negative when $F^{-1'}>0$. Substituting (A9) into (10B) gives the equation for γ accounting for entry and exit:

$$\gamma=\frac{Fi}{q^2(0)}[\frac{1}{n+1}(1+2q_i\frac{\beta-Q^*}{(n+1)^2}-mF^{-1'}(q_i))^{-1}]<0 \qquad (A10)$$

Provided $F^{-1'}$ is positive, allowing free entry and exit does not change the result that foreign entry reduces domestic productivity by forcing domestic firms to spread their fixed costs over lower output.

This prediction holds only if fixed costs vary across domestic firms. If fixed costs are identical for all firms ($F^{-1'}=0$) then enough domestic firms exit in response to foreign entry such that each remaining domestic firm's output remains unchanged ($\gamma = 0$). If, however, fixed costs vary across firms, and firms with the highest fixed cost are the first to exit, then the domestic output will contract in response to foreign entry partially through the exit of domestic firms and partly through lower levels of production for remaining domestic firms.

Although allowing entry and exit does not change the estimation equation, it does introduce sample selection bias when estimating γ. Exit insures that foreign entry drives out the least efficient firms in the sector, lowering the sector's average fixed cost; the firms which remain in sectors experiencing high foreign presence will be more productive, resulting in biased estimates of the impact of foreign presence on a domestic firm's productivity. We show below that entry and exit bias the

estimated γ to be higher (less negative) than the true γ.

Estimation Biases Introduced with Entry and Exit

We begin with the equation for firm i's output derived in equation

$$\log q_i = C + \log x_i + (\alpha + \gamma)Q^* + \eta_i \tag{B1}$$

where it is recalled that entry and exit implies

$$C_i = -\frac{F_i}{\beta - m}(n+1) \tag{B2}$$

We are interested in estimating the impact of foreign presence on the productivity of domestic firm i. The problem arises that C_i in equation is correlated with foreign output. To determine the direction of the bias, we rewrite equation B1 in matrix form:

$$\log q = X\delta + \gamma Q^* + C \tag{B3}$$

where log q, Q^* and C are Nx1 matrices, X is a Nx(K-1) matrix of independent variables, δ is a (K-1)x1 matrix of coefficients, and γ is the coefficient representing the impact of foreign investment on a domestic firm's output after accounting for other factors.

The OLS estimate of γ is defined to be

$$\hat{\gamma} = (Q^{*\prime} M_x Q^*)^{-1} Q^{*\prime} M_x (\log q)$$

$$= \gamma(Q^{*'}M_x Q^*)^{-1}Q^{*'}M_x Q^* + (Q^{*'}M_x Q^*)^{-1}Q^{*'}C$$

$$= \gamma + (Q^{*'}M_x Q^*)^{-1}Q^{*'}M_x Q^* + (Q^{*'}M_x Q^*)^{-1}Q^{*'}C$$

$$= \gamma + (Q^{*'}M_x Q^*)^{-1}Q^{*'}C \qquad \text{(B4)}$$

where $Q^{*'}M_x$ represents the element of Q^* orthogonal to the matrix X. To determine the direction of the bias we compute the correlation between Q^* and C. We show that Q^* is positively correlated with C, and therefore the estimate $\hat{\gamma}$ is biased upward, understating the negative impact of foreign presence on the domestic firm's productivity.

To determine the correlation between Q^* and C, we examine the interaction between Q^* and the stochastic term F_i in equation B2. Firm i's fixed costs can be decomposed into the average fixed cost for industry j to which firm i belongs, and the deviation of firm i's fixed costs from the industry average. The average fixed cost in industry j (denoted $\bar{F}(j)$) is determined by

$$\bar{F}(j) = \frac{1}{n(J)} \int_0^{n(J)} F(u)du \qquad \text{(B5)}$$

where n(j) is given by equation 12 in the text to be

$$n(j) = F^{-1}(q^2(Q^*(j))) \tag{B6}$$

Differentiating equation B6 with respect to foreign output in sector j gives

$$\frac{dn(j)}{dQ^*(j)} = F^{-1}\frac{dq^2}{dQ^*} < 0 \tag{B7}$$

Exogenous increases in foreign output result in the fall in the number of domestic firms in the industry. We can now determine the effect of foreign output on average fixed costs by differentiating equation B5 with respect to Q*:

$$\frac{d\bar{F}(j)}{dQ^*} = \frac{d\bar{F}(j)}{dn(j)}\frac{dn(j)}{dQ^*(j)} < 0 \tag{B8}$$

Average fixed costs in the sector fall with foreign investment as foreign entry drives out the domestic firms with the highest fixed costs.

To solve the correlation between Q* and F_i let $\bar{Q}^*$ denote the average foreign output across sectors, and similarly let $\bar{F}$ be average fixed costs for all domestic firms.

The correlation between F_i and $Q^*(j)$ is given by

$$E_i E_j[F_i - \bar{F}][Q^*(j) - \bar{Q}^*]$$

$$= E_i E_j[F_i - \bar{F}(j) - \bar{F}(j) + \bar{F}][Q^*(j) - \bar{Q}^*] \tag{B9}$$

$$= E_i E_j[(F_i - \bar{F}(j))(\bar{Q}^*(j) - \bar{Q}) + (\bar{F}(j) - \bar{F})(Q^*(j) - \bar{Q}^*)]$$

$$= E_j[\bar{F}(j) - \bar{F})(Q^*(j) - \bar{Q}^*)] < 0$$

and is negative from equation B8.

Since F_i is negatively correlated with $Q^*(i)$ it follows that $C = -F_i \frac{(n+1)}{\beta - m}$ is positively correlated with $Q^*(j)$. Therefore γ understates the true negative impact of foreign presence on domestic productivity.

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