Welfare Gains from Foreign Direct Investment through Technology Transfer to Local Suppliers∗

Garrick Blalock† Paul J. Gertler‡

June 20, 2007

Abstract

We hypothesize that multinational firms operating in emerging markets transfer technology to local suppliers to increase their productivity and lower input prices. To avoid hold-up by any single supplier, the foreign firm must make the technology widely available. This technology diffusion induces entry and more competition which lowers prices in the supply market. As a result, not just the foreign-owned firm, but all firms downstream of that supply market obtain lower prices. We test this hypothesis using a panel dataset of Indonesian manufacturing establishments. We find strong evidence of productivity gains, greater competition, and lower prices among local firms in markets that supply foreign entrants. The technology transfer is Pareto improving—output and profits increase for firms in both the supplier and buyer sectors. Further, the technology transfer generates an externality that benefits buyers in other sectors downstream from the supply sector as well. This externality may provide a justification for policy intervention to encourage foreign investment.

Keywords: Foreign Direct Investment, Technology Transfer, Productivity, Supply Chain

J.E.L. codes: F23, O14, O12, H41

∗We are indebted to Indra Surbakti, Fitria Fitrani, Kai Kaiser, and Jack Molyneaux for their assistance in compiling the data. We received helpful advice from David I. Levine, David C. Mowery, Pranab Bardhan, Ann Harrison, Mary Amiti, Nina Pavcnik, James E. Blalock, Haryo Aswicahyono, Thee Kian Wei, and two anonymous referees. We thank the Institute of Business and Economic Research (IBER) and Management of Technology (MOT) program, both at the University of California, Berkeley, for their generous financial support. We received helpful comments from seminar participants at The Pennsylvania State University and the London School of Economics and Political Science. Finally, we are grateful to the factory managers in Indonesia who kindly participated in interviews.

†Corresponding author. Cornell University, Department of Applied Economics and Management, 346 Warren Hall, Ithaca, NY 14853 USA. +1 (607) 255-0307, +1 (607) 255-9984 fax. garrick.blalock@cornell.edu

‡University of California, Berkeley, Haas School of Business, and NBER. gertler@haas.berkeley.edu
1 Introduction

Many countries try to attract foreign direct investment (FDI) with costly public programs, such as tax holidays, subsidized industrial infrastructure, and duty exemptions. Is this enthusiasm for FDI warranted? In this paper, we investigate the hypothesis that multinational firms transfer technology to their domestic suppliers and that this transfer generates greater competition and lower prices that benefit the entire economy. If true, the effect on competition may justify public encouragement of FDI.

Recently, a number of authors have argued that that multinationals may deliberately transfer technology to local suppliers as part of a strategy to build efficient supply chains for overseas operations (Pack and Saggi 2001; Blalock 2002; Javorcik 2004). By transferring technology to local suppliers, the downstream multinationals lower the cost of non-labor inputs. This cost-reduction motive implies that multinationals transfer technology to suppliers because it confers a private benefit to them. However, unless there is an additional social benefit, there is no case for public subsidies to stimulate technology transfers from multinationals.

How might social benefits develop? The primary motivation for multinationals to transfer technology to suppliers is to enable higher quality inputs at lower prices. One problem with this strategy is that if the enabling technology is transferred to only one upstream vendor, then the multinational is vulnerable to hold-up. To mitigate hold-up risk, the multinational could diffuse the technology widely—either by direct transfer to additional firms or by encouraging spillover from the original recipient. The wide diffusion of the technology would then encourage entry in the supplier market, thereby increasing competition and lowering prices. However, the multinational cannot prevent the upstream suppliers from also selling to others in downstream markets. The lower input prices may induce entry and therefore more competition in downstream markets, which lowers prices and increases output. Pack and Saggi 2001 shows that theoretically, as long as there is not too much entry, profits will rise in both the downstream and upstream markets. If so, then the new surplus generated from increased productivity and the deadweight loss reduced from increased competition will be split between consumers and producers in a Pareto-improving distribution.

In this paper we test the hypotheses that FDI leads to a Pareto-superior increase in welfare via these mechanisms. Specifically, we examine whether there were transfers of technology along
the supply chain, whether the technology transfer leads to increased competition, and whether the increased competition induced welfare improvements in terms of lower prices, greater production, and higher profits in both the supply market and in industries downstream of the supply market. Our chief contribution is to establish and quantify the welfare enhancing externalities of vertical technology transfer.

The analysis is in two parts. The first part measures the effect of FDI on local supplier productivity by estimating a production function using a rich panel dataset on local- and foreign-owned Indonesian manufacturing establishments. In a number of industries, the realized productivity gain is more than two percent. The second part of the paper examines the market and welfare effects of technology diffusion from FDI. We find that downstream FDI increases the output and profits of upstream firms, and decreases prices and market concentration of upstream markets. We also find increased output and profits among downstream firms, and decreased prices and market concentration in markets downstream of markets supplying multinationals. In sum, our findings suggest several welfare effects—i.e., benefits for consumers in terms of lower prices and for firms in the form of greater profitability—transmitted both up and down the supply chain from the adoption of technology brought with FDI.

2 Conceptual Framework

Policymakers often cite technology diffusion to host country firms as a benefit of foreign direct investment (FDI). This belief proliferates in part because of impressive claims of technological development from FDI, such as those of the World Bank 1993, p. 1, which says that “[FDI] brings with it considerable benefits: technology transfer, management know-how, and export marketing access. Many developing countries will need to be more effective in attracting FDI flows if they are to close the technology gap with high-income countries, upgrade managerial skills, and develop their export markets.”

The proponents offer three explanations for how technology spillovers occur from multinationals to domestic firms. First, the local firm may be able to learn simply by observing and imitating the multinationals. Second, employees may leave multinationals to create or join local firms. Third, multinational investment may encourage the entry of international trade brokers, accounting firms,
consultant companies, and other professional services, which then may become available to local firms as well.

However, a number of recent empirical studies, which find mixed evidence of technology transfer from FDI, have prompted many observers to question its existence. Rodrik 1999, p. 37, in a summary of the evidence, comments, “today’s policy literature is filled with extravagant claims about positive spillovers from FDI, [but] the hard evidence is sobering.” The studies to which Rodrik refers ask if local competitors benefit from a positive externality, or “technology spillover,” generated by multinational entry in the same industry.¹

Indeed, it is hard to believe that such horizontal spillovers are likely. First, the technology gap between foreign and domestic firms may often be wide. Local firms may lack the absorptive capacity needed to recognize and adopt the new technology. Similarly, the degree to which foreign and domestic firms actually compete in the same market will also vary. Domestic firms may produce for the local market while multinationals produce for export. Because of differences in quality and other attributes, exported and domestically consumed goods may entail different production methods which reduce the potential for technology transfer. Second, multinationals may enact measures to minimize technology leakage to local competitors. Multinationals with non-protectable technology may not enter the market at all if they rely on a technological advantage to sustain rents. Further, foreign firms typically pay managers higher wages to discourage technology leakage through former employees. In fact, because of the higher wages, foreign firms may instigate a “brain drain” that lures the most capable managers away from domestic firms.

In contrast, technological benefits to local firms through vertical linkages are much more likely since the multinational has incentives to provide technology to suppliers. Vertical technology transfer could occur through both backward (from buyer to supplier) and forward (from supplier to buyer) linkages. Because most multinationals in Indonesia are export-oriented and generally do not supply Indonesian customers, we focus here on technology transfer through backward linkages. That is, we examine the effect of downstream FDI on the performance of local suppliers.

Two arguments suggest that supply chains may be a conduit for technology transfer. First, whereas multinationals seek to minimize technology leakage to competitors, they have incentives

to improve the productivity of their suppliers through training, quality control, and inventory management, for example. To reduce dependency on a single supplier, the multinational may establish such relationships with multiple vendors, which benefits all firms which purchase these vendors’ output. Second, while the technology gap between foreign and domestic producers may limit within-industry technology transfer, multinationals likely procure inputs requiring less sophisticated production techniques for which the gap is narrower.

Evidence of technology transfer through vertical supply chains is well documented in case studies. For example, Kenney and Florida 1993 and Macduffie and Helper 1997 provide a rich description of technology transfer to U.S. parts suppliers following the entry of Japanese automobile makers. Until recently, empirical analysis, however, is generally limited to small samples, such as Lall 1980, which documents technology transfer from foreign firms through backward linkages in the Indian trucking industry. Blalock 2002 finds evidence of technology transfer through the supply chain in production function estimates in Indonesia, and Javorcik 2004 finds similar results in Lithuania.

Multinationals transfer technology to suppliers to reduce input costs and increase quality. However, if the multinational aids only a single supplier, the supplier can play hold-up and capture all of the rents from its increased productivity. In this case, the multinational would not benefit from the technology transfer. The multinational could overcome this vulnerability, however, by distributing the technology widely to multiple suppliers and potential entrants. This would create multiple sources of superior supply and would encourage entry (competition) that would lower supply prices. Total surplus rises because the new technology increases productivity and because the deadweight from imperfect competition falls. The downstream multinational captures some of the rent because the prices it pays for supplies have fallen. However, if there is not too much entry, the suppliers may also capture some of the rent in terms of profits resulting from increased productivity and sales (Pack and Saggi 2001).

Although the multinational has an incentive to aid many suppliers, doing so may inadvertently assist competitors if the more productive supply base is a non-excludable benefit. That is to say that the multinational cannot prevent its now more productive suppliers from also selling to the multinational’s rivals at lower prices. The lower supply prices may induce entry and increase competition so that prices fall in the downstream markets as well. In sum, these actions increase surplus by lowering costs of production and by reducing deadweight loss from imperfect competition.
Moreover, the lower supply prices not only increase surplus in the multinational’s market, but in all of the markets to which the suppliers sell.

In a developing country setting, where generally export-oriented foreign firms are more productive than domestic firms and seldom compete with domestic makers anyway, aiding local buyers may not concern multinationals. However, foreign firms may be concerned that their investment in the local supply chain will eventually benefit later foreign entrants. Given this possibility, one might think that foreign firms would be reluctant to transfer technology to suppliers.

The structural model in Pack and Saggi 2001 shows that, provided new competition is not too great, the benefits of a competitive supply base to the multinational buyer outweigh the rents lost to free-loading rivals. Perhaps surprisingly, technology diffusion and leakage to other local suppliers can also benefit the initial local recipient. In the case of a single supplier and just one buyer with some market power, both parties set prices above marginal cost—the “double marginalization problem.” If technology diffusion to other upstream firms allows more capable suppliers to enter, then one would expect market concentration and input prices to fall. Further, given the benefit of lower-priced inputs, firms downstream of that supply industry will lower prices and increase output, and new firm entry may occur. The stronger demand downstream would, in turn, prompt higher output upstream that would help the initial technology recipient. Lower prices and greater volume clearly generate a surplus for consumers. Pack and Saggi 2001 notes that in some cases, firms also may capture some of the surplus because the benefits of lower input prices and higher volume outweigh the costs of greater competition. Here, we would expect to see firm profits rise. Figure 1 illustrates the total effect of FDI.

If the above argument is true, then technology transfer to suppliers is in multinationals’ interest, but the benefits accrue widely to all industries and consumers not only through improved productivity, but also through increased competition resulting in lower deadweight loss. Hence, technology transfer induces a Pareto improvement in welfare. However, a multinational might not take into account the social benefits of increased competition, and therefore may transfer too little technology. In this case, it would be socially optimal to facilitate the transfer of technology from multinationals to local suppliers.

Although the specific mechanisms for technology transfer described above are typically unobservable in the data, one can identify technology transfer indirectly by otherwise unexplained
productivity gains. If vertical supply chains are a conduit for technology transfer, then one would expect, *ceteris paribus*, that local firms in industries and regions with growing levels of downstream FDI would show greater productivity growth than other local firms. Further, one would expect to see lower concentration, lower prices, higher output, and higher profits in these beneficiary industries, as well as in industries downstream of them. The methodology for testing the productivity effects is described in Section 6, and the methodology for testing the market and welfare effects is described in Section 7. Both are preceded by some background on Indonesian manufacturing and a description of the data in the following two sections.

3 Indonesian Manufacturing and Foreign Investment Policy

Indonesia’s manufacturing sector is an attractive setting for research on FDI and technology transfer for several reasons. First, with the fourth largest population in the world and thousands of islands stretching over three time zones, the country has abundant labor and natural resources to support a large sample of manufacturing facilities in a wide variety of industries. Further, the country’s size and resources support a full supply chain, from raw materials to intermediate and final goods, and both export and domestic markets. Second, rapid and localized industrialization provides variance in manufacturing activity in both time and geography. Third, the country’s widespread island archipelago geography and generally poor transportation infrastructure create a number of local markets, each of which can support independent supply chains. Fourth, a number of institutional reforms of investment law have dramatically increased the amount of FDI and export activity in recent years. In particular, the nature and timing of these reforms provide exogenous variation in FDI by region, industry, and time that will be exploited in the econometric identification. Last, Indonesian government agencies employ a number of well trained statisticians who have collected exceptionally rich manufacturing data for a developing country.

The Indonesian economy and the manufacturing sector grew dramatically from the late 1970’s until the recent financial crisis. Indonesia enjoyed an average annual GDP growth rate of 6-7 percent and much of this growth was driven by manufacturing, which expanded from 11 percent of GDP in 1980 to 25 percent in 1995 (Nasution 1995). Government initiatives to reduce dependency

---

2Hill 1988 and Pangestu and Sato 1997 provide detailed histories of Indonesian manufacturing from the colonial period to the present.
on oil and gas revenue in the mid-1980’s, principally liberalization of financial markets and foreign exchange, a shift from an import-substitution regime to export promotion, currency devaluation, and relaxation of foreign investment laws, facilitated the large increase in manufacturing output (Goelton 1995).

Over the past 40 years, government regulation has shifted dramatically from a policy antagonistic to FDI to a policy actively encouraging it (Wie 1994; Hill 1988; Pangestu 1996). Following independence from the Netherlands in 1945, the Sukarno government nationalized many of the former Dutch manufacturing enterprises. Weak property rights and socialist rhetoric kept foreign investment at a trickle throughout the 1950’s and 1960’s.

Gradual reforms began in 1967 as part of the “New Order” economic regime of Suharto. The reforms allowed investment in most industries, but still required substantial minimum levels of initial and long-term Indonesian ownership in new ventures. Following the collapse of oil prices in the mid-1980’s, the government began to seek outside investment more actively. From 1986 to 1994, it introduced a number of exemptions to the restrictions on foreign investment. The exemptions were targeted to multinationals investing in particular locations, notably a bonded zone on the island of Batam (only 20 kilometers from Singapore), government sponsored industrial parks, and undeveloped provinces of east Indonesia. The new policy also granted exemptions to investment in capital-intensive, technology-intensive, and export-oriented industries. Moreover, the reforms reduced or eliminated import tariffs for certain capital goods and for materials that would be assembled and exported.

Finally, in 1994 the government lifted nearly all equity restrictions on foreign investment. Multinationals in most industries were allowed to establish and maintain in perpetuity operations with 100 percent equity. In a handful of industries deemed strategically important, a nominal 5 percent Indonesian holding was required with no further requirement to divest.

The reforms have been accompanied by large increases in both the absolute and the relative value of foreign production in Indonesian manufacturing. Figure ?? shows the real value added by foreign firms in 1996 by province. The map indicates significant regional variation and shows the absolute level of foreign output to be very large. For example, the value added by multinational manufacturing in the province of Riau (the closest province to Singapore and home to the Batam bonded zone) is 2,335 billion rupiah, or about 10 percent of the province GDP. Large foreign
investment from 1988 to 1996 in chemicals, plastics, electronics assembly, textiles, garments, and footwear dramatically increased the foreign output in many areas. Figure 3 shows the foreign share of manufacturing value added in 1988 and 1996, respectively, by province. In many regions the foreign share of value added increased dramatically from 1988 to 1996 and accounted for more than half of the total in 1996.

4 Data

The analysis is based on data from the Republic of Indonesia’s *Budan Pusat Statistik* (BPS), the Central Bureau of Statistics.³ The primary data are taken from an annual survey of manufacturing establishments with more than 20 employees conducted by *Biro Statistik Industri*, the Industrial Statistics Division of BPS. Additional data include the input-output table and several input and output price deflators.

The principal dataset is the *Survei Tahunan Perusahaan Industri Pengolahan* (SI), the Annual Manufacturing Survey conducted by the Industrial Statistics Division of BPS. The SI dataset is designed to be a complete annual enumeration of all manufacturing establishments with 20 or more employees from 1975 onward. Depending on the year, the SI includes up to 160 variables covering industrial classification (5-digit ISIC), ownership (public, private, foreign), status of incorporation, assets, asset changes, electricity, fuels, income, output, expenses, investment, labor (head count, education, wages), raw material use, machinery, and other specialized questions.

BPS submits a questionnaire annually to all registered manufacturing establishments, and field agents attempt to visit each non-respondent to either encourage compliance or confirm that the establishment has ceased operation.⁴ Because field office budgets are partly determined by the number of reporting establishments, agents have some incentive to identify and register new plants. In recent years, over 20,000 factories have been surveyed annually. Government laws guarantee that the collected information will only be used for statistical purposes. However, several BPS officials commented that some establishments intentionally misreport financial information out of concern

³We identify names in Bahasa Indonesia, the language of most government publications, with italics. Subsequently, we use the English equivalent or the acronym.

⁴Because some firms may have more than one factory, we henceforth refer to each observation as an establishment, plant, or factory. BPS also submits a different questionnaire to the head office of every firm with more than one factory. Although these data were not available for this study, early analysis by BPS suggests that less than 5 percent of factories belong to multi-factory firms. We thus generalize our results to firms in our discussion.
that tax authorities or competitors may gain access to the data. Because the fixed-effect analysis admits only within-factory variation on a logarithmic scale, errors of under- or over-reporting will not bias the results provided that each factory consistently misreports over time. Further, even if the degree of misreporting for a factory varies over time, the results are unbiased provided the misreporting is not correlated with other factory attributes in the right-hand-side of the regression.

The analysis here starts from 1988, the first year data on fixed assets are available. To avoid measurement error in price and other uncertainties introduced by the 1997-1998 Asian financial crisis, the last year of analysis is 1996. The key variables are described in an appendix available on request from the authors and summarized for 1988 and 1996 in Table 1. On average, foreign factories are bigger (as measured by profits, employees, and capital), more capital intensive (as measured by capital per employee), more productive (as measured by profits per employee), and more export-oriented (as measured by percentage of production exported). Table 3 shows the sample count, which grew from 8,888 to 14,912 and from 276 to 888 for domestic and foreign factories respectively.

We derived inter-industry supply chains using input-output (IO) tables published by BPS in 1990 and 1995. The tables show the value added of goods and services produced by industry and how this value is distributed to other industries. The IO tables divide manufacturing activity into 89 industries, and BPS provides concordance tables linking the 1990 and 1995 IO codes to 5-digit ISIC codes as described in an appendix available from the authors.

We deflated output, materials, energy, and capital to express values in real terms. An appendix available from the authors describes the deflator calculation in detail.

Not surprisingly, particularly in a developing country environment, there is a high level of non-reporting and obvious erroneous responses to many of the survey questions, particularly questions that require some accounting expertise, such as the replacement and book value of fixed assets. We removed establishments with especially frequent non-responses to fundamental questions such as number of employees. In other cases, we imputed some variables to correct for non-reporting in just one or two years or to fix obvious clerical mistakes in data keypunching. We cleaned each variable independently and only removed establishments from the analysis for which the needed variables

---

5We proxy profits with revenue minus wages and the cost of materials and energy. This is similar to EBITDA (Earnings before interest, taxes, depreciation, and amortization), a common proxy for profitability.
could not be constructed. For example, establishments with missing wage data could be used for
the output regression but not for the profits regression. Thus, readers will notice slight differences
in the sample count across different regressions. We also note that analysis on completely raw data
yields very similar results to what we report here, although standard errors are slightly higher. An
appendix available from the authors describes the process by which we prepared the data in more
detail.

5 Productivity Effects

Our strategy to identify the effect of downstream FDI on productivity is to examine whether
domestic establishments which sell more to foreign-owned firms produce more, *ceteris paribus*. We
estimate this effect using a translog production function with establishment fixed effects, industry-
year and year-island dummies, and measures of FDI. The production function controls for input
levels and scale effects. The establishment fixed effects control for time-invariant differences across
industries and firms, and the industry-year and year-island dummies control for changes common
to all firms in an industry or part of the country at a particular time. Specifically, we specify the
establishment-level translog production function as:

\[
\ln Y_{it} = \beta_0 \text{Downstream FDI}_{jrt} + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 \ln M_{it} + \beta_4 \ln E_{it} +
\]

\[
\beta_5 \ln^2 K_{it} + \beta_6 \ln^2 L_{it} + \beta_7 \ln^2 M_{it} + \beta_8 \ln^2 E_{it} +
\]

\[
\beta_9 \ln K_{it} \ln L_{it} + \beta_{10} \ln K_{it} M_{it} + \beta_{11} \ln K_{it} E_{it} +
\]

\[
\beta_{12} \ln L_{it} M_{it} + \beta_{13} \ln L_{it} E_{it} + \beta_{14} \ln M_{it} E_{it} + \alpha_i + \tau_t + \gamma_{jt} + \lambda_{gt} + \varepsilon_{it}
\]

where \(Y_{it}, K_{it}, L_{it}, M_{it}\) and \(E_{it}\) are the amounts of production output, capital, labor, raw
materials, and energy (fuel and electricity) for establishment \(i\) in year \(t\), \(\alpha_i\) is a fixed effect for
factory \(i\), \(\tau_t\) is a dummy variable for year \(t\), \(\gamma_{jt}\) is a dummy indicator for the interaction of industry
\(j\) and year \(t\), \(\lambda_{gt}\) is an indicator for the interaction of each of the countries four main island
groups \(g\) and year \(t\). We initially assume that the residual \(\varepsilon_{it}\) is *i.i.d.*, but we later control for
simultaneity bias that may arise if \(\varepsilon_{it}\) is correlated with other right-hand-side variables. Output,
capital, materials, and energy are nominal rupiah values deflated to 1983 rupiah. Labor is the total
number of production and non-production workers. We estimate Equation 1 on a sample of locally owned factories.

5.1 Measuring Horizontal and Downstream FDI

We use a longstanding measure of horizontal FDI in the literature: the share of a industry’s output in a particular market that is produced by foreign-owned firms. Specifically,

$$Horizontal_{FDI}_{jrt} = \frac{\sum_{i \in jrt} Foreign_{OUTPUT}_{it}}{\sum_{i \in jrt} OUTPUT_{it}}$$

where $i \in jrt$ indicates a factory in a given industry, region, and time, $OUTPUT_{it}$ is the output of factory $i$, and $Foreign_{OUTPUT}_{it}$ is the output of factory $i$ if the factory is foreign, and zero otherwise.

The measure of horizontal FDI varies by industry, region, and time. The approach appeals to Indonesia’s vast island geography and poor inter-region transportation infrastructure in assuming local markets, so that any technology spillover from foreign firms to local rivals most likely only occurs between firms that are geographically close. We consider each of Indonesia’s 27 provinces to be a separate region.\(^6\)

While horizontal FDI is straightforward to measure, downstream FDI is more complicated. We measure downstream FDI as the share of the total output of an industry and region that is sold to downstream foreign buyers across all industries. Our measurement choice, detailed further below, is driven in part by data limitations in that we neither know which suppliers were technology recipients nor how much each firm sold to foreign-owned buyers. Rather, we infer the amount sold to foreign-owned firms for each industry using the input-output tables.

One might prefer to use the actual output sold to foreign buyers by each supplier. This would, in principle, be the correct measure if the firms selling to foreign buyers are the only ones that benefit from the technology transfer. However, Pack and Saggi argue that foreign buyers distribute their technology to many suppliers to prevent individual suppliers from playing holdup. If the technology becomes widely available so that all firms might benefit, then the correct measure would be the share of all output from the industry-region sold to foreign firms, in which case our average

\(^6\)The use of geographical variation allows for comparison of two firms in the same strengthens our results. However, we find similar but slighter weaker results when all regions are aggregated together.
measure would more accurately reflect the true downstream FDI. In reality, the truth probably lies somewhere in between, i.e., that the technology is distributed beyond those firms that sell to foreign buyers, but not to all firms. Hence, we would prefer to know which sellers were able to access the foreign technology.

A problem with examining the specific suppliers that sold to foreign firms or even those that adopted the foreign technology is that this is part of the equilibrium and is therefore endogenous. Instead, our measure is intended to capture the availability of buyers’ foreign technology to sellers in a particular industry in a particular region at a point in time. Our estimator is then best interpreted as the effect of an increase in the availability of technology on the average productivity of sellers in a particular industry in a particular region. By considering availability we also step back from the endogeneity issue. Nearly every prior paper in the literature has used the same approach and considered FDI to be a measure of available technology for the same reasons.

How specifically do we measure the share of industry $j$’s output, in region $r$, that is sold to foreign firms in year $t$? From the IO tables we know the amount that firms in one industry purchase from each of the other industries. We also know the share of output in industry $j$ that is produced by foreign-owned firms, i.e., horizontal FDI. If we assume that a firm’s share of a industry’s demand for a particular input is equal to its output share, then a measure of the share of a industry’s output sold to foreign firms is the sum the output shares purchased by other industries multiplied by the share of foreign output in each purchasing industry.

For example, consider three industries: wheat flour milling, pasta production, and baking. Suppose that half of the wheat flour industry’s output is purchased by the bakery industry and the other half is purchased by the pasta industry. Further, suppose that the bakery industry has no foreign factories but that foreign factories produce half of the pasta industry output. The calculation of downstream FDI for the flour industry would yield $0.25 = 0.5(0.0) + 0.5(0.5)$. Formally, equation 3 expresses the calculation for industry $j$, region $r$, at time $t$.

\[
Downstream_{FDI}^{jrt} = \sum_k \alpha_{jkt} \text{Horizontal}_{FDI}^{krt}
\]  

(3)

where $\alpha_{jkt}$ is the proportion of industry $j$ output consumed by industry $k$. Horizontal FDI is our measure of the share of an industry’s output in a local market that is produced by foreign-owned
firms. Values of $\alpha_{jkt}$ before and including 1990 follow from the 1990 IO table, values of $\alpha_{jkt}$ from 1991 through 1994 are linear interpolations of the 1990 and 1995 IO tables, and values of $\alpha_{jkt}$ from 1995 on are from the 1995 IO table. Recall that $\alpha_{jkt}$ does not have a region $r$ subscript because the IO table is compiled for the entire national economy.

The measure of downstream FDI varies by industry, and time. Again, the approach appeals to Indonesia’s vast island geography and poor inter-region transportation infrastructure in assuming local markets, i.e., that intermediate goods output is consumed by firms in the same region. Table 3 shows some summary statistics for these two measures of FDI and a third one described in the next section. Tables 4 and 5 show the 25 industries with the highest levels of downstream and horizontal FDI, respectively, in 1996.

Finally, we also note that we calculate downstream FDI at the region-level but only have a national IO table. We cannot observe differences in the true input-output relationship across regions and over time. Visual inspection of the 1990 and 1995 IO tables shows relatively little change, but we do not know precisely how much variation there is across regions. Our priors are that production technologies should not depend, per se, on location, so we expect the IO table to be relatively stable across regions. But, we cannot be sure. In short, like most empirical studies, ours certainly includes some measurement error. In fixed effect estimation, this measurement error tends to downward bias coefficient. So, our estimated effect of downstream FDI likely understate the true effect.

5.2 Identification and Estimation

One concern in the estimation of the production function is that the inputs and downstream FDI are choice variables. In the later case, foreign investors may be attracted to industries and regions that have more productive suppliers. Correlations between downstream FDI and productivity thus would be explained by multinational location choices rather than by technology transfers to suppliers. In order to establish technology transfer as the dominant explanation, we explain our identification strategy in more detail below. We also briefly discuss anecdotal evidence and survey results that support technology transfer as the likely explanation for our finding.

There are a number of reasons why downstream FDI might be correlated with the error term in the production function. First, multinationals might buy firms that are located near the most
efficient suppliers. We control for this possibility by including establishment fixed effects in the production function. Second, multinationals might buy into firms supplied by industries whose productivity is growing or expected to grow. We control for this possibility by including industry-year fixed effects. Third, multinationals might buy into firms located in areas where supplier productivity is growing or expected to grow. We control for this possibility by including island-year fixed effects.

Finally, multinationals might locate with the motivation to be supplied by specific sellers which have experienced an idiosyncratic productivity shock. In practice, it seems unlikely that the idiosyncratic portion of the error term would be correlated with $Downstream_{FDI}$; the long lead time and high transaction costs of investment and contracting with suppliers suggest that multinationals would invest in industries and regions which offered long-term productivity growth potential rather than chasing transient boosts to supplier performance. Further, if supply markets are competitive, shocks affecting just one supplier may have little effect on market prices. Nonetheless, the possibility of bias remains. Moreover, unobserved productivity shocks could be correlated with other inputs, such as capital, although the direction of such a simultaneity bias on the $Downstream_{FDI}$ coefficient is not clear.

We control for the possible correlations of either downstream FDI or inputs with the idiosyncratic shock by using an estimation procedure suggested by Olley and Pakes 1996. Specifically, it proposes using investment as a proxy for idiosyncratic shocks. The identifying assumption in Olley-Pakes estimation is that investment is monotonically increasing with respect to the shock, conditional on capital. Because capital responds to the shock only in a lagged fashion through contemporaneous investment, the return to the other inputs can be obtained by non-parametrically inverting investment and capital to proxy for the unobserved shock. An appendix available from the authors summarizes the Olley-Pakes estimation approach.\(^7\)

Our causal argument is consistent with the conventional wisdom regarding Indonesia’s development and with survey evidence of firms elsewhere. As we discussed in Section 3, Indonesia’s

\(^7\)Although it is possible to obtain the return to capital variables with an optional second stage of estimation, we do not pursue that here since capital is not a variable of interest. An additional concern expressed in Olley and Pakes 1996 is that of survivorship bias. If downstream FDI were associated with differences in factory survival probability, then changes in the composition of surviving factories could be confounded with changes in individual factories. In our sample, logit estimates of firm deaths reveal no significant correlation between downstream FDI and survival probabilities.
trade liberalization, not supplier productivity, prompted the large increase in FDI inflows during the 1990’s. Moreover, dozens of case studies and surveys of multinationals investing in emerging markets, some of which we cite in Section 2, reveal examples of technology transfer to local suppliers. For example, Moran 2001 and Moran, Graham, and Blomstrom 2005 provide extensive reviews of the case studies and surveys of technology transfer from multinationals. The story that appears over and over is that multinationals enter, foster relationships with domestic suppliers, and eventually transfer technology or otherwise encourage productivity gains. For example, one cited survey of Czech Republic firms, Javorcik and Spatareanu 2005, found that 40 percent of those which acquired ISO 9000 certification did so to obtain contracts with multinational investors after they had entered. In contrast, these surveys of existing literature provide no examples of multinationals entering markets out of attraction for transient gains by local suppliers.

6 Productivity Results

Table 6 reports the results of estimating Equation 1 using an establishment-level fixed-effect estimator on a sample of domestic firms. All models include establishment, industry-year and island-year fixed effects. Column (1) shows downstream FDI, column (2) shows horizontal FDI, and column (3) shows the effect of both. The coefficient on horizontal FDI is close to zero, suggesting that there is little learning from direct foreign competitors. These results are consistent with the arguments in Rodrik 1999 and findings in Aitken and Harrison 1999 and Javorcik 2004. None of our models provide any evidence of horizontal technology transfer.

In contrast, the effect of downstream FDI is large and significant, indicating that firms with growing FDI downstream acquire technology through the supply chain. Because the estimation is a log-linear production function, the coefficients approximate elasticities and have intuitive interpretations. The 0.087 coefficient on downstream FDI suggests that firm output increases almost nine percent as the share of foreign ownership downstream rises from zero to one. In practice, increases in share of downstream FDI of approximately 20 percent are not unusual, suggesting that the actual realized productivity gain might be close to 2 percent (0.2 times 0.087). Table 7 shows the estimated productivity gain based on the 0.087 point estimate and the actual change in

---

8A Hausman test showed significant correlation between individual establishment effects and the other regressors, thereby rejecting a random-effects model.
downstream FDI for the industries with a predicted gain of 2 percent or greater during 1988-1996.

Column (4) of Table 6 shows the results of the Olley-Pakes estimation. The effect of downstream FDI is statistically identical to that measured without the Olley-Pakes correction. In sum, after allowing for static domestic supplier efficiency, year-industry shocks, island group-year shocks, and idiosyncratic firm-specific shocks, we still see a strong productivity effect of downstream FDI. If the causality between FDI and productivity gains were the reverse of our hypothesis, we would expect the effect to disappear when we account for static and transient supplier productivity.

Finally, although the unit of analysis in our estimation is an individual factory, our key variable of interest, downstream FDI, varies at the industry-region-year level. Moulton 1990 shows that if there is a correlation in the disturbance terms of individuals units that share a common aggregate variable value, standard errors can be biased downwards in some instances. The intuition of the concern is that the presence of many factory observations within each cell of actual downstream FDI variation could exaggerate the precision of our estimate. We include industry-year and island-year dummies which should capture some of any common disturbances in each cell. Nonetheless, to be sure our results are robust to any disturbance term correlation, we estimate Equation 1 with clustering at the industry-region-year level. As described in Hoxby 2005, clustering is an over-correction. In most cases, we would significantly overestimate the standard errors. Even with this conservative test, the results of which are shown in column (5) of Table 6, the effect of downstream FDI is still highly significant.

6.0.1 Correlation with Exporting Activity

The results so far reveal only the effect on local firms supplying multinationals that operate within Indonesia. Many of the mechanisms for technology transfer, however, would also benefit local firms that exported. Indeed, one would expect some correlation between local firms that supply multinationals within the country and local firms that export. To the extent that local exporters produce products of international quality and price, in-country multinationals would be likely to select them as suppliers. Further, to the extent that local suppliers learn from multinational customers and improve quality and price, they are more able to export successfully to global markets. Indeed, the factory interviews suggested that multinational customers may sometimes

To remove any effects of exporting, we estimated Equation 1 on a sample including only \textit{never-exporting} domestic firms. Column (6) of Table 6 shows that the positive effect of downstream FDI holds and suggests that exports are not a viable alternative explanation for the observed productivity gains.

6.0.2 Public Goods from FDI

The correlation between downstream FDI and local plant productivity could be explained by multinationals’ provision of public goods rather than by technology transfer. For example, if multinational entry leads to the building of new roads or the installation of more reliable electricity-generating facilities, then local firm productivity may increase \textit{without} any transfer of technology. Since the provision of these public goods would likely be correlated with downstream FDI, analysis could erroneously attribute local firm gains from public goods to technology transfer.

To test for the role of public goods, we assume that all plants would benefit from the provision of roads, bridges, ports, etc. Although some industries would benefit more than others, this proposition seems reasonable on the grounds that public goods are non-excludable. We then estimate Equation 1 substituting $\text{Region}_{\text{FDI}}$, the share of foreign firm share of industrial output in all industries, for $\text{Downstream}_{\text{FDI}}$. Column (7) of Table 6 shows the insignificant coefficient on $\text{Region}_{\text{FDI}}$, indicating that public goods do not have a major impact on local firm productivity.

6.0.3 By-industry Analysis

The analysis above pools factories in all industries. The advantage of a pooled cross-industry sample is that it provides high variation in downstream FDI. Recall that downstream FDI is calculated by industry, region, and year. Because we use fixed-effect estimation, only the variation about a factory’s mean, or within variation, is admitted. If the estimation sample were limited to firms in just one industry, the only between-plant variation in downstream FDI would be by region. That is, one would take factories in regions with changes in downstream FDI over time as the treatment group, and those in other regions with no changes in downstream FDI as the control
group. In practice, we use Indonesia’s 27 provinces as regional indicators and many industries are concentrated in only a few provinces. Thus, there is insufficient variation between provinces for a statistically powerful test. Further, if there is little change in downstream FDI in the industry, there may be insufficient within-plant variation. To increase variation, we have pooled all industries together. The estimation then takes some industries as treatment groups and other industries as control groups.

A pooled sample, however, has two disadvantages. First, because the effect of downstream FDI is also constrained to be uniform across industries, one cannot see which industries benefit from downstream FDI. Second, a pooled sample constrains the return to inputs to be constant across industries. It may be unreasonable to assume that the marginal product of capital or labor is uniform across industries as varied as fish processing and electronics assembly. Such a constraint could bias the results, although it is not obvious in what direction.

To balance the need for variation in downstream FDI and the desire to have industries with similar technologies in the treatment and control groups, we selected three groups: a food group, a textile group, and an electronics group. These groups correspond to the 31, 32, and 38 2-digit ISIC codes respectively, which span several IO codes each and have large between- and within-establishment downstream FDI. Table 8 shows the results of estimating Equation 1 on the three samples. The results indicate a strong benefit from downstream FDI in all three industries.

As an additional test to ensure that forcing constant returns to inputs across industries is not affecting our results, we interacted the inputs with industry dummies. Specifically, we estimated a Cobb-Douglas production function with each of the inputs interacted with a 3-digit ISIC industry code. The result, a return to downstream FDI of 0.074, is remarkably similar to our baseline estimate from Equation 1, which was 0.087. We are thus reassured that inter-industry heterogeneity in production technology is not a large concern.

### 6.0.4 Price Heterogeneity

Our framework suggests that multinationals transfer technology to suppliers to reduce input prices and increase quality. The coupling of technology transfer with price reductions introduces a complication in productivity estimation. Recall that we measure firm output as nominal revenue deflated by the industry price index. In a competitive market with homogenous goods, our measure will
perfectly correlate with the number of units produced. In differentiated markets, however, technology transfer might selectively affect the prices of the recipient firms and, by extension, their estimated unit output.\footnote{See Melitz 2000 and Katayama, Lu, and Tybout 2003 for a detailed discussion of the estimation concerns.}

Fortunately, the likely direction of productivity bias from price heterogeneity is opposite to our findings. Suppose the probable case that foreign buyers obtain lower prices from their suppliers and that these price reductions are not reflected in the industry price index. Deflation would thus understate the unit output of technology-recipient firms and downward bias the measured effect of downstream FDI for the industry overall.

An alternative argument is to consider an industry with little product differentiation. A market of largely commodity inputs and outputs is less likely to demonstrate price heterogeneity across firms. The strong effect of downstream FDI in the textile industry, often an example of a non-differentiated industry, suggests that it is technology transfer that explains the productivity gains of domestic supply industries.

## 7 Market and Welfare Effects

The previous section, we believe, provides evidence that productivity increases when the share of output purchased by foreign firms rises. This is consistent with downstream foreign-owned firms transferring technology to upstream suppliers. In this section, we examine the market and welfare consequences of transferring this technology and test whether it results in Pareto improvements in welfare as hypothesized in Pack and Saggi 2001. In particular, we test the hypotheses that technology transfer upstream to suppliers resulted in entry, lower prices, increased output, and higher profitability in the upstream market; and that the lower supply prices lead to entry, lower prices, increased output, and increased profitability in the downstream market.

### 7.1 Methods and Identification

Again, we are not able to directly measure the transfer of technology. Rather, we measure the industries and location where and when foreign companies entered downstream of local companies. We examine the effect of changes in the share of output purchased by foreign firms on prices,
concentration, and profitability in the supply industry. Specifically, we estimate several reduced form models. Equation 4 measures the effect of FDI on concentration.

\[ HI_{sr t} = \beta_0 \text{Downstream}_{jrt} + \alpha_{sr} + \lambda_{gt} + \tau_{t} + \varepsilon_{sr t} \] (4)

where \( HI_{sr t} \) is the Herfindahl concentration index for 5-digit ISIC industry \( s \) in region \( r \) in time \( t \). Note that we use the 89 IO table codes, indicated by subscript \( j \), to define industries for supply chains. However, for calculating concentration indexes, which do not require the IO table, one can more narrowly define industries by the 329 ISIC codes, indicated by subscript \( s \). \( \alpha_{sr} \) is a fixed-effect for the interaction of industry \( s \) and region \( r \), \( \tau_{t} \) is year indicator, and \( \lambda_{gt} \) is intended to capture time-variant conditions affecting particular island groupings of the country, and \( \varepsilon_{sr t} \) is an error term.

Equation 5 measures the effect of FDI on prices.

\[ Price_{st} = \beta_0 \text{Downstream}_{jlt} + \alpha_{s} + \tau_{t} + \varepsilon_{st} \] (5)

Because prices are not available at the regional level, we use \( \text{Downstream}_{jlt} \) at the national level here. That is, downstream FDI is calculated as if the entire country were one region.

Equations 6 and 7 measure the effect of FDI on firm output and profits respectively.\(^{11}\) We proxy profits with as revenue minus wages and the cost of materials and energy. This is similar to EBITDA (earnings before interest, taxes, depreciation, and amortization), a common proxy for profitability.

\[ Y_{it} = \beta_0 \text{Downstream}_{jrt} + \alpha_{i} + \lambda_{gt} + \tau_{t} + \varepsilon_{it} \] (6)

\[ Profits_{it} = \beta_0 \text{Downstream}_{jrt} + \alpha_{i} + \lambda_{gt} + \tau_{t} + \varepsilon_{it} \] (7)

We then consider the hypotheses regarding feedback to downstream markets, in particular, that the lower supply prices induce entry, lower prices, and higher profits. We test this hypothesis by examining the effects of changes in foreign ownership in industries purchasing from the focal supply

\(^{11}\)The specifications in Equations 6 and 7 do not control for time varying firm- and industry-specific productivity shocks that may affect both firm outcomes and foreign investment in downstream industries. For the reasons discussed in Section 5.2 we believe it is unlikely that a shock to a specific supplier would increase foreign investment in downstream markets. However, the possibility of an industry-wide productivity shock that increases both focal sector outcomes and foreign investment in downstream markets remains.
industry on the performance of other industries supplied by that focal industry. In other words, we ask what is the effect of buying from industries that supply multinationals and call this measure suppliers’ downstream FDI. We measure suppliers’ downstream FDI as the value of downstream FDI in each of the industries upstream of the focal industry weighted by the share of focal industry inputs provided by that industry.

\[ \text{Suppliers’ Downstream FDI}_{jrt} = \sum_{k} \alpha_{jkt} \text{Downstream FDI}_{krt} \]  

where \( \alpha_{jkt} \) is the share of industry \( j \) inputs obtained from industry \( k \).

We then re-estimate equations 4-7 replacing downstream FDI with suppliers’ downstream FDI to gauge the welfare effects in industries downstream of those industries supplying multinationals.

7.2 Market and Welfare Results

We estimate the effect of FDI on concentration and prices at the market level—province markets in the case of concentration and national markets in the case of prices, for which we do not have regional variation. The effect of FDI on output and profitability is calculated at the firm level.

7.2.1 Concentration and Price

Table 9 contains the estimations of equations 4 and 5. Columns (1)-(3) show estimates of regional market concentration with a fixed effect for each 5-digit ISIC product and province cell. Both downstream FDI and suppliers’ downstream FDI are significantly associated with a decrease in market concentration, measured by a Herfindahl index. This association suggests that foreign entry downstream will lead to more competition in upstream supply markets. Likewise, other industries downstream of those upstream markets also show increases in competition.

Columns (4)-(6) display the effect of FDI on prices estimated by Equation 5. Because we do not have regional variation in prices, the identifying estimation is by industry and year. Although one may be cautious in assigning causality from such a reduced form estimation, the results are consistent with the notion that FDI competition lowers prices. In fact, downstream FDI and supplier’s downstream FDI are both associated with a decline in prices.
7.2.2 Output and Profits

We next estimate establishment output and the proxy for profits. Given that FDI lowers prices, one expects to see an increase in output. Indeed, columns (1)-(3) of Table 10 show the effect of FDI on domestic firm output by estimating Equation 6. Both downstream FDI and suppliers’ downstream FDI increase output, likely through the effect of FDI on prices and the demand added by the new entry. Columns (4)-(6) estimate Equation 7 to show whether domestic firms capture any of the surplus generated from lower prices and higher output. Again, both downstream FDI and suppliers’ downstream FDI lead to greater profits, suggesting that firms are capturing some of the welfare benefits of vertical technology transfer.

Table 11 estimates Equations 6 and 7 on the population of just foreign firms. As was the case with domestic firms, an increase in downstream FDI and suppliers’ downstream FDI is associated with increases in both volume and profits.

8 Summary and Implications

Our findings have two key implications. First, vertical supply chains are a conduit for technology transfer from FDI in emerging markets. Second, this technology generates welfare benefits that may warrant public policy intervention.

The observation of technology transfer alone is insufficient to inform public policy. If the full benefit of FDI is internalized between the two private parties, then there is no need for government intervention. Our results suggest that FDI does indeed generate an externality—lower prices and greater output—that benefits suppliers, final goods makers, and consumers. Because the benefits of FDI to the economy exceed the private returns to both the multinational and its direct suppliers, the total amount of FDI may be less than the socially optimal amount without intervention.

To gauge the magnitude of the welfare effect, we calculate a simple “back of the envelope” estimation of producer and consumer surplus gains resulting from FDI in Indonesia during the period of our panel. We can easily approximate producer surplus by using the estimation results of Equation 7 to calculate the effect of FDI on our proxy for profit. If we assume a linear demand curve, we can obtain a rough estimate of consumer surplus as \((p_{1988} - p_{1996}) * q_{1988} + 0.5(q_{1996} - q_{1988}) * (p_{1996} - p_{1988})\). The 1988 price and quantity are in the data and we can forecast the effect.
of FDI on the 1996 values by using the results of equations 5 and 6. Our simple calculations show that producer surplus increased by 1.1 percent in intermediate goods industries and by 0.7 percent in final goods industries. We find a consumer surplus increase of 5.8 percent relative to total sales in final goods industries. Although only rough approximations, the producer and consumer surplus measures are economically substantial.

On the basis of the outcomes we have observed, we conclude that host economy policymakers should, at a minimum, not raise barriers to FDI. In cases where there is potential for multinationals to source supplies from local suppliers, policymakers should consider providing incentives to encourage FDI.

References


### A Tables

Capital, materials, energy, and profits are reported in thousands of 1988 rupiah.

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic</th>
<th>Foreign</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>log(capital)</td>
<td>11.257</td>
</tr>
<tr>
<td></td>
<td>employees</td>
<td>124</td>
</tr>
<tr>
<td></td>
<td>log(materials)</td>
<td>11.171</td>
</tr>
<tr>
<td></td>
<td>log(energy)</td>
<td>7.388</td>
</tr>
<tr>
<td></td>
<td>log(profits)</td>
<td>10.438</td>
</tr>
<tr>
<td></td>
<td>log(profits per worker)</td>
<td>6.447</td>
</tr>
<tr>
<td>1996</td>
<td>log(capital)</td>
<td>11.691</td>
</tr>
<tr>
<td></td>
<td>employees</td>
<td>147</td>
</tr>
<tr>
<td></td>
<td>log(materials)</td>
<td>11.588</td>
</tr>
<tr>
<td></td>
<td>log(energy)</td>
<td>7.347</td>
</tr>
<tr>
<td></td>
<td>log(profits)</td>
<td>11.039</td>
</tr>
<tr>
<td></td>
<td>log(profits per worker)</td>
<td>6.973</td>
</tr>
</tbody>
</table>

Table 1: Descriptive statistics by foreign and domestic firms, 1988 and 1996. We proxy profits with revenue minus wages and the cost of materials and energy.
Table 2: Correlation between measures of FDI.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Downstream FDI</th>
<th>Horizontal FDI</th>
<th>Suppliers’ Downstream FDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downstream FDI</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal FDI</td>
<td>0.34</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Suppliers’ Downstream FDI</td>
<td>0.55</td>
<td>0.44</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 3: Foreign and domestic establishment count, mean horizontal, downstream, and suppliers’ downstream FDI, 1988 and 1996.

<table>
<thead>
<tr>
<th>Year</th>
<th>No. Domestic Firms</th>
<th>No. Foreign Firms</th>
<th>Horizontal FDI</th>
<th>Downstream FDI</th>
<th>Suppliers’ Downstream FDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>8888</td>
<td>270</td>
<td>.131</td>
<td>.060</td>
<td>.074</td>
</tr>
<tr>
<td>1996</td>
<td>14912</td>
<td>888</td>
<td>.232</td>
<td>.094</td>
<td>.118</td>
</tr>
</tbody>
</table>

Table 4: Downstream FDI in 1996 for the 25 industries with the highest levels. Measurements are at the national level (treating the entire country as one region). Our estimations include regional variation not shown in this table.

<table>
<thead>
<tr>
<th>Industry</th>
<th>National Downstream FDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sporting and athletics goods</td>
<td>0.75</td>
</tr>
<tr>
<td>Electrical machinery and apparatus</td>
<td>0.68</td>
</tr>
<tr>
<td>Machinery and apparatus</td>
<td>0.53</td>
</tr>
<tr>
<td>Leather tanneries and leather finishing</td>
<td>0.46</td>
</tr>
<tr>
<td>Musical instruments</td>
<td>0.38</td>
</tr>
<tr>
<td>Household electronic appliances</td>
<td>0.33</td>
</tr>
<tr>
<td>Batteries</td>
<td>0.32</td>
</tr>
<tr>
<td>Basic chemical except fertilizer</td>
<td>0.31</td>
</tr>
<tr>
<td>Jewelry</td>
<td>0.29</td>
</tr>
<tr>
<td>Flour except wheat flour, milled cereals and peeled root</td>
<td>0.28</td>
</tr>
<tr>
<td>Ship and its repair</td>
<td>0.27</td>
</tr>
<tr>
<td>Drying and salting of fish</td>
<td>0.26</td>
</tr>
<tr>
<td>Knitting mills</td>
<td>0.26</td>
</tr>
<tr>
<td>Textile</td>
<td>0.25</td>
</tr>
<tr>
<td>Synthetic resins, plastic and fiber</td>
<td>0.25</td>
</tr>
<tr>
<td>Kitchen wares, hand tools and agricultural tools</td>
<td>0.22</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>0.22</td>
</tr>
<tr>
<td>Other electrical appliances</td>
<td>0.21</td>
</tr>
<tr>
<td>Yarn and cleaning kapok</td>
<td>0.20</td>
</tr>
<tr>
<td>Communication equipment and apparatus</td>
<td>0.19</td>
</tr>
<tr>
<td>Dairy products</td>
<td>0.19</td>
</tr>
<tr>
<td>Processed tea</td>
<td>0.18</td>
</tr>
<tr>
<td>Nonferrous basic metal products</td>
<td>0.17</td>
</tr>
<tr>
<td>Pulp</td>
<td>0.17</td>
</tr>
<tr>
<td>Other chemical products</td>
<td>0.17</td>
</tr>
<tr>
<td>Industry</td>
<td>National Horizontal FDI</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Sporting and athletics goods</td>
<td>0.96</td>
</tr>
<tr>
<td>Machinery and apparatus</td>
<td>0.87</td>
</tr>
<tr>
<td>Pulp</td>
<td>0.85</td>
</tr>
<tr>
<td>Glass products</td>
<td>0.83</td>
</tr>
<tr>
<td>Other electrical appliances</td>
<td>0.82</td>
</tr>
<tr>
<td>Electrical machinery and apparatus</td>
<td>0.82</td>
</tr>
<tr>
<td>Cosmetics</td>
<td>0.77</td>
</tr>
<tr>
<td>Pesticides</td>
<td>0.75</td>
</tr>
<tr>
<td>Household electronic appliances</td>
<td>0.75</td>
</tr>
<tr>
<td>Communication equipment and apparatus</td>
<td>0.75</td>
</tr>
<tr>
<td>Basic chemical except fertilizer</td>
<td>0.66</td>
</tr>
<tr>
<td>Motor cycle</td>
<td>0.64</td>
</tr>
<tr>
<td>Other metal products</td>
<td>0.56</td>
</tr>
<tr>
<td>Synthetic resins, plastic and fiber</td>
<td>0.53</td>
</tr>
<tr>
<td>Jewelry</td>
<td>0.52</td>
</tr>
<tr>
<td>Other food</td>
<td>0.51</td>
</tr>
<tr>
<td>Footwear and leather products</td>
<td>0.50</td>
</tr>
<tr>
<td>Dairy products</td>
<td>0.47</td>
</tr>
<tr>
<td>Structural metal products</td>
<td>0.46</td>
</tr>
<tr>
<td>Prime movers engine</td>
<td>0.46</td>
</tr>
<tr>
<td>Furniture and fixture primarily made of metal</td>
<td>0.43</td>
</tr>
<tr>
<td>Ship and its repair</td>
<td>0.42</td>
</tr>
<tr>
<td>Drugs and medicine</td>
<td>0.41</td>
</tr>
<tr>
<td>Clay and ceramic structural product</td>
<td>0.41</td>
</tr>
<tr>
<td>Drying and salting of fish</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Table 5: Horizontal FDI in 1996 for the 25 industries with the highest levels. Measurements are at the national level (treating the entire country as one region). Our estimations include regional variation not shown in this table.
Table 6: Production function estimation on domestic establishments. (4) Olley-Pakes estimation. (5) With industry-region-year clustering. (6) Population of never-exporting firms. Establishment fixed-effects, industry-year, island group-year and year dummy variables are included but not reported.
Table 7: Predicted gains in productivity during 1988-1996 from downstream FDI for industries for which the prediction was 2 percent or greater. For example, 0.03 indicates a 3 percent increase in output attributable to productivity gains from downstream FDI.

<table>
<thead>
<tr>
<th>Industry</th>
<th>Predicted Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Musicals instruments</td>
<td>0.06</td>
</tr>
<tr>
<td>Non-ferrous basic metal</td>
<td>0.03</td>
</tr>
<tr>
<td>Electric generator and electrical motor</td>
<td>0.03</td>
</tr>
<tr>
<td>Communication equipment and apparatus</td>
<td>0.02</td>
</tr>
<tr>
<td>Flour except wheat flour, milled cereals</td>
<td>0.02</td>
</tr>
<tr>
<td>Jewelry</td>
<td>0.02</td>
</tr>
<tr>
<td>Knitting mills</td>
<td>0.02</td>
</tr>
<tr>
<td>Leather tanneries and leather finishing</td>
<td>0.02</td>
</tr>
<tr>
<td>Other electrical appliances</td>
<td>0.02</td>
</tr>
<tr>
<td>Prime movers and engines</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Table 8: Production function estimation on domestic establishments: (1) food products, (2) electronics, and (3) textiles. Establishment fixed-effects and island-year and year dummy variables are included but not reported.

\[
\begin{array}{cccc}
\text{(1)} & \text{(2)} & \text{(3)} \\
\log(\text{output}) & \log(\text{output}) & \log(\text{output}) \\
\text{Downstream FDI (prov.)} & 0.133 & 0.081 & 0.330 \\
& (2.40) & (2.55) & (2.50) \\
\log(\text{labor}) & 0.320 & 0.926 & 0.599 \\
& (9.26) & (15.31) & (4.56) \\
\log(\text{capital}) & 0.108 & 0.140 & 0.103 \\
& (6.54) & (5.73) & (2.35) \\
\log(\text{materials}) & 0.520 & 0.047 & 0.264 \\
& (31.25) & (1.51) & (4.78) \\
\log(\text{energy}) & -0.026 & 0.088 & 0.009 \\
& (2.30) & (3.98) & (0.21) \\
\log(\text{K})\log(\text{K}) & 0.009 & 0.002 & 0.008 \\
& (10.23) & (1.43) & (3.45) \\
\log(\text{L})\log(\text{L}) & 0.014 & 0.038 & 0.044 \\
& (3.26) & (4.86) & (2.78) \\
\log(\text{M})\log(\text{M}) & 0.047 & 0.051 & 0.049 \\
& (45.76) & (26.91) & (13.33) \\
\log(\text{E})\log(\text{E}) & -0.011 & -0.015 & -0.000 \\
& (17.00) & (9.20) & (0.03) \\
\log(\text{K})\log(\text{L}) & 0.037 & 0.024 & -0.002 \\
& (12.29) & (4.43) & (0.16) \\
\log(\text{K})\log(\text{M}) & -0.048 & -0.023 & -0.021 \\
& (30.62) & (8.56) & (3.96) \\
\log(\text{K})\log(\text{E}) & 0.017 & 0.007 & 0.000 \\
& (14.39) & (3.45) & (0.08) \\
\log(\text{L})\log(\text{M}) & -0.078 & -0.100 & -0.094 \\
& (22.78) & (18.80) & (7.51) \\
\log(\text{L})\log(\text{E}) & 0.035 & -0.002 & 0.062 \\
& (13.68) & (0.43) & (7.20) \\
\log(\text{M})\log(\text{E}) & -0.006 & 0.011 & -0.018 \\
& (4.94) & (3.96) & (4.02) \\
\text{Constant} & 2.909 & 3.832 & 4.094 \\
& (22.54) & (18.47) & (10.36) \\
\text{Observations} & 29297 & 11494 & 3621 \\
\text{Number of establishments} & 6041 & 2376 & 762 \\
\text{R-squared} & 0.82 & 0.80 & 0.82 \\
\end{array}
\]

Absolute value of t statistics in parentheses
Table 9: Concentration and prices. Region-product fixed effects (for concentration columns), product fixed-effects (for price columns), and year fixed-effects are included but not reported. FDI measures are calculated at the province level (as done for all other tables) in columns (1)-(7). Because we not have regional variation in prices, FDI measures for price estimations are calculated at the national level (treating the entire country as one region).

Table 10: Profits and output, domestic firms. Establishment fixed-effects and island-year and year dummy variables are included but not reported. We proxy profits with revenue minus wages and the cost of materials and energy.
<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>log(output)</td>
<td></td>
<td></td>
<td>log(profits)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downstream FDI</td>
<td>1.295</td>
<td>0.392</td>
<td>0.851</td>
<td>0.214</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(6.12)</td>
<td>(1.64)</td>
<td>(2.73)</td>
<td>(0.60)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suppliers’ downstream FDI</td>
<td>3.094</td>
<td>2.81</td>
<td>2.129</td>
<td>1.962</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(9.92)</td>
<td>(7.95)</td>
<td>(4.42)</td>
<td>(3.52)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(342.89)</td>
<td>(277.91)</td>
<td>(276.50)</td>
<td>(209.26)</td>
<td>(166.37)</td>
<td>(166.15)</td>
</tr>
<tr>
<td>Obs.</td>
<td>5210</td>
<td>5210</td>
<td>5210</td>
<td>4120</td>
<td>4120</td>
<td>4120</td>
</tr>
<tr>
<td>Number of establishments</td>
<td>1324</td>
<td>1324</td>
<td>1324</td>
<td>1096</td>
<td>1096</td>
<td>1096</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.22</td>
<td>0.23</td>
<td>0.23</td>
<td>0.13</td>
<td>0.13</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Table 11: Profits and output, foreign firms. Establishment fixed-effects and island-year and year dummy variables are included but not reported. We proxy profits with revenue minus wages and the cost of materials and energy.
B Figures

Figure 1: Flow of technology and welfare effects from FDI.
Figure 2: Value added in manufacturing, 1996, by province.
Figure 3: Share of manufacturing value added by foreign firms, by region, 1988 (top) and 1996 (bottom).