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

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January 14, 2004

Abstract

We measure the diffusion of technology through foreign direct investment (FDI) and the effect of that technology on competition and welfare in the host economy. Multinationals seeking to lower input prices and increase vendor competition may transfer technology to local suppliers. Using a panel dataset of Indonesian manufacturing establishments, we find strong evidence of productivity gains, greater competition, and lower prices amongst local firms upstream from foreign entrants. The technology transfer is Pareto improving—value added and output increase for firms in both the supplier and buyer sectors. Further, the technology transfer generates an externality that benefits buyers in *third* sectors downstream from the supply sector as well. This externality may provide a justification for policy intervention to encourage foreign investment.

*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 Levine, David Mowery, Pranab Bardhan, Ann Harrison, James Blalock, Haryo Aswicahyono, and Thee Kian Wei. 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.

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1 Introduction

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 writes 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." These claims have encouraged developing countries to adopt costly programs, such as tax holidays, subsidized industrial infrastructure, and duty exemptions, to attract multinational enterprises.

Is this enthusiasm for FDI warranted? A number of recent empirical studies, which find mixed evidence of technology transfer from FDI, have prompted many observers to conclude it is not. 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.

In contrast, we argue that technology diffusion from FDI is more likely directed to local suppliers than to local competitors, as a strategy to build efficient supply chains for multinationals' overseas operations. By transferring technology to local suppliers, multinationals may be able to improve quality and lower the price of non-labor inputs. Indeed, while multinational enterprises may invest overseas to obtain low-wage labor or to avoid costly barriers to foreign markets, they realize the full benefit of expansion only if the efficiency of supply markets abroad matches or exceeds that of their home manufacturing base. To lower the prices and raise the quality of inputs abroad, multinationals might deliberately transfer technology to local vendors.

Such a strategy would cause foreign technology to diffuse along supply chains, rather than through spillovers to competitors. Indeed, anecdotal evidence from interviews we conducted with multinational and local firm managers in Indonesia suggests close cooperation through vertical linkages. Such cooperation, described in the next section, exemplifies the mechanisms through which learning from FDI can occur vertically.

A cost-reduction motive implies that multinationals transfer technology along the supply chain to suppliers because it confers a private benefit to them. Therefore, unless there is an additional social benefit, there is no case for public subsidies to stimulate technology transfers from multinationals. However, we argue that market imperfections cause multinationals to transfer technology widely inducing heightened competition that benefits the whole economy. Since the multinational does not take this benefit into account, the social benefits from the technology transfer are greater than the private benefits. Without public subsidy, the multinational may transfer less technology than would be socially optimal.

How might the 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 only transferred to 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 the multinational's competitors in the downstream market. The lower input prices may induce entry and therefore more competition in the downstream market, thereby lowering prices and increasing output.

If prices fall enough, the multinational might be worse off by transferring technology to its upstream suppliers. In this case, the multinational would not have an incentive to transfer the technology. Pack and Saggi 2001, however, demonstrate that this concern is not justified under reasonable assumptions. As long as there is not too much entry, profits will rise in both the downstream and upstream markets, which suggests that the new surplus generated from increased productivity and reduced deadweight loss from increased competition might be split between consumers and producers in a pareto-improving distribution.

In this paper we test the hypotheses that there are transfers of technology along the supply chain from FDI, and that the technology transfer leads to pareto welfare improvements in terms lower prices, higher production, and higher profits. 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. Specifically, we test whether the productivity of firms in sectors in a particular market increased when the share of their output sold to foreign-owned firms increased. The results indicate that local-firm productivity rises as the share of output sold to foreign-owned firms rises, which is consistent with the hypothesis that local suppliers acquire technology from the multinationals that buy the local suppliers' products.

The second part of the paper examines the market and welfare effects of FDI technology diffusion, as hypothesized in Pack and Saggi 2001. We first estimate the effect of downstream FDI on upstream market concentration, prices, output, and value added. Further, we estimate the same metrics on firms in sectors downstream of sectors that supply multinational customers. We find that downstream FDI increases output and firm value added of upstream firms, and decreases prices and market concentration in upstream markets. We also find increased output and firm value added of downstream firms, and decreased prices and market concentration in markets downstream of markets supplying multinationals. This finding suggests that FDI leads to pareto improving welfare effects—i.e., benefits for consumers in terms of lower prices and for firms in the form of greater value added—transmitted both up and down the supply chain from the adoption of technology brought with FDI.

We proceed as follows. The next section reviews the extant literature on technology transfer and introduces the conceptual framework for our study. Section 3 provides some background on manufacturing and FDI in Indonesia, and Section 4 describes the data. Section 5 details the identification strategy and results for the productivity effects of FDI. Section 6 reviews the results for the market and welfare effects of FDI, and Section 7 concludes.

2 Conceptual Framework

Most of the literature recognizes two major channels for technology transfer from FDI: horizontal flows to local competitors (sometimes called "spillover" because it is largely an externality), and vertical flows to backwardly linked suppliers. We define technology broadly to mean the managerial practices, production methods, and other tacit and codified know-how by which a firm transforms capital, labor, and materials into a product. Below we describe the mechanisms by which local firms could learn through each channel and summarize the empirical evidence.[1] We first discuss horizontal transfer, which has been the focus of most empirical work, and suggest why recent studies have found mixed evidence of transfer through this channel. We next discuss vertical transfer, the emphasis of this paper, and argue that the incentives of multinational investors would promote technology transfer through this channel. Finally, we describe why vertical transfers would induce competition and the circumstance under which the technology transfer induces a pareto improvement in welfare.

2.1 Horizontal Technology Transfer

Multinational entry may provide positive technological externalities to local competitors through a number of mechanisms. 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.

[1] Kumar 1996, Blomstrom and Kokko 1997, Keller 2001, and Moran 2001 provide extensive literature reviews.

Multinational entry may also hurt local firms. First, foreign firms may hire talent away from local firms, thereby creating a "brain drain." Second, foreign firms, which often pay higher wages, may raise wages for all firms in competitive labor markets (Aitken, Harrison, and Lipsey 1996). If the higher wages do not reflect an improvement of employee capabilities, which may be the case if the multinational faces public pressure in its home market to improve overseas workers' conditions, then firms may substitute capital for labor in an otherwise (prior to the wage increase) inefficient manner.

Empirical studies of technology spillover have found mixed results. The studies, which regress local-firm productivity on within-sector FDI, fall into two categories: those that use cross-sectional data, e.g., Caves 1974, Globerman 1979, and Blomstrom and Wolff 1994, and those that use panel data, e.g., Haddad and Harrison 1993, Kokko 1994, Aitken and Harrison 1999, and Haskel, Pereira, and Slaughter 2002. The former typically find positive correlation between local firm productivity and FDI. However, cross-sectional analysis cannot distinguish whether FDI actually increases local-firm productivity, or whether multinational investors simply invest in inherently more productive sectors. Studies using panel data, which can control for investor selection bias, reach differing conclusions. On one hand, Aitken and Harrison's examination of Venezuelan factories finds net negative benefits to local firms, a result they attribute to the effect of foreign competition. On the other hand, Haskel, Pereira, and Slaughter employ similar methods with a panel dataset of factories in the United Kingdom and draw the opposite conclusion.

Host economy heterogeneity and limitations of production function estimation likely explain the contrary results. First, the technology gap between foreign and domestic firms likely varies by country and industry. In cases in which the gap is 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. In particular, multinationals with non-protectable technology may not enter the market at all if they rely on a technological advantage to sustain rents. Again, the level of technology multinationals bring to the host economy and the degree to which it can be protected will vary widely. Last, production function estimation may confound the productivity gains from technology transfer with the efficiency losses from increased competition. If multinationals capture market share, then local firms may under-utilize existing capacity in the short run. Although local firms will eventually redeploy slack resources, production function estimation will interpret non-utilized resources as a productivity loss in the short run.

2.2 Vertical Technology Transfer

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-sector 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. Empirical analysis, however, is generally limited to small samples, such as that by Lall (1980), which documents technology transfer from foreign firms through backward linkages in the Indian trucking industry. A rare large-sample empirical study is Kugler 2000, which shows that FDI in one sector of Colombian manufacturing can Granger-cause productivity gains in another. Kugler, however, does not identify backward linkages or any particular causal mechanisms for the inter-sector spillover. This study aims to partly fill this gap in the literature.[2]

Anecdotal evidence from interviews with multinational and Indonesian firms points to the specific mechanisms through which vertical technology may occur.[3] An American firm reported that its process of qualifying domestic suppliers involved several stages over a few years. First, the American firm's engineers would visit the local factory to inspect their facilities and suggest needed modifications. Next, sample product was sent to a testing facility in the United States. If the product was approved, the suppliers were sent to overseas training classes to learn the multinational's systems for inventory control, quality control, and cost accounting. Thereafter, the supplier would be asked to produce a small amount of the total production demand. Only after the supplier had successfully established a record of delivering on-time and within-specification would the multinational qualify it as a large-scale supplier.

Managers from a Japanese multinational reported a similar process. They added that it was common for them to introduce good suppliers to affiliate companies in their industrial group, both in Indonesia and in other countries. By doing so, they added, they could increase their suppliers' economies of scale and smooth their capacity utilization. Likewise, the same

[2]Our analysis of vertical technology transfer adopts the methods in Blalock 2002, which finds technology transfer through supply chain in Indonesia. Javorcik 2002 applies the same approach to Lithuanian data and obtains similar results.

[3]We interviewed managers from two American, two Japanese, and two Indonesian firms in Jakarta during July, 2000.

Japanese firm reported that it often used suppliers in Malaysia and Thailand that were referred to it by affiliate companies. This reduced the dependence on local suppliers and ensured that Indonesian vendors were competitive within the region. The goal, noted by the manager, was to guarantee a reliable supply of parts from a handful of the best local firms in Southeast Asia.

Not all of the foreign firms reported success in local procurement. Another Japanese firm noted that it bought very little from local suppliers, other than cardboard boxes and paper packaging. The manager said that, although he would like to buy more locally and faced some pressure to do so, it was just not practical. Most local firms could not meet his requirements for quality, price, and delivery performance. Instead, he preferred to buy from the firm's established vendors in Japan. He added, however, that many of those vendors were themselves producing in Indonesia and surrounding countries.

Indonesian suppliers cited some benefits from selling to foreign customers. One vendor reported that his relationship with a large Japanese firm was valuable because the customer sent engineers from Japan annually to review his production methods and suggest improvements for cost reduction. He added that the Japanese firm's desire for extremely consistent product attributes had prompted him to invest in new machinery imported from Switzerland. In contrast, however, he stated that his relationship with an American buyer had been less successful. The Americans, he complained, had unobtainable goals for cost reduction, did not provide him with sufficient lead time for orders (necessitating that he pay expensive overtime wages), and offered no technical support to meet their requirements. In the end, the American firm rejected much of his supply on quality grounds (he disputed their evaluation), and he voluntarily severed the relationship.

Many of the reported mechanisms for technology transfer through supply chains would apply equally to exports. One Indonesian firm reported that it exported 100 percent of its output to Germany. Its main customer, a large German consumer goods company, reportedly sent efficiency experts to advise on how best to expand production capacity. In fact, during the day of the interview, four product designers from the German customer were at the plant advising how to adapt the product appearance to suit new consumer trends. The Indonesian manager observed that the increased sales, which were largely driven by lower labor costs following the massive devaluation of the rupiah in 1997, had strained his accounting resources. He complained that the higher volume made it difficult for his planners to know if production was on schedule. Consequently, he could not respond quickly to customer requests for time-critical orders. To solve the problem, he had just ordered inventory control software from Europe. When financing the purchase, one of the largest capital investments since building the factory, he had borrowed from the Jakarta branch of an American bank using the German customer's letter of intent to order as evidence of his creditworthiness.[4]

2.3 Market Competition and Welfare Effects of Technology Transfer

We hypothesize that 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 holdup 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 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).

[4] A number of interviewed managers mentioned the role of foreign firms in helping Indonesian suppliers obtain credit during the Asian financial crisis. Because 1996 is the last year of empirical analysis for this study, this role does not affect the results here.

We would thus expect to see direct technology transfer to several suppliers, or a program that makes the technology broadly available to the supply sector. Moreover, technology leakage between the original local technology recipient and its rivals is possible as well. In fact, to the extent that we should expect to see horizontal technology transfer at all, it seems more likely to occur between local supply firms than between foreign and local firms in the end-product market.

Although the multinational has an incentive to aid many suppliers, doing so may inadvertently aid 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 selling to the multinationals' rivals at lower prices in the downstream market. The lower supply prices may induce entry and increase competition so that prices fall in the downstream markets. This increases surplus by lowering costs of production and by reducing deadweight loss from imperfect competition. In addition, 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.

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 upstream sector 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 note that in some cases, firms may be able to capture some of the surplus also because the benefits of lower input prices and higher volume outweigh the costs of greater competition. Hence, we would expect to see firm value added—a proxy for profitability—rise.[5] Figure 1 illustrates the total effect of FDI.

If this is true, then technology transfer to suppliers is in multinationals' interest, but the benefits accrue widely to all sectors 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.

2.4 Testable Implications of Technology Transfer through Supply Chains

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 more value added in these beneficiary sectors, as well as in sectors downstream of them. The method-

[5] We define value added 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.

ology for testing the productivity effects is described in Section 5, and the methodology for testing the market and welfare effects is described in Section 6. 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 remainder of this section provides some background on Indonesian manufacturing and foreign investment policy with the intent of highlighting institutional changes that contribute to the longitudinal variation we exploit in the econometric identification. Readers not interested in this background may skip ahead without loss of continuity.

3.1 Growth in Manufacturing

The Indonesian economy and the manufacturing sector grew dramatically from the late 1970's until the recent financial crisis.[6] 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 1996 (Nasution 1995). Government initiatives to reduce dependency 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 (Goeltom 1995).

3.2 Foreign Investment Policy

Over the past 40 years, government regulation has shifted dramatically from a policy antagonistic to FDI to a policy actively encouraging it (Wie 1994a; 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.

The first reforms came in 1967 as part of the "New Order" economic regime of Suharto, who had purged the government of left-wing elements during his rise to power. Many of the assets nationalized after independence were returned and the enactment of Foreign Investment Law No. 1 in 1967 established a licensing procedure for foreign operations that remains the basis of current policy. Although, in principle, Foreign Investment Law No. 1 allowed FDI with few restrictions, the process of obtaining an operating license was onerous in practice. Nevertheless, FDI, primarily from Japan, did begin to flow into labor-intensive sectors, such as textiles.

Negative nationalistic reaction to the foreign investment and complaints from local firms

[6] Hill (1988) and Pangestu and Sato (1997) provide detailed histories of Indonesian manufacturing from the colonial period to the present.

prompted the government to impose restrictions, particularly on entrants that produced for the local market. Opposition to FDI culminated in violent protests during the 1974 visit to Jakarta of Japanese Prime Minister Kakuei Tanaka. Suharto responded with a presidential decree restricting the sectors open for new foreign investment and limiting the maximum allowable foreign equity in manufacturing operations. Most notably, all new investment had to take the form of a joint venture with Indonesian partners, who were required to own at least 20 percent of equity initially and 51 percent within 10 years of operation.

Because of the restrictions on equity holdings, foreign firms adopted other mechanisms for controlling their operations. Japanese investors, for example, would maintain effective control of joint ventures in which they had minority equity stakes by increasing the debt-to-equity ratio and licensing or leasing production technology and equipment (Wie 1994b). Embedded in such arrangements was the option to withhold the financing, equipment, and know-how needed for the plant's viability if the foreign investor considered it did not have effective control.

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 1974 regulations. 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 sectors. The exemptions typically allowed a lower minimum initial Indonesian equity stake, a lower long-term Indonesian equity target, and a longer period to achieve that target (often as long as 20 years). 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 sectors were allowed to establish and maintain in perpetuity operations with 100 percent equity. In a handful of sectors deemed strategically important, a nominal 5 percent Indonesian holding was required with no further requirement to divest.

3.3 Changes in Investment Following Initiation of Reforms

The reforms have been accompanied by large increases in both the absolute and the relative value of foreign production in Indonesian manufacturing. Figure 2 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.[7] The primary data are taken from an unpublished 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

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

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.[8] 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 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 Appendix A and summarized for 1988 and 1996 in Table 1. The table indicates a large increase in the number of foreign factories, which increases from 276 in 1988 to 888 in 1996. On average, foreign factories are bigger (as measured by value added, employees, and capital),

[8]Because 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.

more capital intensive (as measured by capital per employee), more productive (as measured by value added per employee), and more export-oriented (as measured by percentage of production exported).

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 economic sector and how this value is distributed to other economic sectors. The IO tables divide manufacturing activity into 89 sectors, and BPS provides concordance tables linking the 1990 and 1995 IO codes to 5-digit ISIC codes as described in Appendix B.

We deflated output, materials, energy, and capital to express values in real terms. Appendix B 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 could not be constructed. For example, establishments with missing wage data could be used for output regression but not for value added 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. Appendix B 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 effect, year-region 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 sectors and firms, and the year-region dummies control for local market changes over time common to all firms in that region. Specifically, we specify the establishment-level translog production function as:

$$\begin{aligned} \ln Y_{it} =& \beta_0 Downstream\_FDI_{jrt} + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 \ln M_{it} + \beta 4 \ln E_{it} + \\ & \beta_5 \ln^2 K_{it} + \beta_6 \ln^2 L_{it} + \beta_7 \ln^2 M_{it} + \beta_8 \ln^2 E_{it} + \\ & \beta_9 \ln K_{it} \ln L_{it} + \beta_{10} \ln K_{it} M_{it} + \beta_{10} \ln K_{it} E_{it} + \\ & \beta_{11} \ln L_{it} M_{it} + \beta_{12} \ln L_{it} E_{it} \beta_{13} \ln M_{it} E_{it} + \lambda_{gt} + \alpha_i + \gamma_t + \varepsilon_{it} \end{aligned} \tag{1}$$

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 at time t, and λ_{gt} is a dummy indicator for the interaction of each of the four island groupings g and year t, α_i is a fixed effect for factory i, and γ_t is a dummy variable for year t. A positive coefficient on downstream FDI indicates that it is associated with higher productivity. 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 initially assume that ε_{it} is *i.i.d.*, but we later control for simultaneity bias that may arise if ε_{it} is correlated with other right-hand-side variables. 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 sector's output in a particular market that is produced by foreign-owned firms. Specifically,

$$Horizontal\_FDI_{jrt} = \frac{\sum_{i \in jrt} Foreign\_OUTPUT_{it}}{\sum_{i \in jrt} OUTPUT_{it}} \quad (2)$$

where $i \in jrt$ indicates a factory in a given sector, 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 industrial sector, 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 23 provinces on the main island groups of Sumatra, Java and Bali, Kalimantan, and Sulawesi, to be a separate region. Because there is little industrialization in the rural outer islands of the nation, we have not included them in the sample.

While horizontal FDI is straightforward to measure, downstream FDI is somewhat more complicated. In principle, we would like to measure that share of a firm's output that is sold to foreign-owned firms. However, we would then have to worry about the endogeneity of a particular factory's decision to sell to multinational customers. Moreover, and more importantly, this information is not available in our dataset or, for that matter, in most datasets. Instead, we proxy the share of an establishment's output sold to foreign firms with the share of a sector's output in a market that is sold to foreign firms.

How do we measure the share of sector j's output, in market k, that is sold to foreign firms in year t? From the IO tables we know the amount that firms in one sector purchase from each of the other sectors. We also know the share of output in sector j that is produced by foreign-owned firms, i.e, horizontal FDI. If we assume that a firm's share of a sector's use of a particular input is equal to its output share, then a measure of the share of a sector's output sold to foreign firms is the sum the output shares purchased by other sectors multiplied by the share of foreign output in each purchasing sector.

For example, consider three sectors: wheat flour milling, pasta production, and baking. Suppose that half of the wheat flour sector output is purchased by the bakery sector and the other half is purchased by the pasta sector. Further, suppose that the bakery sector has no foreign factories but that foreign factories produce half of the pasta sector output. The calculation of downstream FDI for the flour sector would yield $0.25 = 0.5(0.0) + 0.5(0.5)$. Formally, equation 3 expresses the calculation for sector j, region r, at time t.

$$Downstream\_FDI_{jrt} = \sum_{k} \alpha_{jkt} Horizontal\_FDI_{jrt} \qquad (3)$$

where α_{jkt} is the proportion of sector j output consumed by sector k. Horizonal FDI is our measure of the share of a sector's output in a local market that is produced by foreign-owned firms. Values of α_{jkt} before and including 1990 follow from the 1990 IO table, values of α_{jkt} from 1991 through 1994 are linear interpolations of the 1990 and 1995 IO tables, and values of α_{jkt} from 1995 on are from the 1995 IO table. Recall that α_{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 industrial sector, region, 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 2 shows some summary statistics for these two measures of FDI and a third one described in the next section. Table 3 displays the correlation between them. We note that sectors often buy from themselves. That is, the value of sector index j and index k may be the same. In sectors that sell heavily to themselves, some overlap between the three measures of FDI exists. To limit the estimation to the non-overlapping variation in the three measures, we include both downstream FDI and horizontal FDI in our examination of productivity.

5.2 Productivity Results

Table 5 reports the results of estimating Equation 1 using an establishment-level fixed-effect estimator on a sample of domestic firms.[9] 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. 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 over eight 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 common, suggesting that the actual realized productivity gain might be close to 2 percent (.2 times .087).

We next perform several checks to examine the robustness of these results.

5.2.1 Potential Simultaneity Bias

The positive correlation between downstream FDI and domestic factory productivity could result from multinationals selectively locating in areas where supplier productivity was improving. That is, productivity shocks could simultaneously determine downstream FDI and measured performance. Fixed-effect estimation allows some establishments to be inherently more productive than others, but assumes that the conditions that make some factories "better" remain unchanged. Suppose, however, that establishments were affected by productivity shocks during the interim of the panel. Such a shock, e.g., the hiring of a skilled manager or the discovery of a better production technique, is potentially observable to both the supplier

[9] A Hausman test showed significant correlation between individual establishment effects and the other regressors, thereby rejecting a random-effects model.

and potential investors, but would remain unobservable to the econometrician. If either local factories or multinationals reacted to those shocks by adjusting inputs or investment, then the error term in Equation 1 would not be independent of other right-hand-side variables. Of particular concern, such simultaneity would introduce correlation between the error term ε_{it} and $Downstream\_FDI_{it}$.

The error term in Equation 1 can be decomposed to show potential sources of productivity shocks:

$$\varepsilon_{it} = \epsilon_i + \epsilon_{jt} + \epsilon_{rt} + \epsilon_{it}$$

One can consider the error term for factory i at time t to consist of four (and potentially more) sources of error: ϵ_i, a static "fixed-effect" for factory i, ϵ_{jt}, a shock to industry j at time t, ϵ_{rt}, a shock to region r at time t, and a fully idiosyncratic shock, ϵ_{it}, affecting factory i at time t. The fixed-effect estimator controls for the error term ϵ_i by only admitting variation about a factory's mean. We control for the industry and region shocks, such as sudden price changes in key inputs, political strife, or government intervention, by including dummy variables for the interaction of year and industry or the interaction of year and region.

Other variation in the error terms, such as a factory-specific shock or a shock to a particular industry in a particular region, is captured in the idiosyncratic error term, ϵ_{it}. In practice, it seems unlikely that ϵ_{it} 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.

Olley and Pakes 1996 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. Appendix C summarizes the Olley-Pakes estimation approach. Although it is possible to obtain the return to capital variables with an optional second stage of estimation, we do not implement that here since capital is not a variable of interest[10]

Column (4) of Table 5 shows the results of the Olley-Pakes estimation. The effect of downstream FDI is statistically identical to that measured without the Olley-Pakes correction, suggesting that simultaneity bias is not driving the contribution of downstream FDI to upstream supplier productivity.

5.2.2 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 assist their local suppliers in accessing export markets.[11].

To remove any effects of exporting, we estimated Equation 1 on a sample including only

[10] An additional concern expressed in Olley and Pakes 1996 is that of survivorship bias. If downstream FDI was 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.

[11] See Clerides, Lach, and Tybout 1998, Bernard and Jensen 1999, and Aw, Chung, and Roberts 2000 for discussion of firm learning and exporting

never-exporting domestic firms. Column (5) of Table 5 shows that the positive effect of downstream FDI holds and suggests that exports are not a viable alternative explanation for the observed productivity gains.

5.2.3 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 *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 $Region\_FDI_{rt}$, the share of foreign firm share of industrial output in all industries, for $Downstream\_FDI_{jrt}$. Column (6) of Table 5 shows the insignificant coefficient on $Region\_FDI$, indicating that public goods do not have a major impact on local firm productivity.

5.2.4 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 the estimation uses 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. Rather, one can observe only the overall effect. 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 have divided the full sample into three groups: a food group, a textile group, and an electronics group.[12] Each group comprises several of the 39 input-output table industry codes upon which the calculation of downstream FDI was based. Industries without sufficient variation, either within or between, in downstream FDI, or with few observations were not included. Hence, a number of industries, such as paper, chemicals, and metals, could not be included in a group. Table 6 shows the results of estimating Equation 1 on the three samples.

The results indicate a strong benefit from downstream FDI in the food and electronics sectors. The effect for the textile sector is positive, but not statistically significant.

[12]These groups correspond to the 31, 32, and 38 2-digit ISIC codes respectively, which span several IO codes each.

6 Market and Welfare Effects

The previous section, we believe, provides convincing 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.

6.1 Methods and Identification

Again, we are not able to directly measure the transfer of technology. Rather, we measure the sectors 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 sector. Specifically, we estimate several reduced form models. Equation 4 measures the effect of FDI on concentration.

$$HI_{srt} = \beta_0 Downstream\_FDI_{jrt} + \alpha_{sr} + \lambda_{gt} + \gamma_t + \varepsilon_{srt} \tag{4}$$

where HI_{srt} is the Herfindahl concentration index for 5-digit ISIC sector s in region r in time t. Note that we use the 89 IO table codes, indicated by subscript j, to define sectors 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. α_{sr} is a fixed-effect for the interaction of sector s and region r, λ_{gt} is intended to capture time-variant conditions affecting particular island groupings of the country, and ε_{srt} is an error term.

Equation 5 measures the effect of FDI on prices.

$$Price_{st} = \beta_0 Downstream\_FDI_{jt} + \alpha_s + \gamma_t + \varepsilon_{st} \tag{5}$$

Because prices are not available at the regional level, we use $Downstream\_FDI$ 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 value added respectively. We define value added 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.

$$Y_{it} = \beta_0 Downstream\_FDI_{jrt} + \alpha_i + \lambda_{gt} + \gamma_t + \varepsilon_{it} \tag{6}$$

$$VA_{it} = \beta_0 Downstream\_FDI_{jrt} + \alpha_i + \lambda_{gt} + \gamma_t + \varepsilon_{it} \tag{7}$$

We then consider the hypotheses regarding feedback to the downstream market, 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 sectors purchasing from a particular supply sector on the performance of other sectors supplied by that sector. In other words, we ask what is the effect of buying from sectors that supply multinationals and call this the suppliers' downstream FDI. We measure suppliers' downstream FDI as the value of downstream FDI in each of the sectors upstream of the focal sector weighted by the share of focal sector inputs provided by that sector.

$$Suppliers'\_Downstream\_FDI_{jrt} = \sum_k \alpha_{jkt} Downstream\_FDI_{jrt} \tag{8}$$

where α_{jkt} is the share of sector j inputs obtained from sector k.

We then re-estimate equations 4-7 replacing downstream FDI with suppliers' downstream

FDI to gauge the welfare effects in sectors downstream of those sectors supplying multinationals. We calculate the effect of horizontal FDI on the same metrics to capture the effect of direct competition with foreign firms on domestic industry.

6.2 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 value added is calculated at the firm level.

6.2.1 Concentration and Price

Table 7 contains the estimations of equations 4 and 5. Columns (1)-(5) 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 sectors downstream of those upstream markets also show increases in competition.

Columns (6)-(9) 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, in-sector horizontal FDI, downstream FDI, and supplier's downstream FDI are all associated with a decline in prices. In other words, FDI competition lowers prices in the entry market, the supply markets, and other markets downstream of the supply markets.

6.2.2 Output and Value Added

We next estimate establishment output and value added. Given that FDI lowers prices, one expects to see an increase in output. Indeed, columns (1)-(5) of Table 8 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. In isolation, in-sector horizontal FDI has no effect on volume. However, as noted in column (5), when horizontal FDI is considered together with downstream FDI and suppliers' downstream FDI, it lowers output. This is likely to due to some correlation among the three measures of FDI. Whereas downstream FDI and suppliers' downstream FDI reflect the benefits of technology transfer, horizontal FDI also has competitive effect if foreign firms take away market share from domestic rivals. Columns (5)-(10) 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 value added, suggesting that firms are capturing some of the welfare benefits of vertical technology transfer. Domestic firms, however, fare far worse when they compete directly with foreign entrants as evidenced the lower value added associated with horizontal FDI.

Table 9 estimates Equations 6 and 7 on the population of just foreign firms. To avoid the obvious endogeneity that an establishment's own foreign ownership adds to horizontal FDI, we have only included *other* firms foreign equity in the calculation. As was the case with domestic firms, an increase in downstream FDI and suppliers' downstream FDI is associated with increases in both volume and value added. As with domestic firms, there is no direct effect of horizontal FDI in isolation. However, when horizontal FDI is included together with downstream FDI and suppliers' downstream FDI (thereby removing any part of horizontal FDI that might overlap with the downstream FDI measures), it significantly reduces both output and value added. We interpret this to mean that foreign firms benefit from the entry of other multinationals *provided* that the new entrants do not directly compete in the same sector.

7 Summary and Implications

Our findings have two key implications. First, FDI is a source of technology in emerging markets. Second, this technology generates welfare benefits that may warrant pubic policy intervention.

Both the econometric analysis and the manager interviews suggest that vertical supply chains are a conduit for technology transfer from FDI. Indonesian factories in industries in regions with growing downstream FDI experience greater productivity growth, *ceteris paribus*, than other factories. This finding is consistent with the incentives of multinational enterprises, which only realize the full benefit of investment abroad if they can procure high-quality inputs at low cost. To build efficient supply chains overseas, many multinationals will strategically transfer technology to local vendors.

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 show 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 will be less than the socially optimal amount without intervention.

On the basis of the outcomes we have observed, we conclude that host economy policy-makers 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

Aitken, Brian, Ann E. Harrison, and Robert E. Lipsey (1996): "Wages and Foreign Ownership: A Comparative Study of Mexico, Venezuela, and the United States," *Journal of International Economics*, 40(3-4), 345–371.

Aitken, Brian J., and Ann E. Harrison (1999): "Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela," *American Economic Review*, 89(3), 605–618.

Aw, Bee Yan, Sukkyun Chung, and Mark J. Roberts (2000): "Productivity and Turnover in the Export Market: Micro-level Evidence from the Republic of Korea and Taiwan (China)," *The World Bank Economic Review*, 14(1), 65–90.

Bernard, Andrew B., and J. Bradford Jensen (1999): "Exceptional Exporter Performance: Cause, Effect, or Both?," *Journal of International Economics*, 47(1), 1–25.

Blalock, Garrick (2002): "Technology Adoption from Foreign Direct Investment and Exporting: Evidence from Indonesian Manufacturing," Ph.D. thesis, University of California, Berkeley, Haas School of Business.

Blomstrom, Magnus, and Ari Kokko (1997): *How Foreign Investment Affects Host Countries*. World Bank International Economics Dept., International Trade Division, Washington, DC.

Blomstrom, Magnus, and Edward N. Wolff (1994): "Multinational Corporations and Productivity Convergence in Mexico," in *Convergence of Productivity: Cross-National Studies and Historical Evidence*, ed. by W. J. Baumol, R. R. Nelson, and E. N. Wolff. Oxford University Press, New York.

Caves, Richard E. (1974): "Multinational Firms, Competition and Productivity in Host-Country Markets," *Economica*, 41(162), 176–193.

Clerides, Sofronis K., Saul Lach, and James R. Tybout (1998): "Is Learning by Exporting Important? Micro-Dynamic Evidence from Colombia, Mexico, and Morocco," *Quarterly Journal of Economics*, 113(3), 903–947.

Globerman, Steven (1979): "Foreign Direct Investment and Spillover Efficiency Benefits in Canadian Manufacturing Industries," *Canadian Journal of Economics*, 12(1), 42–56.

Goeltom, Miranda S. (1995): *Indonesia's Financial Liberalization: An Empirical Analysis of 1981-88 Panel Data*, Iseas Current Economic Affairs Series. ASEAN Economic Research Unit Institute of Southeast Asian Studies, Singapore.

Haddad, Mona, and Ann Harrison (1993): "Are There Positive Spillovers from Direct Foreign Investment? Evidence from Panel Data for Morocco," *Journal of Development Economics*, 42(1), 51–74.

Haskel, Jonathon E., Sonia C. Pereira, and Matthew J. Slaughter (2002): *Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms?*, Working Paper 8433. National Bureau of Economic Research, Cambridge, MA.

Hill, Hal (1988): *Foreign Investment and Industrialization in Indonesia*, East Asian Social Science Monographs. Oxford University Press, Singapore and New York.

Javorcik, Beata Smarzynska (2002): "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages," Working Paper 2923, World Bank, Washington, DC.

Keller, Wolfgang (2001): "International Technology Diffusion," Working Paper 8573, National Bureau of Economic Research, Cambridge, MA.

Kenney, Martin, and Richard L. Florida (1993): *Beyond Mass Production: The Japanese System and Its Transfer to the U.S.* Oxford University Press, New York.

Kokko, Ari (1994): "Technology, Market Characteristics, and Spillovers," *Journal of Development Economics*, 43(2), 279–293.

Kugler, Maurice (2000): "The Diffussion of Externalities from Foreign Direct Investment: Theory Ahead of Measurement," Discussion papers in economics and econometrics, Department of Economics, University of Southampton.

Kumar, Nagesh (1996): "Foreign Direct Investments and Technology Transfers in Development: A Perspective on Recent Literature," Discussion paper series, The United Nations University, Institute for New Technologies.

Lall, Sanjaya (1980): "Vertical Inter-Firm Linkages in LDCS: An Empirical Study," *Oxford Bulletin of Economics and Statistics*, 42, 203–226.

Macduffie, John Paul, and Susan Helper (1997): "Creating Lean Suppliers: Diffusing Lean Production through the Supply Chain," *California Management Review*, 39(4), 118–151.

Moran, Theodore H. (2001): *Parental Supervision: The New Paradigm for Foreign Direct Investment and Development.* Institute for International Economics, Washington, DC.

Nasution, Anwar (1995): "The Opening-up of the Indonesian Economy," in *Indonesian Economy in the Changing World*, ed. by D. Kuntjoro-Jakti, and K. Omura, vol. 32. Institute of Developing Economies, Tokyo.

Olley, G. Steven, and Ariel Pakes (1996): "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica*, 64(6), 1263–1297.

Pack, Howard, and Kamal Saggi (2001): "Vertical Technology Transfer Via International Outsourcing," *Journal of Development Economics*, 65(2), 389–415.

Pangestu, Mari (1996): *Economic Reform, Deregulation, and Privatization: The Indonesian Experience*. Centre for Strategic and International Studies, Jakarta.

Pangestu, Mari, and Yuri Sato (1997): *Waves of Change in Indonesia's Manufacturing Industry*. Institute of Developing Economies, Tokyo.

Pavcnik, Nina (2001): "Trade Liberalization, Exit, and Productivity Improvements: Evidence from Chilean Plants," *Review of Economic Studies*, forthcoming.

Rodrik, Dani (1999): "The New Global Economy and Developing Countries: Making Openness Work," Policy Essay 24, Overseas Development Council; Johns Hopkins University Press, Washington, DC.

Wie, Thee Kian (1994a): "Intra-Regional Investment and Technology Transfer in Indonesia," in *Symposium on Intra-Regional Investment and Technology Transfer*, ed. by K. Yanagi, pp. 137–166, Kuala Lumpur. Asian Productivity Organization.

——— (1994b): *Technology Transfer from Japan to Indonesia*. International Research Center for Japanese Studies, Kyoto.

World Bank (1993): "Foreign Direct Investment—Benefits Beyond Insurance," Development Brief 14, Development Economics Vice-Presidency, Washington, DC.

A Data Appendix

A.1 Product Class, Location, and Age

The main product class of each establishment is identified by 5-digit International Standard of Industrial Classification (ISIC) codes published by the United Nations Industrial Development Organization (UNIDO). The ISIC standard divides manufacturing activity into 329 codes at the 5-digit level.[13] The data include plant age and location at the province and *kabupaten* (district) level. The province and district codes divide the country into 27 and 304 areas respectively. The analysis in this paper uses province to identify region.[14]

A.2 Ownership

Two survey questions relate to establishment ownership. First, establishments report whether they operate under a domestic or a foreign investment license. All new enterprises in Indonesia must obtain an operating license from *Badan Koordinasi Penanaman Modal* (BKPM), the Investment Coordinating Board. Establishments funded with any foreign investment operate under *Penanaman Modal Asing* (PMA), foreign capital investment licenses. Establishments with only domestic investment obtain *Penanaman Modal Dalam Negeri* (PMDN), wholly domestic capital investment licenses. Second, each establishment reports the percentage of foreign equity.[15] Establishments with more than 20 percent foreign equity were defined as foreign. This definition yielded a sample of foreign factories very similar to those operating with PMA licenses. Estimation with foreign plants defined as those with any foreign equity, or those with more than 50 percent foreign equity, yielded nearly identical results.

A.3 Capital

The survey asks for the book value and current replacement value of fixed assets. Respondents report assets in five categories: land, buildings, machinery and equipment, vehicles, and other assets. The value of investment is also reported yearly.

A.4 Labor and Wages

The numbers of production and non-production workers are reported in all years. Workers are categorized as either paid or unpaid (e.g., family members). In many years, the labor force is broken down by gender. In 1995-1997, the highest level of education obtained by all workers is available. In 1996, the highest degree and field of specialization for research and development workers are recorded.

[13] ISIC codes are revision 1 codes prior to 1990 and revision 2 codes thereafter. The method of concordance between the two revisions is discussed in Appendix B.

[14] Following the independence of East Timor, there are now 26 provinces and 291 districts.

[15] The source country of foreign capital is reported only in the 1988 survey. Although the survey instruments asked for this information in most years, BPS keypunched the responses in just 1988. Sadly, BPS has destroyed the original paper survey responses, so this information cannot be retrieved.

Cash and in-kind wages are available for production and non-production workers in all years. In most years, wage payments are detailed in four categories: normal wages, overtime, gifts and bonuses, and other payments.

A.5 Materials and Energy

The value of all consumed materials is reported every year. The data also indicate the quantity and price of consumed petroleum products, e.g., gasoline and lubricants, and purchased and self-generated electricity.

A.6 Output

The nominal rupiah value of production output is available every year.

B Data Cleaning

This section provides more detail on the construction and cleaning of the dataset.

B.1 Construction of Price Deflators

Output, materials, and capital are deflated to express values in real terms. The deflators are based on *Indeks Harga Perdangangan Besar* (IHPB), wholesale price indexes (WPI), published monthly in BPS's *Buletin Statistik Bulanan Indikator Ekonomi*, the Monthly Statistical Bulletin of Economic Indicators. To calculate WPI, BPS field officers interview representative firms in all provinces to collect prices for five categories of commodities: agriculture, manufacturing, mining and quarrying, imports, and exports. In total, prices are available for 327 commodities, 192 of which are manufactured commodities.

B.1.1 Output, Materials, and Energy Deflators

Nominal rupiah output and materials values are deflated using the WPI for the nearest corresponding manufactured commodity. BPS officials provided an unpublished concordance table mapping the 192 WPI commodity codes to the 329 5-digit ISIC product codes. Energy is deflated using Indonesian petroleum prices.

B.1.2 Capital Deflators

Fixed assets are deflated using the WPI for manufactured construction materials and imported machinery. Specifically, the capital deflator combines the WPI for construction materials, imported electrical and non-electrical machinery, and imported transportation equipment. We weighted these price indexes by the average reported value shares of building and land, machinery, and vehicle fixed assets in the SI survey to obtain an annual capital deflator.

B.2 Correction for Outliers and Missing Values in Industrial Survey

We have cleaned key variables to minimize noise due to non-reporting, misreporting, and obvious mistakes in data keypunching. A three-stage cleaning process was used for capital, labor, materials, and energy. First, the earliest and latest years in which a plant reported were identified, and interpolation was used to fill-in up gaps of up to two missing years within the reporting window. If more than two continous years of data were missing, the factory was dropped from the sample. The first stage of cleaning removed about 15 percent of the total sample. Second, sudden spikes in key data values likely attributable to keypunch error (often due to an erroneously added or omitted zero) were corrected with interpolation. Third, plants with remaining unreasonably large jumps or drops in key variables not accompanied by corresponding movements in other variables (for example, large increases in labor not accompanied by any increase in output) were dropped. This third stage removed about 10 percent of the sample.

The replacement value of fixed assets is used as the measure of capital stock for most factories. For the few factories that reported only the book value of fixed assets, those figures were used instead.

The percentage of foreign equity in the establishment was cleaned to remove erroneously added or omitted zeros resulting from keypunch error. For example, a factory with foreign equity reported over time as 100, 100, 10, and 100 percent was cleaned to show 100 percent in all years.

B.3 Concordance of Rev. 1 and Rev. 2 ISIC Codes

The industrial survey reports revision 1 ISIC codes prior to 1990 and revision 2 codes thereafter. Attempts to create a concordance table at the 5-digit level from rev. 1 to rev. 2 codes yielded disappointing results. Comparing code changes for the same establishment before and after 1990 showed that the concordance table predictions were incorrect as often as half the time. Rather than accept the noise introduced by these mistakes, the analysis attempts to assign each establishment's actual rev. 2 code to its observations in 1988-1989. Specifically, for each establishment that appears in either 1988 or 1989, the analysis looks for the earliest appearance of the same establishment in 1990 and later years. In most cases, the rev. 2 code from the 1990 observation could be used. If the establishment did not appear in 1990, the rev. 2 code from 1991 or 1992 was used. If the establishment did not appear between 1990 and 1992, it was dropped. This process greatly improved the precision of ISIC code assignments at the cost of dropping about 5 percent of the 1988-1989 sample. Since the dropped establishments appear in only one or two years anyway, the 5 percent loss has little effect on the results.

B.4 Concordance of Input-Output Table Code and ISIC Codes

The IO table was published in 1990 and 1995 with four variants: domestic transactions at producer prices, domestic transactions at purchaser prices, domestic and export transactions at producer prices, and domestic and export transactions at purchaser prices. The analysis here considers domestic transactions at producer prices.

Both the 1990 and 1995 IO tables classified industrial production into 89 categories. To merge the IO table with the SI, first the 1995 IO table codes were concorded with the 1990 IO table codes. Next, the 1990 IO table codes were concorded with the 329 5-digit ISIC codes reported in the SI. The 1990 IO codes were used to define industries in the analysis.

C Olley-Pakes Estimation

Although a full description of Olley-Pakes estimation is beyond the scope of this paper (interested readers are referred to Olley and Pakes 1996), the steps implemented here are briefly outlined below.[16]

The Olley-Pakes estimation consists of three stages. First, investment is used as a proxy for idiosyncratic shocks to determine the contribution of variable inputs (labor and materials) conditional on the shock and state variables (capital and downstream FDI). Second, the effect of state variables on factory exit is estimated with a probit model to control for self-selection bias in plant closings. The concern here is that factories with certain state attributes, such as low levels of capitalization, may be more likely to close if they experience a negative shock. Third, the contribution of state variables is calculated conditional on the prior period's shock and the likelihood of closure. The assumption driving the identification in this stage is that state variables respond to shocks in a lagged manner. That is, the unexpected portion of the current-period shock does not immediately affect capital or downstream FDI. Rather, only investment in the current period, which yields capital or downstream FDI in the subsequent period, is affected.

STAGE 1

The estimation starts with a Cobb-Douglas production function

$$\begin{aligned} y_{it} = \beta_0 + \beta_l l_{it} + \beta_m m_{it} + \beta_k k_{it} + \\ \beta_v Downstream\_FDI_{jrt} + \omega_{it} + \eta_{it} \end{aligned} \tag{9}$$

where ω_{it} is the factory's idiosyncractic productivity shock (that could affect the factory's choice of freely variable inputs) and η_{it} is measurement error (or error that does not affect the factory's choice of inputs), and lower case variable names represent logs. Olley and Pakes show that investment is monotonically increasing in ω_{it} and can hence be used a proxy for the shock conditional on state variables. That is, investment, i, can be expressed as a function of the state variables and the shock.

$$i_{it} = i_{it}(\omega_{it}, k_{it}, Downstream\_FDI_{jrt}) \tag{10}$$

Provided that $i_{it} > 0$, investment can be inverted to reveal ω_{it}.

$$\omega_{it} = h_{it}(i_{it}, k_{it}, Downstream\_FDI_{jrt}) \tag{11}$$

Conditioning output on ω_{it} and the state variables yields the following semi-parametric estimation.

$$y_{it} = \beta_l l_{it} + \beta_m m_{it} + \phi_{it}(i_{it}, k_{it}, Downstream\_FDI_{jrt}) + \eta_{it} \tag{12}$$

where

$$\begin{aligned} \phi_{it}(i_{it}, k_{it}, Downstream\_FDI_{jrt}) = \beta_0 + \beta_k k_{it} + \beta_v Downstream\_FDI_{jrt} + \\ h_{it}(i_{it}, k_{it}, Downstream\_FDI_{jrt}) \end{aligned} \tag{13}$$

[16] The analysis here follows the Olley-Pakes estimation implementation in Pavcnik 2001.

Since the error term η_{it} is uncorrelated with the inputs, estimation of Equation 12 provides unbiased estimates of β_l and β_m. We use a third-order polynomial expansion in i_{it}, k_{it}, and $Downstream\_FDI_{jrt}$ to estimate ϕ_{it}.

STAGE 2

The second stage considers factories' decision each period of whether to continue operation or exit the market, and then calculates the returns to the quasi-fixed inputs. Factories will continue operation only if the expected value of continuing operation exceeds the liquidation value of the assets. Conditional on the state variables, the expected value of continued operation will increase monotonically with the factory's productivity. Hence, the factory's decision to continue or exit can be expressed in terms of its productivity: the factory will operate only if its productivity is greater than a threshold level, $\varpi_{it}(k_{it}, Downstream\_FDI_{jrt})$, that is revealed at the beginning of each period. Otherwise, the factory will sell its assets and exit. Letting $\chi_{it} = 1$ if factory i survives in period t and $\chi_{it} = 0$ if it exits, one can estimate survival probabilities.

$$
\begin{aligned}
Pr\{\chi_{it+1} &= 1|\varpi_{it}(k_{it}, Downstream\_FDI_{jrt})\} \qquad (14)\\
&= Pr\{\omega_{it+1} > \varpi_{it}(k_{it}, Downstream\_FDI_{jrt}|\varpi_{it+1}(k_{it}, Downstream\_FDI_{jrt}, \omega_{it})\}\\
&= \rho_{it}\{\varpi_{it+1}(k_{it}, Downstream\_FDI_{jrt}, \omega_{it})\}\\
&= \rho_{it}(i_{it}, k_{it}, Downstream\_FDI_{jrt})\\
&\equiv P_{it}
\end{aligned}
$$

The third equality follows from the fact that both the factory's exit productivity threshold, ϖ_{it+1}, and productivity shock, ω_{it}, are functions of i_{it}, k_{it}, and $Downstream\_FDI$. We estimate P_{it} by performing a probit regression of χ_{it} on a third-order polynomial expansion of i_{it}, k_{it}, and $Downstream\_FDI_{jrt}$.

We must still obtain estimates β_k and β_v conditional on ω and survival. Consider the expectation of $y_{t+1} - \beta_l l_{it+1} - \beta_m m_{it+1}$, the output less the contribution of labor and materials (calculated in the first stage), conditional on capital, downstream FDI, and survival.

$$
E[y_{t+1} - \beta_l l_{it+1} - \beta_m m_{it+1}|k_{it+1}, Downstream\_FDI_{jrt+1}, (\chi_{it+1} = 1)
$$

$$
\begin{aligned}
&= \beta_0 + \beta_k k_{it+1} + \beta_v Downstream\_FDI_{jrt+1} + E[\omega_{it+1}|\omega_{it}, \chi_{it+1} = 1] \qquad (15)\\
&= \beta_0 + \beta_k k_{it+1} + \beta_v Downstream\_FDI_{jrt+1} + g(\varpi_{it+1}, \omega_{it})
\end{aligned}
$$

where $g(\varpi_{it+1}, \omega_{it})$ is the expectation of ω_{it+1} conditional on the prior period productivity and survival. Inverting ρ_{it} to reveal ϖ_{it+1} gives:

$$
\begin{aligned}
g(\varpi_{it+1}, \omega_{it}) &= g[\rho_{it}^{-1}(P_t, \phi_{it} - \beta_k k_{it} - \beta_v Downstream\_FDI_{jrt}), \phi_{it}\\
&\quad - \beta_k k_{it} - \beta_v Downstream\_FDI_{jrt}]\\
&\equiv g(P_t, \phi_{it} - \beta_k k_{it} - \beta_v Downstream\_FDI_{jrt}) \qquad (16)
\end{aligned}
$$

Recall from Equation 12 that $\omega_{it} = \phi_{it} - \beta_k k_{it} - \beta_v Downstream\_FDI_{jrt}$. I can substitute

(16) into (15) to yield:

$$y_{t+1} - \beta_l l_{it+1} - \beta_m m_{it+1} = \beta_k k_{it} - \beta_v Downstream\_FDI_{jrt} + g(P_t, \phi_{it} - \beta_k k_{it} - \beta_v Downstream\_FDI_{jrt}) + \xi_{t+1} + \eta_{it+1} \tag{17}$$

where ξ_{t+1} is the unanticipated portion of the shock, $\xi_{t+1} = \omega_{it+1} - E[\omega_{it+1}|[\omega_{it}, \chi_{it+1} = 1]$, (that affects the factory's choice of inputs), and η_{it+1} is measurement error (that does not affect input choices). The key identifying assumption here is that the state variables (capital and downstream FDI) in time $t+1$ respond only to the lagged productivity shock, ω_{it}, that is calculated in the first stage. So, the error terms in Equation 17 are independent of the state variables and non-linear least squares estimation will yield unbiased estimates of β_k and β_v. Again, a third-order polynomial expansion in P_t and $\phi_{it} - \beta_k k_{it} - \beta_v Downstream\_FDI_{jrt}$ is used in the estimation.

We calculated standard errors for the coefficients obtained above using bootstrap methods.

D Tables

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

		domestic	foreign
1988	log(capital)	11.257	14.086
	employees	124	364
	log(materials)	11.171	14.421
	log(energy)	7.388	8.881
	log(value added)	10.438	14.068
	log(value added per worker)	6.447	8.765
1996	log(capital)	11.691	14.659
	employees	147	584
	log(materials)	11.588	14.893
	log(energy)	7.347	8.618
	log(value added)	11.039	14.580
	log(value added per worker)	6.973	8.967

Table 1: Descriptive statistics by foreign and domestic firms, 1988 and 1996.

Variable	Obs.	Mean	Std. Dev.
Downstream FDI	7772	.042	.097
Horizontal FDI	7690	.112	.250
Suppliers' Downstream FDI	7772	.036	.062

Table 2: Descriptive statistics for measures of FDI.

Variable	Downstream FDI	Horizontal FDI	Suppliers' Downstream FDI
Downstream FDI	1.00	.042	.097
Horizontal FDI	0.42	1.00	.250
Suppliers' Downstream FDI	0.54	0.49	1.00

Table 3: Correlation between measures of FDI.

Year	No. Domestic Firms	No. Foreign Firms	Horizontal FDI	Downstream FDI	Suppliers' Downstream FDI
1988	8888	276	.131	.060	.074
1996	14912	888	.232	.094	.118

Table 4: Foreign and domestic establishment count, mean horizontal, downstream, and suppliers' downstream FDI, 1988 and 1996.

	(1) log(output)	(2) log(output)	(3) log(output)	(4) log(output)	(5) log(output)	(6) log(output)
Downstream FDI	0.087		0.090	0.091	0.073	
	(4.33)		(4.40)	(4.48)	(3.12)	
Horizontal FDI		-0.004	-0.009	-0.010	-0.018	
		(0.34)	(0.88)	(0.96)	(1.52)	
FDI in all industries						-0.017
						(0.58)
log(labor)	0.590	0.590	0.590	0.578	0.480	0.590
	(29.98)	(29.94)	(29.98)	(28.77)	(17.50)	(29.94)
log(capital)	0.109	0.109	0.109		0.125	0.109
	(12.67)	(12.66)	(12.66)		(12.22)	(12.66)
log(materials)	0.200	0.200	0.200	0.202	0.250	0.200
	(21.76)	(21.71)	(21.76)	(21.87)	(22.53)	(21.72)
log(energy)	0.123	0.124	0.123	0.125	0.135	0.124
	(17.98)	(18.17)	(17.99)	(18.14)	(16.59)	(18.17)
log(K)*log(K)	0.005	0.005	0.005		0.005	0.005
	(9.57)	(9.57)	(9.58)		(9.91)	(9.56)
log(L)*log(L)	0.026	0.026	0.026	0.025	0.027	0.026
	(10.53)	(10.52)	(10.53)	(10.40)	(7.60)	(10.52)
log(M)*log(M)	0.050	0.050	0.050	0.050	0.053	0.050
	(89.47)	(89.53)	(89.45)	(89.36)	(80.58)	(89.53)
log(E)*log(E)	-0.010	-0.010	-0.010	-0.010	-0.009	-0.010
	(24.24)	(24.24)	(24.25)	(24.22)	(18.57)	(24.24)
log(K)*log(L)	0.028	0.028	0.028		0.038	0.028
	(16.35)	(16.41)	(16.35)		(17.47)	(16.41)
log(K)*log(M)	-0.028	-0.028	-0.028		-0.034	-0.028
	(32.50)	(32.51)	(32.50)		(34.09)	(32.51)
log(K)*log(E)	0.006	0.006	0.006		0.005	0.006
	(8.57)	(8.55)	(8.57)		(5.95)	(8.55)
log(L)*log(M)	-0.089	-0.089	-0.089	-0.089	-0.091	-0.089
	(49.64)	(49.61)	(49.64)	(49.56)	(40.57)	(49.61)
log(L)*log(E)	0.023	0.023	0.023	0.023	0.025	0.023
	(15.88)	(15.80)	(15.87)	(16.10)	(13.86)	(15.80)
log(M)*log(E)	-0.005	-0.005	-0.005	-0.005	-0.008	-0.005
	(6.52)	(6.60)	(6.51)	(6.39)	(9.60)	(6.60)
Constant	3.882	3.885	3.883	3.830	3.663	3.887
	(56.04)	(56.09)	(56.05)	(11.80)	(41.89)	(56.03)
Observations	108100	108100	108100	108100	81112	108100
Number of establishments	23815	23815	23815	23815	18414	23815
R-squared	0.81	0.81	0.81	0.81	0.79	0.81
Absolute value of t statistics in parentheses						

Table 5: Production function estimation on domestic establishments. (4) Olley-Pakes estimation. (5) Population of never-exporting firms. Establishment fixed effects and island-year and year dummy variables are included but not reported.

	(1)	(2)	(3)
	log(output)	log(output)	log(output)
Downstream FDI (prov.)	0.131	0.097	0.499
	(2.36)	(2.98)	(3.57)
Horizontal FDI (prov.)	0.006	-0.151	-0.225
	(0.30)	(2.52)	(3.67)
log(labor)	0.320	0.929	0.611
	(9.25)	(15.37)	(4.66)
log(capital)	0.108	0.139	0.107
	(6.54)	(5.73)	(2.44)
log(materials)	0.520	0.049	0.261
	(31.25)	(1.55)	(4.73)
log(energy)	-0.026	0.087	0.006
	(2.29)	(3.95)	(0.14)
log(K)*log(K)	0.009	0.002	0.008
	(10.23)	(1.61)	(3.36)
log(L)*log(L)	0.014	0.038	0.041
	(3.25)	(4.83)	(2.59)
log(M)*log(M)	0.047	0.051	0.049
	(45.76)	(26.86)	(13.16)
log(E)*log(E)	-0.011	-0.016	-0.000
	(16.98)	(9.33)	(0.11)
log(K)*log(L)	0.037	0.023	-0.001
	(12.29)	(4.31)	(0.14)
log(K)*log(M)	-0.048	-0.023	-0.021
	(30.62)	(8.60)	(4.00)
log(K)*log(E)	0.017	0.007	0.000
	(14.39)	(3.37)	(0.12)
log(L)*log(M)	-0.078	-0.100	-0.091
	(22.77)	(18.79)	(7.33)
log(L)*log(E)	0.035	-0.001	0.059
	(13.68)	(0.28)	(6.94)
log(M)*log(E)	-0.006	0.011	-0.016
	(4.95)	(4.05)	(3.72)
Constant	2.908	3.838	4.114
	(22.53)	(18.50)	(10.44)
Observations	29297	11494	3621
Number of ID - Backcast	6041	2376	762
R-squared	0.82	0.80	0.82
Absolute value of t statistics in parentheses			

Table 6: 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.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	log(province Herfindahl index)					log(national prices)			
Downstream FDI (prov.)	-0.076			-0.057	-0.088				
	(2.31)			(1.59)	(2.39)				
Suppliers' Downstream FDI (prov.)		-0.114		-0.077	-0.079				
		(2.15)		(1.34)	(1.27)				
Horizontal FDI (prov.)			0.003		0.015				
			(0.31)		(1.18)				
Downstream FDI (nat.)						-0.462			-0.282
						(9.83)			(5.11)
Suppliers' Downstream FDI (nat.)							-0.778		-0.453
							(9.95)		(4.80)
Horizontal FDI (nat.)								-0.146	-0.060
								(6.66)	(2.56)
Constant	0.631	0.632	0.627	0.633	0.614	5.051	5.078	5.036	5.089
	(148.84)	(138.78)	(148.92)	(137.55)	(122.05)	(708.15)	(556.01)	(692.29)	(542.35)
Obs.	13592	13592	13592	13592	11766	2581	2581	2581	2581
No. region-product groups	1982	1982	1982	1982	1671				
No. product groups						307	307	307	307
R-squared	0.05	0.05	0.05	0.05	0.04	0.78	0.78	0.77	0.78

Absolute value of t statistics in parentheses

Table 7: 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).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	log(output)				log(value added)			
Downstream FDI	0.175			0.080	0.118			0.039
	(3.94)			(1.73)	(1.73)			(0.55)
Suppliers' downstream FDI		0.496		0.744		0.367		0.806
		(7.75)		(9.28)		(3.78)		(6.65)
Horizontal FDI			-0.018	-0.175			-0.121	-0.284
			(0.81)	(6.29)			(3.52)	(6.84)
Other firms' horizontal FDI								
Constant	11.977	11.958	11.986	11.959	10.449	10.435	10.465	10.437
	(1779.48)	(1637.08)	(1750.77)	(1622.61)	(1022.91)	(944.57)	(1010.91)	(936.02)
Obs.	108615	108615	108615	108615	91616	91616	91616	91616
Number of Establishments	23861	23861	23861	23861	21377	21377	21377	21377
R-squared	0.07	0.07	0.07	0.07	0.04	0.04	0.04	0.04
Absolute value of t statistics in parentheses								

Table 8: Value added and output, domestic firms. Establishment fixed effects and island-year and year dummy variables are included but not reported.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	log(output)				log(value added)			
Downstream FDI	1.295			0.419	0.851			0.227
	(6.12)			(1.76)	(2.73)			(0.63)
Suppliers' downstream FDI		3.094		3.408		2.129		2.698
		(9.92)		(8.96)		(4.42)		(4.48)
Other firms' horizontal FDI			0.033	-0.422			-0.139	-0.508
			(0.36)	(4.24)			(0.97)	(3.22)
Constant	14.810	14.575	14.941	14.596	13.646	13.478	13.767	13.506
	(342.89)	(277.91)	(344.93)	(275.26)	(209.26)	(166.37)	(208.73)	(165.68)
Obs.	5210	5210	5210	5210	4120	4120	4120	4120
Number of establishments	1324	1324	1324	1324	1096	1096	1096	1096
R-squared	0.22	0.23	0.21	0.24	0.13	0.13	0.13	0.14
Absolute value of t statistics in parentheses								

Table 9: Value added and output, foreign firms. Establishment fixed effects and island-year and year dummy variables are included but not reported.

E Figures

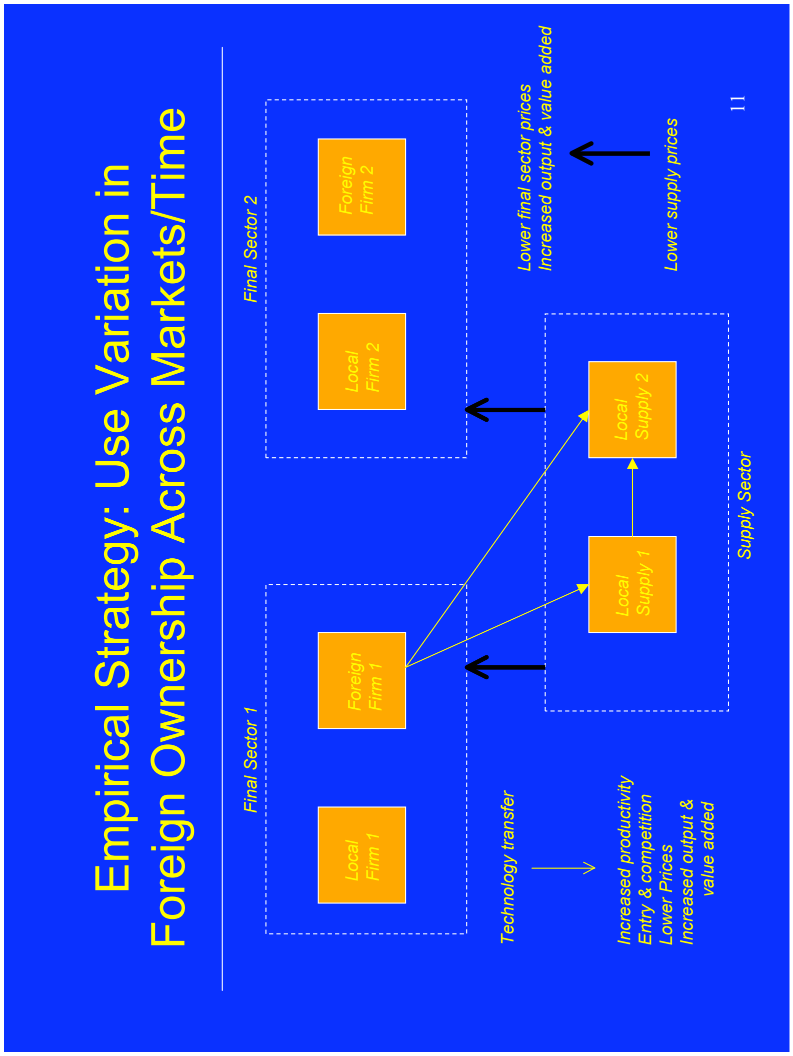

Figure 1: Flow of technology and welfare effects from FDI.

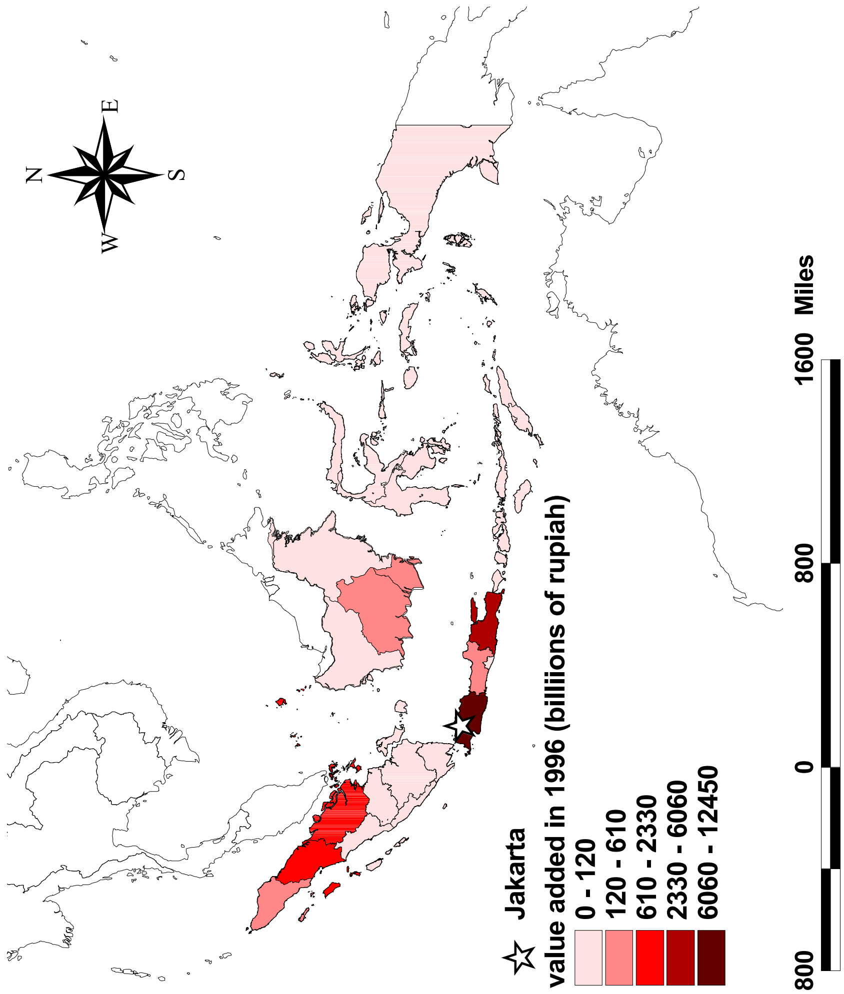

Figure 2: Value added in manufacturing, 1996, by province.

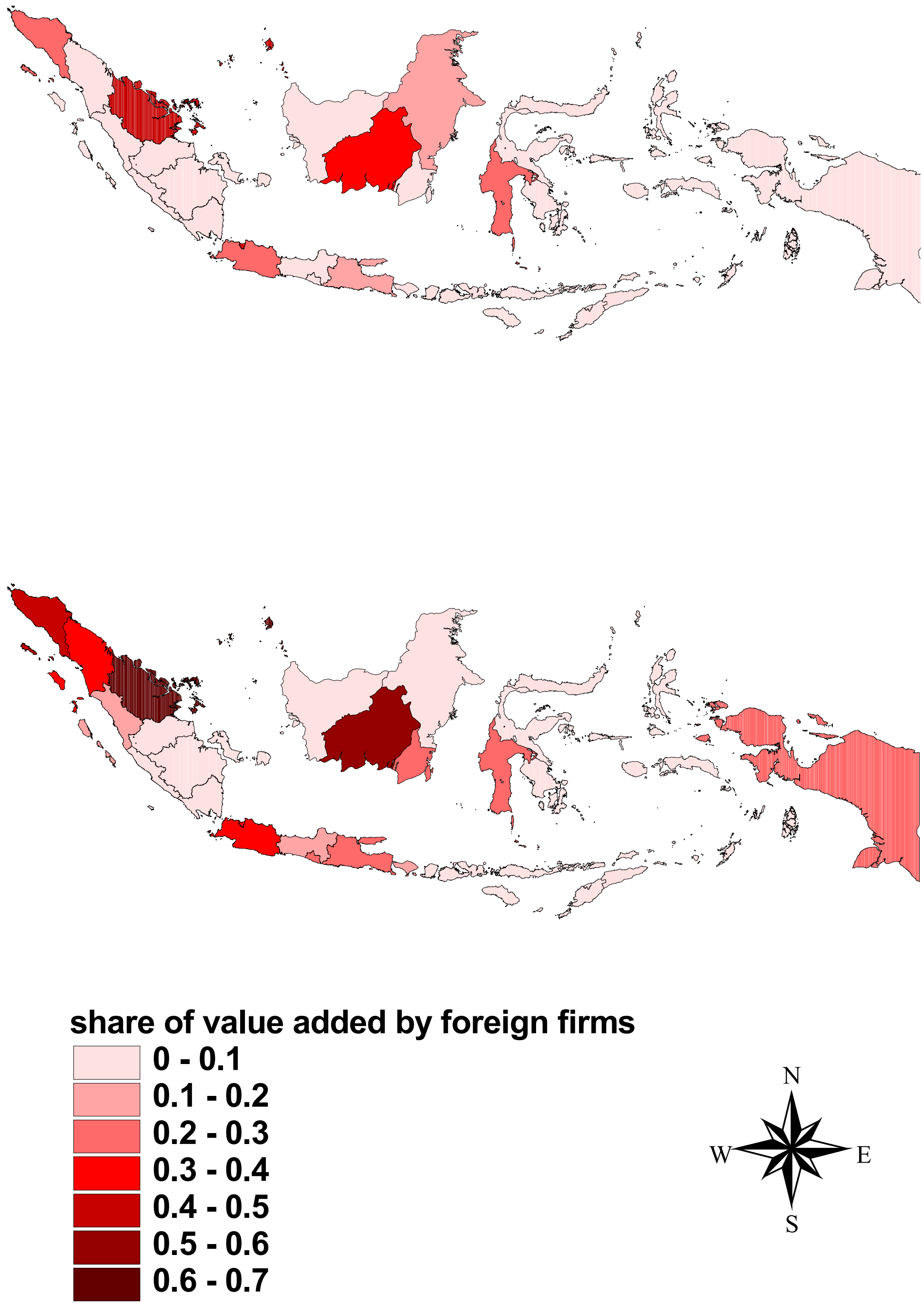

Figure 3: Share of manufacturing value added by foreign firms, by region, 1988 (top) and 1996 (bottom).