Foreign Direct Investment, Exports and Aggregate Productivity*

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Abstract

Empirical evidence confirms that trade exposure can shift resources towards the most efficient firms in an industry and induce substantial increases in aggregate productivity. Although recent studies document that much of world trade is controlled by multinational firms, few examine the effect of foreign direct investment decisions on resource allocation and aggregate productivity. This paper presents an open economy model where producers make simultaneous production and export decisions across different countries. In particular, the model highlights the interaction between firms' location and export decisions and their effect on aggregate productivity. The theoretical model is estimated using detailed plant-level Indonesian manufacturing data. The results are broadly consistent with the pattern of productivity, exports and foreign investment across firms. I use the model to perform a number of counterfactual experiments to assess the effects of barriers to international trade and investment on aggregate productivity. The experiments suggest that there are substantial productivity gains due to international trade and investment. Moreover, they highlight that evaluating the substitutability and complementarity of trade and investment is crucial to determining the aggregate effects of international trade and foreign direct investment policy.

KEYWORDS: exports, foreign direct investment, firm heterogeneity, aggregate productivity, resource allocation

JEL: C23, E23, F21, O40

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1 Introduction

This paper builds an open economy model of international trade and foreign direct investment with heterogeneous firms. The model extends Melitz (2003) by allowing firms to offshore production to foreign low-wage countries. While firms can set up plants in foreign countries in order to access foreign markets as in Helpman, Melitz and Yeaple (2004), the model also allows firms to locate plants abroad in order to export back to the country of origin. The model highlights how differences in production, location and export costs affect the structure of international trade. The theoretical model is estimated using Indonesian plant-level manufacturing data. The estimated model is then used to perform a variety of counterfactual experiments to assess the positive and normative effects of international barriers to trade and foreign direct investment.

Recent evidence suggests that the current volume and direction of trade are intimately related to multinational production decisions. It is estimated that total sales from multinational firms accounts for 60% of world GDP and over 35% of world trade in 2001.[1] At the same time, empirical studies have repeatedly confirmed that trade can substantially impact resource allocation across firms and aggregate productivity within an industry. Both Pavcnik (2002) and Trefler (2004) find that increasing openness induces productivity gains among exporters, while Pavcnik (2002) also finds increases in aggregate productivity.[2] Yet, few studies have examined the role of foreign direct investment decisions (FDI) on trade flows, resource allocation and their effect on aggregate productivity.

A separate but related set of empirical evidence suggests that among firms producing in a given country, multinational firms are the most productive. Domestic exporters are reportedly less productive than multinationals, but significantly more productive than domestic non-exporters.[3] In this paper, I confirm these productivity differences across foreign and domestic firms and provide new evidence emphasizing important differences within foreign firms. The data suggests that firms who invest in Indonesia to serve the Indonesian market are substan-

[1] Ramondo (2006).

[2] Pavcnik (2002) finds substantial productivity gains due to resource reallocation from less to more productive after trade liberalization in Chile. Similarly, Trefler (2004) finds productivity improvements among both exporters and importers after the Canada-U.S. free trade agreement.

[3] See Helpman, Melitz and Yeaple (2004) for a comparison of multinationals, domestic exporters and domestic non-exporters. Arnold and Javocik (2005) provide evidence that foreign owned firms are more productive than domestic firms. Similarly, Aw, Chung, and Roberts (2000), Bernard and Jensen (1999), Bernard et. al. (2003), Clerides, Lack and Tybout (1998), and Eaton, Kortum, and Kramarz (2004) find that more productive firms are more likely to export.

tially more productive than those who invest in Indonesia as a platform for exports.

Economists have traditionally separated FDI into horizontal and vertical components. Horizontal FDI, the largest of the two components, usually refers to firms which set up affiliate plants in multiple countries to serve the domestic market in each of those countries. By investing in a foreign country, a firm saves the export transportation costs, but incurs additional fixed production costs by operating multiple plants (c.f. Brainard (1997), for example). Helpman, Melitz and Yeaple (2004) extend the traditional proximity-concentration framework to examine the choice between exports and horizontal FDI in an economy where firms are characterized by heterogeneous productivity. They demonstrate that only the most productive firms will produce in multiple countries. Most importantly, they show that allowing productivity to vary across firms generates richer trade patterns and provides an explanation for the co-existence of exports and multinational production across developed countries.

In contrast, vertical FDI often represents the production of goods in foreign countries for re-export back to the domestic parent. Though smaller in aggregate than horizontal FDI, vertical FDI is often reported to be growing quickly, particularly in developing countries.[4] Typically, vertical FDI is driven by a desire to take advantage of low foreign production costs in an environment where contracting with local producers is either impossible or sub-optimal. For example, Antras and Helpman (2004) combine the insight of Melitz's (2003) heterogeneous firms framework with the vertical integration model of Antras (2003) to explore the effects of incomplete contracts and multiple stage production.

Several studies include both types of foreign investment. However, models encompassing the multistage nature of vertical FDI, along with the proximity-concentration trade-off of horizontal FDI are inherently complex. Ekholm et al. (2003), Yeaple (2003) and Grossman, Helpman and Szeidl (2006) construct increasingly complex models to elucidate the interplay between FDI and the structure of international trade flows.[5] In particular, these models illustrate that as

[4]Yeats (2001) argues that trade in intermediate inputs has grown much faster than trade in final goods. Moreover, he estimates that trade in intermediates accounts for 30% of world trade in manufactures. Similarly, Hummels, Ishii and Yi (2001) assert that within firm transfers of goods across national borders accounted for one-third of world export growth between 1970 and 1990.

[5]The Grossman, Helpman and Szeidl (2006) model is particularly appealing because it includes firm level heterogeneity and captures a wide variety of firm structures and trade flows across countries. Moreover, it can generate predictions for firm behavior in relation to the determinants of trade and investment. Unfortunately, while it is possible to test the model's aggregate implications across countries, it is would be practically impossible to evaluate the plant level predictions using even the most detailed modern data sets.

one varies the determinants of international trade or investment,[6] it is possible to generate a myriad of different equilibria. Unfortunately, none of these models are well suited to empirically examine the plant-level decisions to export and/or invest abroad.[7]

One objective of this paper is to provide a framework that is rich enough to describe the principal channels for international capital and trade flows, while remaining suitable for estimation using plant-level data. The advantage of this approach is that all of the model's predictions can be readily tested. Moreover, the model is used to empirically assess the influence of policy on plant-level decisions, and thus provides a framework for evaluating economic policy and predicting changes in aggregate productivity, exports and foreign investment.[8]

I begin by extending the international trade and investment framework of Helpman, Melitz and Yeaple (2004) by allowing firms to offshore production in a foreign country. In my environment, firms may set up plants in foreign countries for two reasons. First, as in Melitz, Helpman and Yeaple (2004), firms can set up plants solely to access the local market in foreign countries. Relative to a model without FDI, such as Melitz (2003), FDI provides an avenue in addition to exports for firms to make sales to foreign consumers. Second, firms can set up plants in a foreign country in order to export back to the country of origin. While there are a number of papers that address offshoring,[9] my model simultaneously allows firms to engage in horizontal FDI and studies how the model's theoretical predictions match observed differences across foreign and domestic firms. In particular, I examine how the structure of fixed and transport costs affect the firm level location and export decisions across high and low wage countries. I show that my model can generate productivity differences across plants with different ownership and export status which are consistent with the observed differences in the Indonesian manufacturing data.

Using the theoretical model and a panel of Indonesian manufacturing plants, I develop and estimate a structural empirical model of exports and FDI. Indonesia is a country of particular interest because it is one of the largest economies in South East Asia and one of the largest hosts

[6]Such as transport costs, set up costs, country size, wages, etc.

[7]As noted by Grossman, Helpman and Szeidl (2006), the distinction between horizontal and vertical FDI is increasingly blurred. Feinberg and Keane (2003) report that 69% of all multinational firms in the US have elements of both horizontal and vertical FDI. A similar pattern is found here for Indonesia.

[8]It is important to note, however, that a disadvantage of this approach is that it requires abstracting from the details of contractual arrangements that cannot be observed. To the extent that incomplete information is important in determining the types the structure of FDI, the estimates may be biased.

[9]See Antras and Helpman (2004) and Grossman, Helpman and Sziedl (2006) for examples.

of multinational corporations (Ramstetter and Sjoholm (2006)).[10] The estimated model captures the pattern of productivity, exports and market share across firms with different ownership and export status. I find that the mean of productivity at the steady state is substantially higher than the estimated mean at entry, indicating that endogenous exit decisions play an important role in determining aggregate productivity. Moreover, to examine the effects of trade and foreign investment policies, I perform a number of counterfactual policy experiments which demonstrate that restrictions on investment and trade can potentially have widely different effects on aggregate productivity. I find that the impact of FDI restrictions account for a fall in average total factor productivity between 8 and 27 percent across industries. Trade restrictions, in contrast, are estimated to have a smaller impact on average productivity. Across the food, manufactured metals and textiles industries average total factor productivity is estimated to fall by 1 to 4 percent. Since foreign and domestic plants respond differently to policy change, failing to account for these differences will lead to biased estimates of the impact of trade restrictions. The results suggest that policies which induce inwards flows of FDI will have a much larger impact on aggregate productivity relative to those that encourage exports. The welfare impact on Indonesia of simultaneous trade and FDI restrictions are estimated to be approximately 1% across industries. However, when trade or FDI are individually restricted, the welfare impacts are very small. This last result is due to the fact that trade (FDI) flows provide some insurance against FDI (trade) restrictions.

The next section outlines the differences across and within foreign and domestic producers. The third section presents a theoretical model of exports and FDI with heterogeneous firms and countries, while the fourth describes the model's empirical analog. The fifth section presents empirical results and the sixth concludes.

2 Empirical Motivation

In this section I briefly describe the Indonesian manufacturing data and provide summary statistics to characterize patterns across plants with varying degrees of international integration.

[10] In fact, the World Bank (1993) identified rapid industrialization, export growth and inflows of foreign direct investment as key elements to the accelerated growth experienced by Indonesia and surrounding countries in the preceding years.

2.1 Data

I use the Indonesian manufacturing census for 1993-1996. The data set reports the total value of domestic and export sales, the percentage of foreign ownership and the number of workers. I determine the export status of each firm by checking whether the value of export sales is positive or zero. Likewise, I determine the ownership status of each firm by checking whether foreign investors hold a positive amount of equity in the plant.[11] Nominal values are converted to real values using the industry output price deflators. I identify the entry/exit decisions by observing the number of workers across years. After cleaning the data, I use an unbalanced panel of 24,519 plants. Each plant is observed for at least one year between 1993 and 1996.[12]

2.2 Exports and Foreign Ownership

It is well known that multinational and/or foreign-owned firms are typically the largest firms in a country. Table 1 documents this fact for Indonesian manufacturing plants between 1993-1996. Although only six percent of all firms have any foreign ownership, foreign firms account for more than one quarter of total output and over one third of all exports in manufacturing. Moreover, foreign firms are not solely export oriented but also capture one quarter of the Indonesian domestic market for manufactured goods. This suggests that the Indonesian market may also be an important market for foreign plants.

Table 1: Foreign Plants Over Time

	1993	1994	1995	1996	1993-1996 avg.
Exports	0.30	0.38	0.35	0.38	0.36
Output	0.23	0.27	0.29	0.34	0.28
Domestic Market Share	0.20	0.22	0.27	0.31	0.25
% of Firms	0.06	0.06	0.06	0.06	0.06

Notes: The top three rows document the percentage of the total manufacturing sales attributed to foreign firms. The bottom row documents the percentage of foreign manufacturing plants.

A common explanation for these findings is that multinational or foreign firms are substantially larger and more productive than their domestic counterparts.[13] Comparing the top two rows with the bottom two rows of Table 2 it is evident that foreign plants are not only much

[11] Using other threshold values (e.g. 10% or 50% of equity) yielded similar results.
[12] I omit 729 plants which are wholly owned by the government.
[13] See Helpman, Melitz and Yeaple (2004) or Arnold and Javorcik (2005) for an example

larger than domestic firms but they also appear to be more capital-intensive, use a higher fraction of skilled employees and produce more output per worker than their domestic counterparts.

Similarly, it is often cited that domestic exporters are relatively large, capital and skill-intensive, and more productive relative to domestic non-exporters.[14] The bottom two rows of Table 2 are consistent with this result for the Indonesian manufacturing sector. Although the Indonesian data confirms that foreign plants are always larger and more productive than their domestic counterparts with the same export status, the disparity in differences across export groups is striking. For instance, while foreign exporters are approximately twice as large and productive as domestic exporters, foreign non-exporters are ten to fifteen times larger than domestic non-exporters and produce eight times the output per worker.

Table 2: Descriptive Statistics

	Total Sales^a	Export Intensity^{a,b}	Labor	Skill Ratio^c	Capital	K/L Ratio^a	Output/ Worker	No. of Obs.
All	35.47	0.70	185.57	0.14	6.00	0.02	0.12	72,732
Plants	(261.88)	(0.33)	(613.13)	(0.15)	(22.00)	(0.03)	(0.59)	—
Foreign	166.38	0.71	700.14	0.18	30.13	0.06	0.35	2,563
Exporters	(381.88)	(0.34)	(1,047.91)	(0.17)	(47.30)	(0.05)	(0.58)	—
Foreign	167.76	—	411.23	0.28	29.09	0.09	0.48	1,803
Non-Exporters	(361.14)	—	(649.24)	(0.20)	(49.08)	(0.06)	(1.08)	—
Domestic	81.14	0.70	445.81	0.15	14.53	0.03	0.16	10,784
Exporters	(495.38)	(0.33)	(1,192.23)	(0.14)	(37.84)	(0.03)	(0.37)	—
Domestic	11.77	—	74.25	0.10	1.81	0.01	0.06	57,582
Non-Exporters	(139.75)	—	(286.21)	(0.14)	(8.43)	(0.02)	(0.50)	—

Notes: Reported number are sample means with standard deviations in parentheses. (*a*) In millions of Indonesian Rupiahs. (*b*) Computed using the sample of exporting plants. (*c*) The of skilled workers to total workers.

The differences between foreign exporters and non-exporters are less obvious. Several studies have previously examined the differences across a variety of attributes for domestic exporters and non-exporters (e.g. Bernard and Jensen, 1999 or Kasahara and Lapham, 2007), but few have examined differences across ownership status,[15] and even fewer have examined differences *across* foreign firms. Although foreign exporting plants employ almost twice as many workers, they earn little more revenue, employ a smaller percentage of skilled workers, are less capital-intensive and produce less output per worker than foreign non-exporters. The difficulty in comparing foreign exporters and non-exporters arises from the fact that exporters serve multiple markets from

[14]See Kasahara and Lapham (2006) for an example.

[15]A notable study examining the differences across ownership status using the Indonesian manufacturing census is Arnold and Javorcik, 2005.

one plant while non-exporters only serve the Indonesian market. On average foreign exporting plants sold 63.5 million rupiahs worth of goods to the Indonesian market per year.[16] Thus, foreign non-exporters sold approximately 2.5 times more on average than foreign exporters sold to the Indonesian market.[17]

While the mean differences between firms with different export and ownership status are striking it is not clear that they are statistically significant. In fact, the standard deviations are often large, particularly for foreign firms where there are fewer observations. Following Bernard and Jensen (1999) and Kasahara and Lapham (2007) I estimate the export and ownership premia using a pooled ordinary least sqruares regression over the 1993-1996 period:

$$\ln X_{it} = \alpha_0 + \alpha_1 d^x_{it}(1 - d^f_{it}) + \alpha_2 d^x_{it} d^f_{it} + \alpha_3 (1 - d_i t^x) d^f_{it} + Z_{it}\beta + \epsilon_{it}, \quad (1)$$

where X_{it} is a vector of plant attributes such as total employment, domestic sales, output per worker, average wages, the percentage of non-production workers and capital per worker. A firm's export status is captured by the dummy variable d^x_{it}, while d^f_{it} is a dummy variable capturing whether any of the plant's equity is held by foreign investors. Last, Z_{it} is matrix of control variables including industry dummies at the 5-digit ISIC level, year dummies, province dummies, municipality dummies and total employment to control for size. The export premium α_1 is the average log point difference between exporters and non-exporters among domestic plants. The foreign exporter premium α_2 is the average log point difference between domestic non-exporters and foreign exporters, while the foreign non-exporter premium α_3 is the average log point difference between domestic and foreign plants who do not export.

The results in Table 3 show that there are not only substantial differences between domestic exporters and non-exporters but also between foreign exporters and non-exporters. Column 3 indicates that foreign non-exporters tend to demonstate the highest premia across all measures other than those related directly to size. In particular, foreign non-exporting plants tend to demonstrate higher productivity foreign exporters or domestic plants.[18] Similar results are

[16] See table 11 in the appendix for documentation of domestic performance across all types of plants and all variables. A similar calculation can be made for domestic exporters and non-exporters, but it does not change any of the above implications.

[17] Table 13 in the appendix documents further differences in productivity across ownership and export states.

[18] Another possiblity is that differences in prices across countries causes spurious correlation in our measurement of productivity across firms. In particular, if mark-ups are higher in domestic markets than exports markets the productivity measurement of foreign exporters would be biased downwards. In contrast, it is likely that the mark-

found at the industry level.[19] It is natural to ask why the larger, more productive foreign non-exporters do not export while the smaller, less productive foreign exporters do? A likely reason is that foreign non-exporters are part of a larger multinational corporations that serve multiple markets though multiple plants located in different countries. I will further develop this hypothesis to explain the effects of foreign barriers to trade and investment across different plants in Indonesia.[20]

Table 3: Export & Ownership Premia

	Pooled OLS: 1993-1996		
Export/Ownership Status	Domestic Exporters	Foreign Exporters	Foreign Non-Exporters
Output per Worker	0.217	0.710	0.871
	(0.012)	(0.021)	(0.024)
Average Wage	0.114	0.443	0.604
	(0.007)	(0.013)	(0.015)
Non-Production/Total Workers	0.086	0.006	0.246
	(0.010)	(0.018)	(0.021)
Capital per Worker	0.351	0.712	0.932
	(0.011)	(0.019)	(0.022)
Domestic Sales	-0.789	-0.043	0.848
	(0.016)	(0.030)	(0.029)
Total Sales	0.250	0.737	0.883
	(0.014)	(0.024)	(0.027)
Total Employment	1.062	1.528	1.045
	(0.010)	(0.019)	(0.022)
No. of Observations	72732		

Notes: Standared errors are in parentheses.

up in export markets is higher than in domestic markets due to income differences across countries. This would imply that Tables 2 and 3 underestimate the differences between foreign exporters and non-exporters. Table 20 in the Appendix reports imputed "approximate mark-ups" across producers and industries. A last possibilty is that foreign firms use transfer pricing to earn profits abroad due to high corporate tax rates. However, the World Tax Database reports that over 1993 to 1996 the top Indonesian corporate tax rates were slightly lower than those in Japan, the United Kingdom and the United States on average. Table 19 in the Appendix reports top corporate tax rates across countries.

[19]With the exception of the chemicals industry. The chemicals industry in Indonesia tends to display a distinctly different pattern where foreign exporters are the most productive firms. This is not surprising since the chemicals industry is dominated by fuel and natural gas related products for which there are large export markets. Results for the chemicals industry are reported in the Appendix.

[20]Although the estimates between foreign exporters and non-exporters in Table 3 are statistically significant, these differences could be driven by unobserved plant-specific differences. Discussion of fixed effects estimation in this context and results controlling for plant-specific heterogeneity are reported in the Appendix.

3 A Model of FDI and Exports

The model extends the environment outlined by Helpman, Melitz and Yeaple (2004) to include FDI and exports back to the country of origin to capture vertical FDI.[21]

3.1 Environment

Consider two countries, Home and Foreign, which are endowed with non-depreciating stocks of labour, L.[22] In each country there are two sectors: a homogeneous good sector (agriculture) and a differentiated good sector (manufacturing).

3.2 Consumers

Consumers supply capital and labour inelastically. Their preferences are defined by a Cobb-Douglas utility function over the agriculture product z and a continuum of manufactured goods indexed by v:

$$U = z^{1-\delta} \left[\int_{v \in V} q(v)^{\alpha} dv \right]^{\delta/\alpha}.$$

The elasticity of substitution between different varieties of manufactured goods is given by $\varepsilon = 1/(1-\alpha) > 1$.[23]

3.3 Producers

3.3.1 Agriculture

There is a continuum of potential firms that can freely enter the agricultural sector and produce a homogeneous agricultural product, z, with linear technology, $z = \phi_l l$. Producers hire labour on perfectly competitive markets which pins down wages in each country. I assume that the foreign agricultural technology is more productive than the technology employed in the home country, $\phi_l^* > \phi_l$, so that wages in the foreign country are greater than those in the home country.

[21]Specifically, I exclude strict vertical integration here. I do not consider the case where foreign firms set up a subsidiary or subcontract with a domestic firm solely to supply the parent firm further up the supply chain. The reason for this choice is two-fold. First, strict vertical integration represents at most 2% of domestic firms and 7-9% of foreign firms. Second, strict vertical integration likely involves more complex contractual arrangements where incomplete information between plants may play a larger role in determining the direction of FDI and trade. See Antras and Helpman (2004) for an example.

[22]All foreign country variables are starred.

[23]The set of available goods is denoted by V and all goods are substitutes, $0 < \alpha < 1$.

3.3.2 Manufacturing

The model allows for a wide variety of potential outcomes across countries. To keep the model as transparent as possible, I focus on the case in which both foreign and domestic exporters and non-exporters are present. Specifically, I allow each country to have 4 types of firms: non-exporters, exporters, multinational non-exporters and multinational exporters who are owned by either domestic residents or those of the other country.[24]

I denote variables for non-exporting plants by D and exporting plants by X. Following the nomenclature in the literature I will refer to multinational exporters as "vertical multinationals" and will denote their variables by V while I refer to multinational non-exporters as "horizontal multinationals" and will denote their variables by H.[25]

To enter the market each firm must pay a fixed cost, f_E. Once the entry cost is paid, each firm receives a productivity draw a from the distribution, $G_a(a)$, and an extreme cost shock with constant probability ξ. A firm's productivity draw is constant over the life of the firm. If the firm suffers the extreme cost shock it is forced to exit the industry regardlessly of its productivity.

Conditional on survival, each firm can decide to exit immediately or to produce according to the linear production function

$$q = \frac{l}{a} \tag{2}$$

where l is labour hired on competitive markets.

It is well known that the Dixit-Stiglitz (1977) framework generates a demand function $\gamma R P^{1-\varepsilon}/p^{\varepsilon}$ for each variety where R is the total revenue earned in each country, P is an index of manufacturing prices and p is the price chosen by each individual producer.[26] Since demand is exogenous to each individual producer the optimal pricing rule for each firm depends only the firm-specific productivity level

$$p(a) = \frac{aw}{\alpha}$$

[24] I exclude the possibility of joint ownership.

[25] I exclude the possibility that a firm owned by foreign investors will produce in the home country solely for the home market without producing in the home market. While it is possible to extend the model to allow for this to occur, I omit it here for tractability. See the Appendix for conditions under which no firm will optimally choose to only operate abroad for the foreign market.

[26] $R = wL$ where L is the total amount of labour and w is the wage in the home country. The price index is $P = [\int_V p(v)^{1-\varepsilon} dv]^{1/(1-\varepsilon)}$

where w is the wage in the home country.

To produce domestically each firm must pay a fixed overhead cost f_D each period. If the firm also decides to export abroad it bears additional fixed cost f_X and iceberg transport costs $\tau > 1$ per unit shipped to the foreign country. As in Helpman, Melitz and Yeaple (2004) the firm may choose to set up production in the foreign country rather than export to that market. While the firm saves on the fixed export costs, f_X, and on the transport costs, τ, by choosing to produce abroad, it incurs the additional fixed overhead cost, f_I.[27] In my model, firms may choose not to produce domestically at all. In this case, each firm sets up a plant abroad and exports back to its country of origin.[28] The firm then incurs the fixed costs f_D, f_X and f_I and the transport cost τ. If $f_I > 0$, any firm that produces abroad to export back home incurs higher fixed costs and the same transport costs of a home exporter. Thus, to give firms an incentive to produce abroad and export there must be some difference in factor prices across countries.

I interpret f_X as the cost of forming and maintaining distribution and service networks in export markets. It is important to note that firms must pay this cost even if they are exporting back to their home market.[29] Similarly, f_I includes the distribution, servicing, overhead and set up costs of operating a subsidiary abroad. The relative size of the fixed costs plays an important role in determining each firm's optimal production and export decisions.

3.4 Profits, FDI & Exports

I assume that each firm that chooses not to exit will always serve the domestic market. It accomplishes this through domestic production or exports from the foreign country. Similarly, firms will never choose to produce solely for export. As argued below, casual empiricism suggests that a small number of firms produce solely for export markets.[30] In equilibrium, I rule out the possibility that multinational firms produce solely for the foreign market or that any firm will serve the same market by both exports and FDI.[31]

The operating profits for any firm with productivity level a producing in the home country

[27] In the multi-country setting each firm would pay f_X or f_I for each export/production destination.

[28] This can be thought of as "offshoring". However, as described below, no firm will ever choose to produce domestically and solely export back to its country of origin. Although it is possible to extend the model to include this possibility, for simplicity I omit it here.

[29] The empirical model allows for differences in fixed export costs across firms.

[30] It would be possible to generate production solely for export by allowing fixed costs to vary across countries.

[31] Rob and Vettas (2001) use uncertainty in a dynamic setting to explain this phenomenon.

solely for domestic consumption are

$$\pi_D = (awB)^{1-\varepsilon} - f_D, \tag{3}$$

where $B = [(1-\alpha)\gamma wL]^{1/(1-\varepsilon)}/(\alpha P)$. Since market size, B, is positively related to country size L, larger countries will have a larger market, for a given price level. Exporters earn both profits from selling abroad, in addition to those earned at home. Thus, the operating profits for an exporter are

$$\pi_X = \pi_D(a) + (\tau awB^*)^{1-\varepsilon} - f_X. \tag{4}$$

Similarly, firms that produce in both countries for each domestic market earn the additional operating profits from their plants abroad. The operating profits for a *horizontal* multinational are

$$\pi_H = \pi_D(a) + (aw^*B^*)^{1-\varepsilon} - (f_D + f_I). \tag{5}$$

Lastly, *vertical* multinationals do not produce at home for the home market, but instead produce abroad for both home and foreign markets. The profits these firms earn in either country will depend upon the factor prices in the foreign country. The operating profits for a vertical multinational are

$$\pi_V = (aw^*B^*)^{1-\varepsilon} + (\tau aw^*B)^{1-\varepsilon} - (f_D + f_X + f_I) = \pi_X^* - f_I. \tag{6}$$

Equations (3)-(6) indicate that export and investment decisions will depend primarily on both firm-specific characteristics (productivity) and the differences across countries (wages, fixed costs, size). Suppose that the foreign country is a large, high-wage country, while the home country is relatively small and characterized by low-wages. Consider the export and investment decisions facing foreign country firms. The first decision is whether to produce domestically and export abroad versus producing abroad and exporting back to the country of origin. This decision will clearly depend upon the cost of exporting in either direction. However, even if transport costs are equal there will be substantial differences in these two production and export decisions. When transport costs are equal, the advantage to exporting from the foreign country is that the foreign firm incurs lower fixed overhead costs. The disadvantage is that labour costs are high.[32] Thus, foreign firms that produce in the home country must be productive enough to afford the higher fixed costs.

Similarly, consider the firm deciding whether to produce all units abroad and export back to the foreign country versus opening a plant in each country. By producing all units abroad the firm incurs the lowest marginal costs on each unit of output and saves the extra fixed costs from operating multiple plants. However, by producing all units abroad the firm incurs the transport cost on each unit exported. This is particularly costly when the foreign country is large.

The model has several intuitive implications. First, since exporting is costly, firms that export must be productive enough to afford these extra costs. Second, higher fixed costs associated with investing abroad suggests that multinational firms will be more productive than their domestic counterparts. Finally, if country size is equal across countries, only firms from the foreign (high wage) country will invest in the home (low wage) country and export back to the foreign country. In other words, the model predicts that vertical multinationals will originate in the high wage country and produce in the low wage country. This does not mean that FDI only flows from the foreign country to the home country. Highly productive home firms may still want to invest in the foreign country in order to save the transport costs from exporting. It will never, however, be profit maximizing for home firms to use the foreign country as an export platform for home country sales.

It is well known that multinational firms are more productive than domestic exporters and that domestic exporters are more productive than domestic non-exporters.[33] The evidence presented in section 2 demonstrates that we can further divide multinational firms into more productive horizontal multinationals and less productive vertical multinationals.[34] Similar to Helpman, Melitz and Yeaple (2004), I must place restrictions on the size of fixed and transport costs to ensure that firms can be partitioned into four groups. These conditions are as follows:

$$f_D \left(\frac{\tau B}{B^*} \right)^{1-\varepsilon} < f_X \tag{C1}$$

[32]Country size also plays an important role here. Firms will be more likely to enter larger markets by FDI, *ceteris paribus*. However, to focus on the effect of factor prices I abstract from country size differences here.

[33]See Helpman, Melitz and Yeaple (2004), for example.

[34]Since the evidence in Section 2 is not conclusive, I consider the possibility of vertical multinationals as the most productive firms in the appendix.

$$f_X \frac{w^{1-\varepsilon}(B^{1-\varepsilon} + (\tau B^*)^{1-\varepsilon}) - w^{*1-\varepsilon}(B^{*1-\varepsilon} + (\tau B)^{1-\varepsilon})}{(w^* \tau B)^{1-\varepsilon})} < f_I \tag{C2}$$

$$f_I < \left[\frac{(wB)^{1-\varepsilon} - (w^* \tau B^*)^{1-\varepsilon}}{(w^* B^*)^{1-\varepsilon} - (w \tau B^*)^{1-\varepsilon}} \right] (f_D - f_X) \tag{C3}$$

$$w^* < \tau w \tag{C4}$$

The first condition is identical to that of Melitz (2003) except that it allows for differences in country size. It ensures that the continuum of domestic firms is partitioned between domestic non-exporters and exporters. In essence, the fixed cost to exporting must be large enough that not all domestic firms are willing to export. The second condition implies that the fixed costs of production abroad must be large enough to ensure that not all exporting firms are more profitable by offshoring production. The third condition implies that the fixed cost to domestic production cannot be so low that no firm would ever want to offshore production.[35] Moreover, for condition (C3) to hold the fixed cost of maintaining a plant in the home country must be greater than the fixed cost of exporting from the foreign country.[36] Finally, the last condition states that the marginal production cost in the home country must be lower than joint production and transport costs in the foreign country. If (C4) did not hold, production in the foreign country would be so inexpensive that no multinational firm would ever choose to produce in the home country.

Condition (C3) also allows us to refine the model's prediction about the direction of vertical FDI. It is consistent with vertical FDI flows from large, high wage countries to small, low wage countries. However, it also suggests that vertical FDI may flow from small, high wage countries to large, low wage countries if the wage gap is large enough. [37]

There are a variety of other production and export possibilities that I have purposely omitted here. For instance, it is possible that foreign investors may open plants in the home country exclusively for sales to the home country consumers without operating a plant in any other country. I exclude this possibility for two reasons. First, I cannot empirically separate plants

[35]Note: If $B^* \geq B$ then the term in square is positive. However, if $B > B^*$, then (C3) can only hold if the difference between w^* and w is sufficiently big.

[36]Although, I maintain the symmetry of fixed export costs across countries, one might expect MNCs to have much lower fixed export costs than domestic exporters. I allow for this possibility in the estimation of the model.

[37]Similarly, the inequality $w^*B^* > wB$ also suggests vertical FDI to flow from large, low wage countries to small, high wage countries if the difference in country size is large enough. However, in this case, condition (C4) would be violated.

which are multinationals and those which stand-alone but have foreign ownership. Second, Indonesia is a small country relative to its major sources of FDI.[38] If foreign investors are able to profitably operate a plant which sells exclusively to Indonesian consumers, it is likely they are also able to the same in their home countries.

Table 5 documents the other production and sales combinations that I have purposely restricted from the set possibilities by placing bounds on the fixed and transport costs. The first row of Table 5 shows that firms can locate in the home country and produce only for the home country or both markets, but not just the foreign market. As in Melitz (2003) I exclude this possibility since less than two percent of all Indonesian plants receive all revenues from export sales. Similarly, in the second row I exclude all foreign plants that receive all revenues from export sales. Although seven percent of foreign firms strictly export all output, it is likely that these plants do so to protect technological advantages, patents or product features from local rivals.[39] I exclude this possibility since it is not observable in the Indonesian manufacturing data.[40] The last row simply indicates that if a firm produces in both countries, then it must sell in both countries. Since firms must pay all of the fixed costs to produce in a given country and the Dixit-Stiglitz framework implies some residual demand for each variety, selling to local consumers can always increase profits.[41]

Table 4: Production and Sales Combinations

Production	Sales Location		
Location	Home	Foreign	Both
Home	Yes*	No	Yes
Foreign	No	Yes*	Yes
Both	No	No	Yes

Only if the ownership is the same as the country where production is located.

[38] Japan, the United States and Europe.

[39] Since the large majority of plants (93%) have positive amounts of domestic sales it is not likely that these firms are subject to the same restrictions.

[40] See Antras and Helpman (2004) for a model with incomplete contracts and vertical integration.

[41] Over 98% of Indonesian producers and 93% of foreign producers sell to the local Indonesian market.

3.5 Exit & Entry Decisions

Upon drawing their firm-specific productivity level each firm must decide whether or not to enter each market. For convenience, first consider the decisions of foreign country firms. The least productive firms expect negative profits and choose not to produce. Marginal firms earn just enough profits to cover the fixed cost f_D:

$$(aw^*B^*)^{1-\varepsilon} = f_D \tag{7}$$

since $\varepsilon > 1$ and all of the profit functions are monotonically increasing in $1/a$. For convenience, I denote productivity by the index $a^{1-\varepsilon}$ and let the productivity of the marginal foreign firm be $a_D^{*1-\varepsilon}$. Figure 1 graphs the profit functions for all firms originating in the foreign (high wage) country under the assumption that the demand level is the same in both countries. Any firm with a productivity level below $a_D^{*1-\varepsilon}$ will earn negative profits and choose to exit the market altogether. Similarly, as shown in Figure 2, the same is true for all home country firms with productivity below $a_D^{1-\varepsilon}$.

Two important features of the model are highlighted in Figure 1. First, the profit functions for foreign country firms are increasingly steep across non-exporters, exporters, vertical multinationals and horizontal multinationals. Second, the fixed costs are increasingly high across the same four groups of firms.[42] The slope of the profit function is determined by factor prices, transport costs and country size. Increases in factor prices reduce the profitability of every unit sold and thereby reduce the slope of profit function. Similarly, increases in transport costs reduce the profitability of every unit sold in the export market which will flatten the slope of exporters' profit functions. For example, vertical multinationals have the lowest marginal cost of production for every unit sold, while horizontal multinationals only benefit from low marginal costs of production in the foreign plant. However, horizontal multinationals do not suffer the transport costs in the home country. Conditional on productivity, both firms are equally profitable in the foreign country. Which firm is more profitable in the home country will depend on the relative size of marginal costs across countries and the transport cost. If the total marginal cost of producing a unit for sale abroad by a vertical multinational τw is greater than the marginal cost

[42] As demonstrated in conditions (C1)-(C4) the fixed costs do not have to have this strict of a ranking. I assume such a ranking here to improve the exposition of the cutoff values.

of the horizontal multinational w^*, the latter will earn higher profits in the home country. On the other hand, if $w^* > \tau w$ and fixed costs are higher for the horizontal multinational[43] then no firm will ever choose to be a horizontal multinational.

The last effect on the slope of the production function is country size. Although figure 1 abstracts from differences in country size, it will always increase the profitability of any firm producing for that market. Thus, the greater the country size, the greater the amount of entry from any type of firm. This is particularly true for home country firms, which would otherwise suffer substantial transport costs by exporting to the large country.

Figure 1 demonstrates that the differences in the slopes and intercepts create four distinct cutoff levels between foreign country firms. The first cutoff $a_D^{*1-\varepsilon}$ partitions the active from the non-active firms. Between cutoffs $a_D^{*1-\varepsilon}$ and $a_X^{*1-\varepsilon}$ all firms have positive profits in the domestic market, but are not productive enough to engage in exports or FDI. Likewise, all firms with productivity levels between $a_X^{*1-\varepsilon}$ and $a_V^{*1-\varepsilon}$ are productive enough to export abroad, but not productive enough to establish home plants and capture lower foreign wages. Any firm with productivity above $a_V^{*1-\varepsilon}$ establish plants abroad, but only those with productivity above $a_H^{*1-\varepsilon}$ establish them in both countries. Thus, given a firm's productivity index $a^{*1-\varepsilon}$ its optimal production strategy can be read off the highest of all four profit functions at that point.

Figure 2 demonstrates a similar pattern for home country firms except for the fact that the profit function for a vertical multinational always lies below at least one of the other profit functions. This implies that home firms who produce abroad and export back home are not maximizing profits.[44] This is intuitive since foreign producers are already located in the country with lower marginal costs. However, as long as $w\tau > w^*$, the most productive home country firms will still want to invest horizontally in the foreign country in order to avoid paying the transport costs.

3.6 Equilibrium

I focus on a stationary equilibrium in which aggregate variables are constant over time. The value of a potential entrant is given by the maximum of its exiting value, which is assumed to

[43]Technically, condition (C3) holds.

[44]Thus, for home country firms I use an economy very similar to that in Helpman, Melitz and Yeaple (2003).

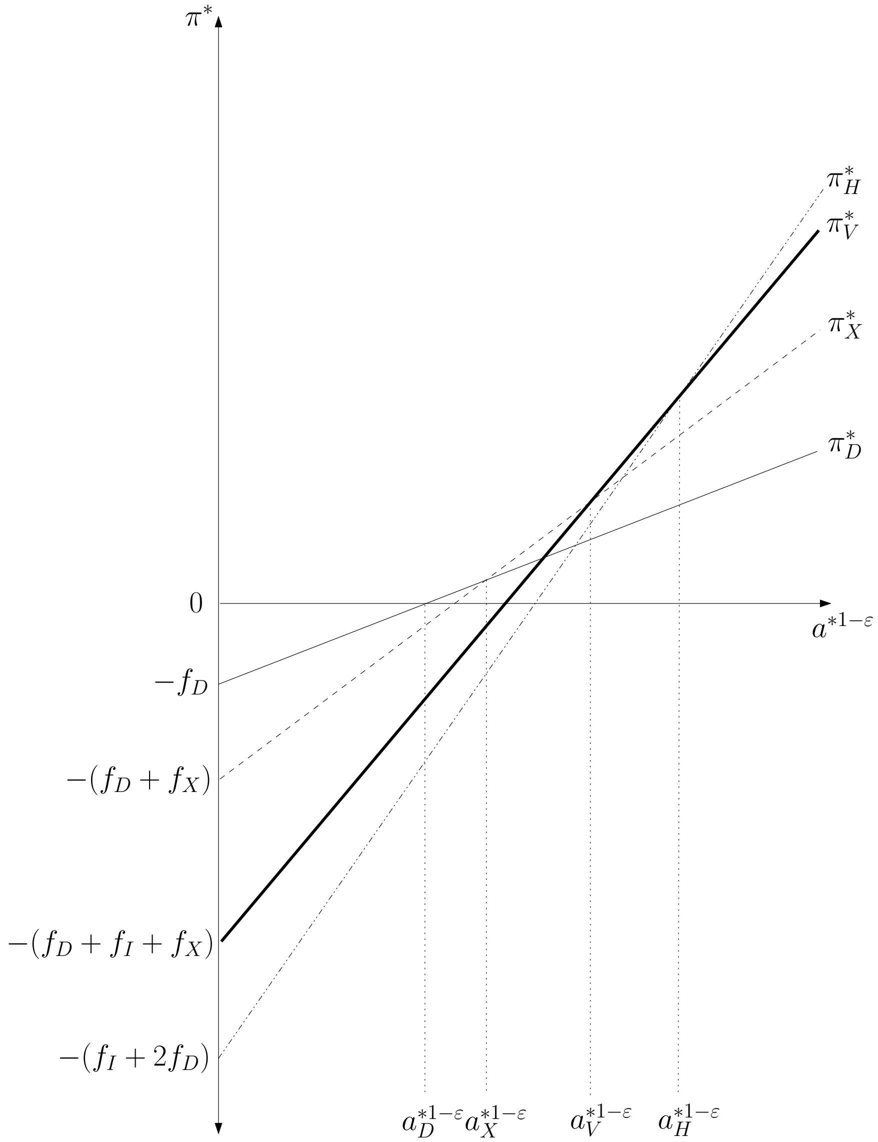

Figure 1: Foreign Country Productivity Cut-off Levels

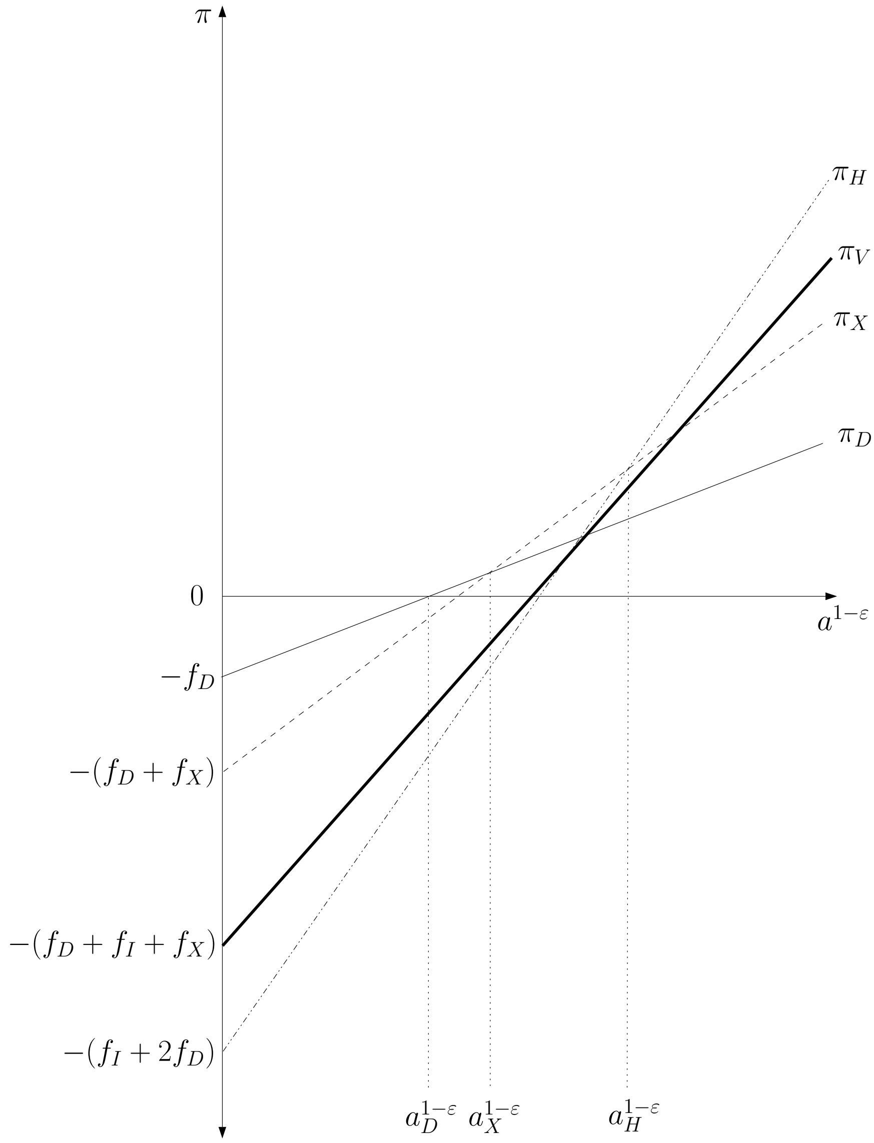

Figure 2: Home Country Productivity Cut-off Levels

be zero, and the discounted sum of expected profits

$$V(a) = \max\left\{0, \sum_{t=1}^{\infty}(1-\xi)^t E\left(\max_{S\in\{D,X,V,H\}}\pi_S(a)\right)\right\} = \max\left\{0, \max_{S\in\{D,X,V,H\}}\frac{\pi_S(a)}{\xi}\right\} \quad (8)$$

where unstarred functions are replaced with starred functions for foreign firms. Following Melitz (2003) I can write the revenue of any firm as a function of the productivity of the marginal firm with productivity a_D

$$r_S(a) = \lambda_S\left(\frac{a}{a_D}\right)^{1-\varepsilon} f_D \quad (9)$$

where I can solve for

$$\lambda_X = 1 + (\tau B/B^*)^{1-\varepsilon},\ \lambda_V = (w^*/w)(\tau^{1-\varepsilon} + (B^*/B)^{1-\varepsilon}) \text{ and } \lambda_H = 1 + ((w^*B^*)/(wB))^{1-\varepsilon}$$

by multiplying and dividing each revenue function by $r_D(a_D) = (a_D w B)^{1-\varepsilon} = f_D$.[45]

Let average profits within each group of firms be denoted by $\tilde{\pi}_S(a_D)$ and the fraction of firms within each group as $\nu_S(a_D)$. Average overall profit, $\bar{\pi}(a_D)$, is then

$$\bar{\pi}(a_D) = \sum_S \nu_S(a_D)\tilde{\pi}_S(a_D). \quad (10)$$

Equation (10) relates average profits to the marginal productivity level in equilibrium. For foreign firms average profits can be expressed as

$$\bar{\pi}^*(a_D^*) = \sum_S \nu_S^*(a_D^*)\tilde{\pi}_S^*(a_D^*) \quad (11)$$

where $a_D = a_D^*\left(\frac{w^*B^*}{wB}\right)$.

A second set of equilibrium relations is provided by the free entry conditions. The free entry conditions imply that the ex-ante expected value of a potential entrant in either country must be zero

$$(1 - G(a_D))\left(\frac{\bar{\pi}(a_D)}{\xi}\right) = f_E \qquad \text{and} \qquad (1 - G^*(a_D^*))\left(\frac{\bar{\pi}(a_D^*)}{\xi}\right) = f_E^*. \quad (12)$$

[45]For the foreign country the same three multipliers exist, λ_X^*, λ_V^*, and λ_H^*, the only difference being that the starred and unstarred variables are switched.

I solve equations (10)-(12) to determine the equilibrium values of a_D and $\bar{\pi}(a_D)$ (and hence a_D^* and $\bar{\pi}^*(a_D^*)$). Unlike Melitz (2003) the lack of symmetry across countries does not allow me to ensure the existence or uniqueness of equilibrium, however, it can be demonstrated numerically that such an equilibrium exists for reasonable parameter values.[46]

4 Empirical Model

4.1 Environment

In this section I construct an empirical analog to the theoretical model presented in the previous section. I extend the theoretical model to incorporate stochastic fixed cost shocks to the exit, export and foreign investment decisions captured in the theoretical model.[47]

I extend Rust's (1987) framework to examine the nature of exit, export and foreign investment decisions in the presence of stochastic fixed costs. Specifically, I reframe the model as a *nested logit* dynamic programming problem in which the set of alternatives facing each producer are partitioned into different subsets. At the beginning of every period, an incumbent firm first draws an idiosyncratic cost shock $\epsilon_t^{\chi} \equiv (\epsilon_t^{\chi}(0), \epsilon_t^{\chi}(1))$ associated with its exiting decision $\chi \in \{0, 1\}$. If the firm decides to exit, $\chi = 0$, it receives the terminal value $\epsilon_t^{\chi}(0)$. If the firm decides to produce, $\chi = 1$ it receives $\epsilon_t^{\chi}(1)$ along with the value of continued operation. I assume that ϵ_t^{χ} is independent of alternatives and is randomly drawn from the extreme-value distribution with scale parameter ϱ_{χ}.

I assume that all Indonesian plants choose to produce only in Indonesia. If an Indonesian firm decides to produce, it then draws cost shocks ϵ_t^{xh} associated with its export decision. The firm's export decision is captured by the binary variable $d^x \in \{0, 1\}$ where $d^x = 1$ if a firm chooses to export. Again, I assume that ϵ_t^{xh} is independent of alternatives and is randomly drawn from an extreme-value distribution with the scale parameter ϱ_{xh}.

Foreign firms have a larger decision tree. After deciding to produce, each firm draws a cost shock associated with its foreign investment decision ϵ_t^{if}. The parameter $d^i \in \{0, 1\}$ denotes the

[46] A numerical example in Matlab is available from the author upon request. See Helpman, Melitz and Yeaple (2004) or Kasahara and Lapham (2006) for other examples of similar models that exploit symmetry to prove the existence and uniqueness of equilibrium.

[47] The cost shocks are necessary to capture certain patterns in the data. For instance, the theoretical model predicts that all firms below a certain cutoff will exit the market. However, the data confirms the existence of many small firms.

firm's foreign investment decision and $d^i = 1$ when a firm chooses to invest in a foreign country. Thus, I capture the firm's export and investment decisions by $d = (d^x, d^i)$. Firms that decide not to invest abroad draw the cost shocks ϵ_t^{xh} associated with their export decisions[48] while firms that invest abroad instead draw a cost shock ϵ_t^{xf} assoiciated with their export decisions. Detailed game trees can be found in the Appendix. All of the cost shocks are independently drawn from extreme value distributions with the scale parameters ϱ_{if}, ϱ_{xh} and ϱ_{xf}, respectively. It is important to emphasize that the scale paramters differ across investment and export decisions for foreign firms and across export decisions for Indonesian and foreign firms. The separation of cost shocks will be important in capturing the differences in productivity distributions across firms.[49]

Given the structure of the cost shocks I can characterize the optimization problem for an incumbent Indonesian firm with productivity level a by the following set of Bellman equations:

$$V_h(a) = \int \max\{\epsilon^{\chi}(0), W_h(a) + \epsilon^{\chi}(1)\} dH^{\chi}(\epsilon^{\chi}), \tag{13}$$

$$W_h(a) = \int \left(\max_{d^x} \pi_h(a, d^{x\prime}) + \beta V_h(a) + \epsilon^{xh}(d^{x\prime}) \right) dH^{xh}(\epsilon^{xh}) \tag{14}$$

where β is the discount factor and H^{χ} and H^{xh} are the cumulative distribution functions of ϵ^{χ} and ϵ^{xh}, respectively. The optimization problem of a foreign incumbent is similar except now the Bellman equations reflect the separation of the export and investment decisions.

$$V_f(a) = \int \max\{\epsilon^{\chi}(0), W_f(a) + \epsilon^{\chi}(1)\} dH^{\chi}(\epsilon^{\chi}), \tag{15}$$

$$W_f(a) = \int \max\{J_f(a, d^i(0)) + \epsilon^{if}(0), J_f(a, d^i(1)) + \epsilon^{if}(1)\} dH^{if}(\epsilon^{if}) \tag{16}$$

$$J_f(a, d^i) = \begin{cases} \int \left(\max_{d^x} \pi_f(a, d^{x\prime}, d^i(0)) + \beta V_f(a) + \epsilon^{xh}(d^{x\prime}) \right) dH^{xh}(\epsilon^{xh}) & \text{for } d^i = 0 \\ \int \left(\max_{d^x} \pi_f(a, d^{x\prime}, d^i(1)) + \beta V_f(a) + \epsilon^{xf}(d^{x\prime}) \right) dH^{xf}(\epsilon^{xf}) & \text{for } d^i = 1 \end{cases} \tag{17}$$

Using the properties of extreme-value distributed random variables[50] along with the solution to the functional equations (13)-(17), the conditional choice probabilities follow the familiar

[48] I assume that firms that decide to produce domestically in either the home or foreign country draw export cost shocks from the same distribution.

[49] This is particularly true since this model does not have any sunk costs to help capture differences in the persistence of investment or export status.

[50] See Ben-Akiva and Lerman (1985) for an example.

nested logit formula (c.f. McFadden, 1978).[51] The probability of producing this period ($\chi = 1$) and the probability of exiting this period ($\chi = 0$) are calculated as:

$$P_j(\chi = 1|a) = (1-\xi)\frac{\exp(W_j(a)/\varrho^{\chi})}{\exp(0) + \exp(W_j(a)/\varrho^{\chi})} \tag{18}$$

and $P_j(\chi = 0|a) = 1 - P_j(\chi = 1|a)$ where ξ is the exogenous probability of exit and $j = H, F$. Conditional on continuously operating, the probability of a producer with productivity level a choosing to export from the domestic country is calculated as

$$P_j(d^x|a, \chi = 1, d^i = 0) = \frac{\exp([\pi_j(a, d^x, d^i = 0) + \beta V_j(a)]/\varrho^{xh})}{\sum_{d^{x\prime}} \exp([\pi_j(a, d^{x\prime}, d^i = 0) + \beta V_j(a)]/\varrho^{xh})} \tag{19}$$

The choice probabilities for foreign investment and export are calculated similarly. Conditional on operating, the probability of investing in Indonesia is given by

$$P_f(d^i|a, \chi = 1) = \frac{\exp(J(a, d^i)/\varrho^{if})}{\exp(0) + \exp(J(a, d^i)/\varrho^{if})} \tag{20}$$

while the exporting probabilities for foreign plants are calculated as

$$P_f(d^x|a, \chi = 1, d^i = 1) = \frac{\exp([\pi_f(a, d^x, d^i = 1) + \beta V_f(a)]/\varrho^{xf})}{\sum_{d^{x\prime}} \exp([\pi_f(a, d^{x\prime}, d^i = 1) + \beta V_f(a)]/\varrho^{xf})} \tag{21}$$

I focus on a stationary equilibrium where the distribution of a is constant over time. I assume that the logarithm of plant-specific productivity, $\ln a$, is drawn from the $N(0, \sigma_{aj})$ distribution where the variance of the distribution, σ_{aj} varies across Indonesian and foreign plants, $j = h, f$.[52] As in the theoretical model, I further assume that these draws are independent of each other and are constant over the life of the firm. Let $g_a(a)$ denote the density function of a for Indonesian

[51] As described in Rust (1994) there are important differences between the static nested logit models and dynamic nested logit models, like the one described here. First, in static models the *independence from irrelevant alternatives* (IIA) property holds within each nest. However, in a dynamic setting the IIA property typically cannot hold even within a nest because the continuation value depends on alternatives outside the nest. Second, a static model usually has a closed-form specification in parameters, such as linear-in-parameters specification. Dynamic models, such as the one here, do not have a closed-form expression in parameters and instead require the solution to the functional equations (13)-(16). Evaluating the conditional choice probabilities in a dynamic setting is a computationally intensive task. Fortunately, the extreme-value specification adopted here substantially simplifies the computation by avoiding the need for multi-dimensional numerical integration in (13)-(17).

[52] I assume that the initial mean of the distribution of initial productivity draws is the same across foreign and domestic plants. It is difficult to identify the initial mean for foreign plants since the data only captures a subset of all foreign plants.

plants.

The above assumptions imply that we can write down the expected value of the firm, which, under free entry, must be equal to the fixed entry cost f_E:

$$\int V(a)g_a(a)da = f_E. \tag{22}$$

Denote the stationary distribution of a among incumbents as $g_a^s(a)$. A stationary equilibrium requires that the number of exiting firms with productivity a must equal the number of successful entrants with the same productivity level. Specifically,

$$MP(\chi = 0|a)g_a^s(a) = M_e P(\chi = 1|a)g_a(a) \qquad \text{for all } a \tag{23}$$

where M is the mass of incumbents and M_e is the total mass of entrants that attempt to enter the market. Rearranging terms, the stationary distribution of productivity $g_a^s(a)$ can be computed as

$$g_a^s(a) = \frac{M_e}{M}\frac{P(\chi = 1|a)}{P(\chi = 0|a)}g_a(a) \tag{24}$$

where

$$\frac{M_e}{M} = \frac{1}{\int \frac{P(\chi=1|a)}{P(\chi=0|a)}g_a(a)da}$$

since $\int g_a^s(a)da = 1$. A similar procedure is followed for foreign plants.

4.2 The Likelihood Function

I define the following function of iceberg shipping costs[53]

$$\varphi_\tau \equiv (1 - \varepsilon)\ln\tau. \tag{25}$$

I assume that total revenue is measured with error and that exogenous technological change occurs at rate ρ. By modifying the profit functions to include measurement error and a time trend, I use equations (3)-(6) to write the logarithm of *observed* revenue for any plant i as

$$\ln r_{it} = \rho_t t + \ln\varphi_B(1 - d_{it}^X) + \ln[\varphi_B + \varphi_W \exp(\varphi_\tau)]d_{it}^X - \ln a_i + \nu_{it} \tag{26}$$

[53] Allowing transport costs to vary across foreign and domestic plants makes little difference to the final results.

where r_{it} is observed revenue, φ_W measures the ratio of wages across countries $(w^*/w)^{1-\varepsilon}$, φ_B is a function of the country sizes and prices $(B^*/B)^{1-\varepsilon}$ and ν_{it} is the associated measurement error. Equation (26) highlights an important limitation of the data: I only observe the revenue, exports and ownership from plants located in Indonesia. I do not observe any variables for plant parents or subsidiaries abroad. Estimating the model requires imposing some consistency across plants located in different countries. In particular, I assume that every foreign non-exporting plant also produces in a separate plant located in the foreign country with the same firm-specific productivity level as the plant located in Indonesia.

Using the empirical specification, a firm's detrended net profit may be expressed in terms of reduced-form parameters[54] as:

$$\pi_h(a_h, d_{ht}) = r_h(a_h, d_{ht}) - F_h(d_{ht}) \qquad \text{for Indonesian Firms} \tag{27}$$

$$\pi_f(a_f, d_{ft}) = r_f(a_f, d_{ft}) - F_f(d_{ft}) \qquad \text{for Foreign Firms} \tag{28}$$

The revenue functions for Indonesian (r_h) and foreign (r_f) firms can be written as

$$r_h(a_i, d_{it}) = \exp\left(\Psi_{Dh}(1 - d_{it}^X) + \Psi_{Xh} d_{it}^X - \ln a_i\right) \tag{29}$$

$$r_f(a_i, d_{it}) = \exp\left(\Psi_{Xf} d_{it}^X (1 - d_{it}^I) + \Psi_{Xh} d_{it}^X d_{it}^I + \Psi_{Ih} d_{it}^I (1 - d_{it}^X) - \ln a_i\right) \tag{30}$$

where $\Psi_{Dh} = \ln \varphi_B$, $\Psi_{Xh} = \ln[\varphi_B + \varphi_W \exp(\varphi_\tau)]$, $\Psi_{Xf} = \ln[1 + \varphi_B \exp(\varphi_\tau)/\varphi_W]$ and $\Psi_{Ih} = \ln[1 + \varphi_B]$. I specify the fixed costs for Indonesian and foreign firms as

$$F_h = \begin{cases} f_{Dh} & \text{for } (d_{it}^X, d_{it}^I) = (0,0) \\ f_{Dh} + f_{Xh} & \text{for } (d_{it}^X, d_{it}^I) = (1,0) \end{cases}$$

$$F_f = \begin{cases} f_{Df} & \text{for } (d_{it}^X, d_{it}^I) = (0,0) \\ f_{Df} + f_{Xf} & \text{for } (d_{it}^X, d_{it}^I) = (1,0) \\ f_{Df} + f_{Dh} + f_{Ih} & \text{for } (d_{it}^X, d_{it}^I) = (0,1) \\ f_{Dh} + \zeta f_{Xh} + f_{Ih} & \text{for } (d_{it}^X, d_{it}^I) = (1,1) \end{cases}$$

where F_h and F_f are the fixed cost functions for Indonesian and foreign firms, respectively. The

[54] The detrended firm's problem uses a trend-adjusted discount factor $\beta \exp(\rho)$ when solving the Bellman's equation.

fixed cost of an Indonesian non-exporter is f_{Dh}, while f_{Xh} and f_{Ih} represent the additional fixed costs of exporters located in Indonesia and foreign firms investing in Indonesia. The parameter ζ captures any reduction in fixed export costs that are enjoyed by foreign firms. Fixed costs with a subscript f represent the same costs in the foreign country.

Due to limitations of the data it is not possible to identify the parameters φ_W, f_{Df}, and f_{Xf}. The first parameter represents differences in wages across countries. I calibrate this parameter using data on manufacturing wages in different countries.[55] The last two parameters are fixed cost parameters in the foreign country. To calibrate the fixed cost of operating in a foreign country, f_{Df} I use an index of labour rigidity to estimate that $f_{Df} = 0.51 f_{Dh}$. Similarly, I calibrate that the fixed cost of exporting from the foreign country is $f_{Xf} = 0.38 f_{Xh}$ using the number of days needed to process export applications across countries. The information for this calibration is taken from the World Bank's *Doing Business Report*. To test for possible misspecification around the fixed cost parameters, I check the robustness of the results with regards to this calibration by estimating the model under various alternative fixed cost assumptions.[56]

The vector of remaining parameters θ is estimated by the method of maximum likelihood where[57]

$$\theta = (\rho, \varphi_B, \varphi_\tau, f_{Dh}, f_{Xh}, f_{Ih}, \zeta, \xi, \varrho^{\chi}, \varrho^{xh}, \varrho^{xf}, \varrho^{if}, \sigma_{ah}, \sigma_{af}).$$

Denote $T_{i,0}$ as the first year the firm appears in the data. Then, conditional on a_i the likelihood contribution of plant i in year $t > T_{i,0}$ is

$$L_{it}(\theta|a_i) = \begin{cases} P(\chi_{it} = 0|a_i) & \text{for } \chi_{it} = 0 \\ \underbrace{P(\chi_{it} = 1|a_i)}_{\text{Stay/Exit}} \underbrace{P(d_{it}|a_i, \chi_{it} = 1)}_{\text{FDI/Export}} \underbrace{g_\nu(\tilde{\nu}_{it}(a_i))}_{\text{Revenue}} & \text{for } \chi_{it} = 1 \end{cases}$$

Note that the endogeneity of the export, investment and exiting decisions are controlled by simultaneously considering the likelihood contribution from each decision.

In the first year of the sample, T_{i0}, I only observe plants that stay in the market. Thus, I

[55] The wage data is taken from the International Labour Organization Bureau of Statistics. The foreign wage is a weighted average of foreign wages using the share of FDI in Indonesia as weights.

[56] In particular, I re-estimate the model assuming that the fixed operation costs are equal across countries and that fixed costs are much higher in Indonesia.

[57] The discount factor is not estimated and is set to 0.95. It is difficult to identify the discount factor β in dynamic discrete choice models. I also assume that the mean of the distribution of initial productivity draws is the same for Indonesian and foreign firms.

calculate the likelihood contribution of these plants in the initial year conditional on $\chi_{it} = 1$:

$$L_{it}(\theta|a_i) = P(d_{it}|a_i, \chi_{it} = 1) g_\nu(\tilde{\nu}_{it}(a_i)) \tag{31}$$

Let $T_{i,1}$ denote the last year plant i appears in the data. Then, the likelihood contribution from each plant i with productivity level a_i is

$$L_i(\theta|a_i) = \prod_{t=T_{i,0}}^{T_{i,1}} L_{it}(\theta|a_i).$$

If plant i enters the sample after the initial year, I assume that a_i is drawn from the distribution of initial draws. For domestic plants that enter after the initial sample year, I need to use the distribution of initial draws of home firms upon successful entry into the home country given by

$$g_a^e(a) = \frac{P(\chi = 1|a) P_{in}^h(a)}{\int P(\chi = 1|a') P_{in}^h(a') da'} g_a(a). \tag{32}$$

Similarly, for foreign plants, I use the distribution of initial draws upon successful entry of foreign firms into the home country given by

$$g_a^{e*}(a) = \frac{P(\chi = 1|a) P_{in}^f(a)}{\int P(\chi = 1|a') P_{in}^f(a') da'} g_a^*(a). \tag{33}$$

where $P_{in}^f(a) = P(d = (0,1)|a, \chi = 1) + P(d = (1,1)|a, \chi = 1)$. The likelihood contribution from each plant i is calculated by numerically intergrating out unobserved plant-specific productivity a_i as

$$L_i(\theta) = \begin{cases} \int L_i(\theta|a') g_a^s(a) da' & \text{for } T_{i,0} = 1993, \\ \int L_i(\theta|a') g_a^e(a) da' & \text{for } T_{i,0} > 1993, \end{cases}$$

where the starred distributions are used in place of the unstarred distributions for foreign firms. The parameters vector θ can then be estimated by maximizing the logarithm of the likelihood function

$$\mathcal{L}(\theta) = \sum_{i=1}^{N} \ln L_i(\theta). \tag{34}$$

The evaluation of the log-likelihood function involves solving the dynamic programming problem that approximates the Bellman equations (13)-(17) by discretization of the state space.

I first fix ω which determines the fixed export cost in the foreign country. Then for each candidate choice of parameter vector, I solve the discretized dynamic programming problem (13)-(17), calculate the conditional choice probabilities (18)-(21) and the stationary distributions. Using the conditional choice probabilities and the stationary distributions, I evaluate the log-likelihood function (34). Searching over the parameter space of θ, I maximize (34) to find the estimates.

4.3 Reduced-Form & Structural Parameters

It is not possible to identify all of the parameters of the model. Equation (26) is a reduced-form specification where the reduced-form parameters represent the structural parameters as follows.

$$\varphi_B = \left(\frac{wB}{w^* B^*}\right)^{1-\varepsilon}, \tag{35}$$

$$\varphi_W = \left(\frac{w}{w^*}\right)^{1-\varepsilon}. \tag{36}$$

It is important to note that policy changes may affect the value of reduced-form parameters if the underlying structural parameters change. For instance, any change to the aggregate price levels P will lead to a change in $B = [(1-\alpha)\gamma E]^{1/(1-\varepsilon)}/(\alpha P)$ and φ_B. The counterfactual experiments in this paper explicity account for equilibrium price changes on the reduced-form coefficients using our knowledge of the relationship between the reduced-form coefficients and the aggregate prices.

4.4 Identification

The identification of the revenue function (26) parameters follows from the within-plant variation in export status along with the moment restrictions $E[\nu_{it} - \nu_{i(t-1)}|d_{it}] = 0$ where $i \in \{h, f\}$. The latter condition is obtained by first-differencing the plant-level revenue function (26). I further assume that the panel is long enough that given the parameters identified in the revenue function, I can identify the value of plant-specific productivity a for each plant.[58]

Since the exiting probabilities are strictly increasing in the fixed cost, f_{Dh}, I can identify f_{Dh} by relating the probability of exit to the variation in a. At the same time, the elasticities of the exiting probabilities tend to decrease as the variance of the exiting shocks increases.

[58]Even though I only use four years of data, the distributional assumptions on a allow me to identify each plant's likelihood of having a particular value of a.

The variation in the differences between different a's across firms and the difference in exiting probabilities identify the scale parameter ϱ_χ separately from f_D.[59] We may similarly identify the fixed cost and scale parameters by relating the variation in a to the variation in export and investment probabilities.

Lastly, the scale of the profit function cannot be identified because multiplying the profit function by a constant leads to the same optimal choice. Thus, for identification I normalize the profit functions (27)-(28) by $\kappa = \varepsilon/(w^* B^*)^{1-\varepsilon}$.[60]

4.5 Data

I employ data from the Indonesian manufacturing census for 1993-1996.[61] The census enumerates all plants with at least 20 employees.[62] I focus on Indonesian food, textile and manufactured metals industries since they are among Indonesia's largest industries and receive substantial foreign direct investment.[63] I omit all plants that are owned entirely by the Indonesian government.[64] The food, textile and manufactured metals industry data consists of unbalanced panels of 6,042, 4,491 and 2,497 plants, respectively, where each plant is observed for at least one year between 1993 and 1996.[65]

The advantage of this data set relative to many other plant-level data sets is that I am able to observe the percentage of foreign ownership for each individual plant. I identify a foreign plant as any plant that has positive foreign ownership as a foreign plant. It is possible that if foreign investors own a small minority of plant equity the plant may not be foreign controlled. However, in over 66% of the foreign firms in the sample, foreign investors own at least 50% of the equity, while foreign investors own at least 25% of foreign firms in 95% of the sample.[66]

[59] The variance of the exit decision cost shocks is calculated as $Var(\epsilon^\chi(\chi)) = \frac{(\varrho_\chi \pi)^2}{6}$.

[60] Specifically, by multiplying the profit function by ε, I estimate the parameters κf_{Dh}, κf_{Xh}, κf_{Ih}, $\kappa \varrho_\chi$ and $\kappa \varrho_d$ instead of f_{Dh}, f_{Xh}, f_{Ih}, ϱ_χ and ϱ_d.

[61] Two-digit ISIC classification.

[62] It is believed that over this period the coverage was close to complete since regional offices had financial incentives to enumerate plants (Blalock and Gertler, 2005).

[63] Approximately 58% of all foreign plants in the Indonesian manufacturing census are in the food, textile and manufactured metals industries.

[64] Overall, I eliminate 669 plants over the 1993-1996 period.

[65] A description of the Indonesian manufacturing industry over this period can be found in Blalock and Gertler, 2005.

[66] Blalock and Gertler (2005) argue that firms with significant foreign ownership are likely to be foreign controlled even if they are not majority owned. Moreover, this variable correlates very well with a government status variable that indicates whether a firm if a plant has official foreign status by the Indonesian government.

Similarly, I identify exporters as plants that receive any positive revenues from export sales. As discussed in the second section this definition is the most conservative of all possible thresholds.

The unit of observation is that of the individual plant, not the firm. This is particularly important to this empirical exercise because I do not observe if the plant is a parent or a subsidiary, but only if it is foreign or domestically owned. To estimate the model I will have to make an assumption that all foreign plants are part of a multinational firm and that all domestic plants are strictly national firms.[67] Although the assumption that all foreign plants are part of a larger multinational firm is a strong assumption, to the extent that the model captures the decision of foreign plants to enter Indonesia, the model's implications for Indonesia will remain valid.[68]

Since I only observe plants located in Indonesia, I calibrate the foreign country parameters using data the International Labour Organization Bureau of Statistics and the World Bank's Doing Business Report. Specifically, I use the wage data from the International Labour Organization Bureau of Statistics for manufacturing wages and the World Bank's Doing Business Report to estimate the relative size of fixed operation and export costs across countries.

Another limitation of the data is that I do not observe the export destinations of each firm. Thus, I cannot identify plants that export to developed markets versus those who use Indonesia as an export platform for nearby regional markets. However, Table 6 suggests that Indonesian industries that earn a higher percentage of revenues from exports are more likely to export to developed countries. Along with the discussion in Section 2, this would suggest that vertical multinationals are more likely to export-intensive foreign firms. In order to be conservative I assume that all foreign exporters are vertical multinationals and all foreign non-exporters are horizontal multinationals.[69]

I focus on the following four variables for each plant i in year t: χ_{it}, r_{it}, d_{it}^X and d_{it}^I. I convert the nominal value of total sales by the manufacturing output price deflator to calculate the real

[67]Several other empirical papers use data that directly connects parents and subsidiary plants (see Helpman, Melitz and Yeaple (2004), for example). Unfortunately, these data sets are inadequate to estimate the model presented here, since it requires observing all plants in the industry. Baily, Hulten and Campbell (1992) show that accounting for productivity differences across plants is particularly important when evaluating policy. Thus, in order to perform the policy experiments in this paper I must observe all plants in the industry.

[68]The OECD Direct Investment Statistics (2006) reports that Indonesia received over 14,352 million US dollars of foreign investment from 1993-1996, while it only supplied just over 40 millions US dollars worth of FDI to the world economy.

[69]The results would not change if I included firms that only receive a small percentage of revenues from export sales in the "non-exporting" group.

Table 5: Indonesian Export Destinations

Industry	Export Intensity[a]	% of Industry Exports to Developed Nations	No. of Obs.
Wood	0.67	58%	1,860
Textiles	0.55	75%	1,816
Food	0.46	64%	956
Manufactured Metals	0.41	49%	892
Minerals	0.41	47%	275
Chemicals[b]	0.35	47%	1,065
Basic Metals	0.33	32%	144
Paper	0.27	19%	147

Notes: Data compiled from the United Nations Commodity Trade Statistics 1994. (a) Export Intensity is the mean export intensity of all exporting firms in the industry. (b) I have omitted firms in the petroleum industry as they were large outliers. This resulted in the removal of twelve plant-year observations.

value of total sales, r_{it}. The binary variables d_{it}^X and d_{it}^I are constructed by checking the value of export sales and foreign ownership in each year. The entry/exit decision, χ_{it} is identified by checking whether plants employed a positive number of workers in each year.

Table 7 provides descriptive statistics for all five variables over the sample period. The large standard deviations indicate substantial variation across plants in terms of total sales, export sales and labour. The percentage of foreign plants is highest in the manufactured metals industry and lowest in the food industry. Table 7 also demonstrates high exit and entry rates which are important for identifying the parameters that affect the choice probabilities as well as the initial distribution of productivity shocks. On average 906, 674 and 400 new plants enter the Indonesian food, textiles and manufactured metals industries each year, respectively, while 544, 359, 150 incumbents exit. A substantial amount of turnover is important for identifying the parameters that determine the exiting choice probabilities and the distribution of initial draws.

5 Estimation Results

Table 8 presents the maximum likelihood parameter estimates of the empirical model along with the associated asymptotic standard errors. The standard errors are computed using the outer product of gradients estimator. The parameters are evaluated in millions of Indonesian rupiahs in 1983.

Table 6: 1993-96 Descriptive Statistics

	Total Sales[a]	Export Sales[a,b]	Labour	Mark-Up Rate[c]	% Foreign Plants[d]	Entry Rates[e]	Exit Rates[f]	No. of Plants
Food	25.51	44.67	106.64	0.26	0.02	0.15	0.09	6,042
	(410.97)	(312.42)	(703.44)	(0.18)	—	—	—	—
Metals[g]	45.77	45.70	168.87	0.33	0.10	0.16	0.06	2,497
	(210.26)	(102.67)	(325.05)	(0.19)	—	—	—	—
Textiles	38.35	56.76	245.09	0.26	0.04	0.15	0.08	4,491
	(198.91)	(144.16)	(730.25)	(0.16)	—	—	—	—

Notes: Reported numbers are sample means with standard deviations in parentheses. (*a*) In millions of Indonesian Rupiahs. The percentage change is calculated as the mean percentage change across plants. (*b*) Computed using the sample of exporting plants. (*c*) The mark-up rate is computed as (revenue-variable cost)/revenue where variable cost is measured as the sum of materials, energy, fuel and the wages paid to production workers. (*d*) The average is computed as the percentage of plants with foreign ownership. (*e*) The number of new entrants divided by the total number of plants in 1993. (*f*) The number of exiting plants divided by the total number of plants. (*g*) Metals refers to manufactured metals rather than basic metals.

Table 7: Structural Estimates

Industry	Food		Metals		Textiles	
$\kappa\varrho_X$	52.416	(4.481)	31.780	(2.815)	35.490	(2.053)
$\kappa\varrho_{xh}$	10.287	(0.587)	4.897	(0.373)	7.902	(0.464)
$\kappa\varrho_{xf}$	3.428	(6.545)	1.055	(16.411)	0.455	(0.619)
$\kappa\varrho_{if}$	0.0001	(1.423)	0.001	(4.421)	0.0001	(1.667)
κf_{Dh}	2.379	(1.167)	3.567	(0.830)	5.870	(0.680)
κf_{Xh}	42.860	(2.307)	21.923	(1.548)	23.513	(1.324)
κf_{Ih}	28.041	(3.361)	29.293	(10.881)	46.737	(4.9860
ζ	0.078	(0.110)	0.088	(0.082)	0.034	(0.093)
ρ	-0.009	(0.010)	0.011	(0.013)	0.008	(0.009)
φ_B	0.853	(0.020)	1.531	(0.048)	1.486	(0.027)
φ_τ	-5.346	(0.060)	-3.799	(0.078)	-5.369	(0.060)
σ_{ah}	1.041	(0.007)	0.996	(0.008)	1.011	(0.003)
σ_{af}	1.139	(0.010)	0.971	(0.009)	0.941	(0.007)
ξ	0.006	(0.001)	0.021	(0.002)	0.014	(0.001)
$\varepsilon = 1/\text{mark-up}$	3.8		3.0		3.8	
log-likelihood	-34,806.143		-16,819.565		-31,866.159	
No. of Obs.	17,786		7,549		13,287	

Notes: Standard errors are in parentheses. The parameters are evaluated in units of millions of Indonesian Rupiahs in 1983. Metals refers to manufactured metals.

5.1 Fixed Costs

The average fixed cost of operation in Indonesia ranges from 12 and 19 thousand 1983 US dollars in the food and manufactured metals industries, respectively, to 25 thousand 1983 US dollars for the textiles industry. Although the average fixed cost is typically a large percentage (70 to 105% across industries) of the average domestic non-exporters revenue it is important to recall that the fixed costs *incurred* are substantially lower since the estimated model predicts many plants only produce when they receive beneficial cost shocks.

The average fixed export cost ranges from 101 and 114 thousand 1983 US dollars in the manufactured metals and textiles industries, respectively, to 222 thousand 1983 US dollars in the food industry. The differences in fixed costs are likely picking up larger differences in productivity between exporters and non-exporters in the food industry. The prevalence of less productive exporters in the textiles and metals industries may potentially be attributed to government export subsidies in those industries. Similarly, the fixed investment costs range from 145 thousand US dollars in the food industry, to 152 thousand 1983 US dollars in the manufactured metals industry and 202 thousand 1983 US dollars in the textiles industry. Again, the large differences in fixed FDI costs may not only reflect differences in fixed investment costs, but also government subsidies across industries.

The estimates imply that plants that engage in FDI and exports incur substantial per-period fixed costs to continue these activities. However, the large estimated size of the fixed export and investment costs are likely capturing the fact that the model does not allow for sunk costs associated with export or investment behaviour and may be biased upwards.[70] Also, the parameter capturing the fixed export cost savings of foreign exporters in Indonesia indicates that foreign plants save an average 91 and 92 percent of the fixed export costs relative to domestic exporters in the manufactured metals and food industries, while foreign textile exporters save 97 percent of the fixed export costs. This may be indicative of the prevalence of trade occuring across plants within the same multinational firm.

5.2 Exports and FDI

The parameters φ_τ and φ_B indicate that the impact of exports is substantial. In fact, the estimates imply that the average plant can increase their revenues by 64, 65 and 113 percent in the textiles, manufactured metals and food industries. These numbers are particularly large in light of the fact that the transport cost is estimated to be approximately 6.7 to 6.8 across industries. The large increase in revenues reflect the substantial productivity differences between exporting

[70]See Kasahara and Lapham (2007) and Das, Roberts and Tybout (2007).

Table 8: Distribution of Plants by Ownership/Export Status

Actual	Domestic Non-Exporters	Domestic Exporters	Foreign Non-Exporters	Foreign Exporters
Food	0.931	0.046	0.016	0.008
Metals	0.824	0.071	0.058	0.047
Textiles	0.839	0.114	0.025	0.023
Predicted				
Food	0.949	0.028	0.018	0.006
Metals	0.864	0.032	0.058	0.047
Textiles	0.865	0.088	0.021	0.026

Note: Metals refers to manufactured metals.

and non-exporting firms and the small size of Indonesian economy relative to that of the rest of the world.[71] The estimates also imply that on average 39percent of a domestic exporters revenues are from export sales in the manufactured metals and textiles industries, while exporters in the food industry receive 53 percent of revenues from export sales. Relative to the data, the model underpredicts the average percentage of revenues from exports in the manufactured metals and textiles industries by 1 and 14 percent, respectively, while overpredicting the average percentage of revenues from exports in the food industry by 4 percent.

We can examine the fit of the model by comparing its predictions of the actual distribution to plants in the data. Table 9 documents the predicted distribution of plants export and ownership status for all industries.[72] The model's predictions match the distribution of plants across export and ownership status very closely in all industries. Table 10 reports the models predicted domestic market and export shares across export and ownership status. While one would expect the model to predict the dominant role of foreign plants in the domestic and export markets, Table 10 demonstrates that it often overstates their importance in both domestic and export markets. Because of the substantial productivity difference in foreign and domestic plants, small differences in the distribution of plants or the predicted productivity differences can have large impacts at the aggregate level.

Table 9: Export/Domestic Market Share by Ownership/Export Ownership

	Export Share		Domestic Market Share			
Actual	Domestic	Foreign	Domestic Non-Exp.	Domestic Exp.	Foreign Non-Exp.	Foreign Exp.
Food	0.837	0.163	0.551	0.289	0.126	0.032
Metals	0.458	0.542	0.462	0.099	0.300	0.138
Textiles	0.717	0.283	0.602	0.238	0.097	0.062
Predicted						
Food	0.605	0.395	0.703	0.084	0.159	0.055
Metals	0.247	0.753	0.487	0.066	0.248	0.200
Textiles	0.452	0.548	0.550	0.136	0.149	0.165

Note: Metals refers to manufactured metals.

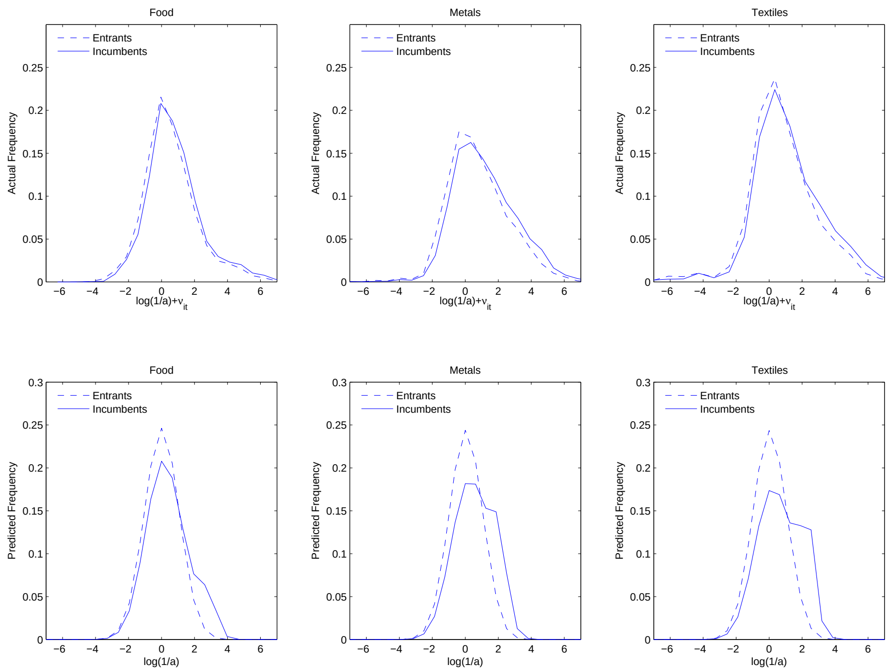

Figure 3: Productivity Distributions of Domestic Entrants and Incumbents (Actual vs. Predicted)

5.3 Productivity

The model predicts that only the most productive firms are able to produce profitably in Indonesia. Figure 3 shows the importance of survival selection among domestic plants in Indonesia.

[71]The parameters ϕ_B and phi_W jointly imply that Indonesia's economy is roughly 0.4 to 3.5 percent of the world economy.

[72]The estimated model does not provide a prediction in terms of the total number of foreign firms relative to the total number of domestic firms. As such, I take the percentage of foreign in the data as given.

The actual productivity distribution for incumbents in the top three panels is skewed to the right relative to the distribution of new entrants for all three industries. The bottom three panels of Figure 3 show that the model's predicted productivity distributions for entrants and incumbents capture this selection mechanism. Similarly, Table 11 confirms that domestic incumbents are on average 20 to 37 percent more productive than new domestic entrants across industries.

Figure 4 shows the productivity distributions for foreign entrants and incumbents. The top and bottom panels demonstrate both an important similarity and difference. First, the top panel shows that the distributions of foreign entrants and incumbents into Indonesia are very close. As Table 11 indicates, the estimated difference between foreign entrants and incumbents is relatively small. The predicted productivity distributions match this feature well in all 3 industries since the distribution of entrants and incumbents in Indonesia are almost identical. Second, there is a much smaller predicted productivity variance among foreign firms than we observe in the actual distribution. The reason for this is that both the exit and investment shocks are estimated to be very low relative to the profitability of foreign plants. As such, if a plant is productive enough to invest abroad there is little chance that they will receive a stochastic shock that will induce it to leave Indonesia. The difference between the predicted and actual distributions is suggestive of the presence of one-time sunk costs. That is, if a firm realizes a beneficial stochastic cost shock to a one-time sunk cost that allows it to invest in Indonesia, lower productivity foreign firms may be more likely to choose to invest in Indonesia. However, in a model with only fixed costs, one-time beneficial cost shocks will encourage many low productivity firms to temporarily enter Indonesia. However, this will quickly cause the exit rate of foriegn firms to rise to levels which are inconsistent with the observed exit rate in the data.

Table 10: Average Productivity

	Food		Metals		Textiles	
	Indonesian	Foreign	Indonesian	Foreign	Indonesian	Foreign
Mean at entry trial	1.000	1.000	1.000	1.000	1.000	1.000
Mean at successful entry in Indonesia	1.080	3.619	1.161	4.650	1.088	3.619
Mean at steady state in Indonesia	1.300	3.739	1.585	4.837	1.421	3.676
Non-Exporters	1.278	3.752	1.533	4.846	1.373	3.745
Exporters	2.060	3.703	2.983	4.824	1.901	3.621

Note: Metals refers to manufactured metals.

As shown in section 2 domestic exporters tend to have higher productivity than domestic

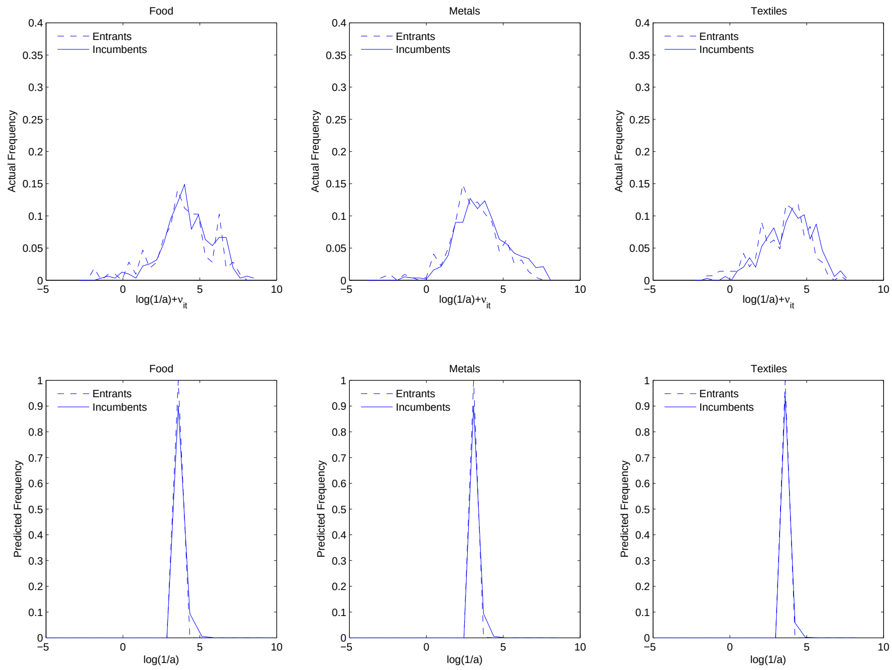

Figure 4: Productivity Distributions of Foreign Entrants and Incumbents (Actual vs. Predicted)

non-exporters, while the opposite is true for foreign plants. Also, foreign plants tend to be more productive than domestic plants. Figure 5 shows the actual and predicted productivity distributions for domestic non-exporters, domestic exporters, foreign non-exporters and foreign exporters, while Table 11 reports their average productivities. The top panel shows that in all three industries the plants follow the same productivity ranking that we observed in the section 2. In particular, it is notable that the productivity distribution of foreign non-exporters is skewed to the right of the productivity distribution of foreign exporters, though the differences across foreign plants are much less clear in the manufactured metals and textiles industries. However, the large difference between foreign and domestic firms is quite evident. The predicted distribution matches these rankings and Table 11 confirms that on average foreign non-exporters are the most productive plants, followed by foreign exporters, domestic exporters and domestic non-exporters. Again, it is important to note that the variance on the productivity distribution for foreign plants is smaller than that observed in the data.

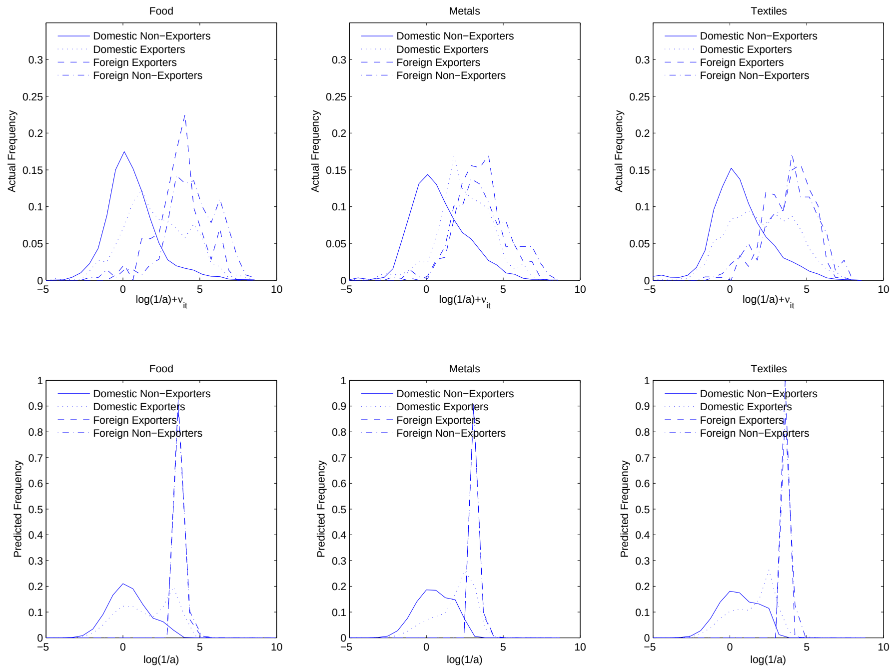

Figure 5: Productivity Distributions of Domestic and Foreign Firms by Export Status (Actual vs. Predicted)

5.4 Dynamics

Table 12 documents the actual and predicted transition probabilities of investment, export and exit in the textiles industry.[73] It is noteworthy that despite the model's restriction that no domestic plant can become a foreign plant, the model captures many of the transition probabilities between investment and export status relatively well. The data indicates that foreign ownership and export status are quite persistent. Although the model captures much of the persistence in export and ownership status, it still underpredicts the degree persistence for both foreign and domestic exporters. This could be indicative of the presence of the sunk export or investment costs.[74]

[73]Similar tables can be found in the appendix for the food and manufactured metals industries.

[74]Kasahara and Lapham (2007) also find that fixed export costs alone cannot explain the persistence in export status and suggest the potential presence of sunk export costs.

Table 11: Distribution of Ownership/Export Status - Textiles

Actual	Dom. Non-Exporters	Dom. Exporters	For. Non-Exporters	For. Exporters	Exit
Dom. Non-Exporters at t	0.945	0.051	0.003	0.001	0.088
Dom. Exporters at t	0.309	0.679	0.001	0.011	0.068
For. Non-Exporters at t	0.138	0.031	0.581	0.256	0.030
For. Exporters at t	0.027	0.066	0.178	0.732	0.016
Predicted					
Dom. Non-Exporters at t	0.912	0.088	—	—	0.144
Dom. Exporters at t	0.820	0.180	—	—	0.094
For. Non-Exporters at t	—	—	0.487	0.513	0.031
For. Exporters at t	—	—	0.414	0.586	0.029

5.5 Counterfactual Experiments

I present the results from a series of counterfactual experiments intended to examine the effect of trade and investment barriers for the textiles industry.[75] In particular, to determine the quantitative implications of barriers to trade and investment, I conduct the following three counterfactual experiments by manipulating three counterfactual parameters:

1. Autarky: $f_{Xh}, f_{Xf}, f_{Ih} \rightarrow \infty$,
2. No Trade: $f_{Xh}, f_{Xf} \rightarrow \infty$,
3. No Investment in Indonesia: $f_{Ih} \rightarrow \infty$,

To determine the full impact of trade or investment barriers on the Indonesian economy it is important to consider the effect policy changes have on the aggregate price level. To do this I employ the free entry conditions (22) and solve for the new price levels in Indonesia and the rest of the world which satisfies (22) under the policy change.[76]

Table 13 presents the results from the counterfactual experiments in the textiles industry.[77] The effect of trade and investment on average productivity can be best understood by comparing the steady state level of average productivity between the estimated (base) model and that of the counterfactual experiments in the first row. The second row compares welfare across the experiments and will be left to the end.

Eliminating trade and investment reduces average productivity in the textiles industry by 20.6 percent. As I discuss below, much of the fall in productivity can be attributed to the removal

[75] The results for the food and manufactured metals industries are presented in the appendix.
[76] See the Appendix for details.
[77] Results for the manufactured metals and food industries are presented in the Appendix.

Table 12: Counterfactual Experiments - Textiles

	Base	Autarky	No Trade	No FDI
Avg. Productivity[a]	2.772	2.200	2.728	2.268
$-(\varepsilon-1)\delta\Delta\ln P$	—	$-\delta 0.053$	0	0
Exit/Entry Rate of Foreign Firms in Indonesia	—	-1	0.017	-1
% of For. Non-Exporters	0.021	0	0.052	0
% of Dom. Exporters	0.088	0	0	0.092
%Δ in Dom. Exports	—	-1	-1	0
Dom. Mkt. Shr. of Dom. Non-Exp.	0.551	1	0.665	0.802
Dom. Mkt. Shr. of Dom. Exp.	0.136	0	0	0.198
Dom. Mkt. Shr. of For. Non-Exp.	0.149	0	0.335	0
Dom. Mkt. Shr. of For. Exp.	0.165	0	0	0

Notes: a) Average productivity of all plants located in Indonesia in the steady state and is calculated using plant-level revenue shares as weights.

of foreign firms from the economy. I find a 18.1 fall in average productivity when investment barriers alone are raised, while trade barriers cause a smaller 1.6 percent fall in average productivity. The explanation behind the rise in average productivity with trade restrictions and the large fall in average productivity lies in the substitutability of trade and FDI. On one hand, trade restrictions reduce the incentive to invest in Indonesia and use it as an export platform, hence, foreign firms are less likely to invest in Indonesia. On the other hand, trade restrictions cause resources to be released from all exporting plants, raising the average price level and increasing the profitability of the Indonesian domestic market. In fact, column 3 suggests that the number of foreign plants located in Indonesia rises by by 1.7 percent when there is no trade in Indonesia with rest of the world. In this sense, one can think of FDI as a substitute for exports to Indonesia. The entry and growth of foreign firms mitigates the resource reallocation from domestic exporters to domestic non-exporters.

It is important to note that the increase in foreign firms rests heavily upon the assumption of normality for the productivity distribution of foreign firms. However, even if there was no new foreign entry into Indonesia due to the trade restrictions, our measure of average productivity in an economy with no trade would fall only by another 0.2 percent. Thus, the model suggests that it is the growth of existing incumbents that largely mitigates the fall in average productivity due to the trade restrictions. The economic implication is that the Indonesian market, though small relative to the rest of the world, is large and profitable enough that existing multinational firms would continue serving Indonesian consumers even if they were unable to continue using Indonesia as an export platform. Moreover, failing to account for the presence of foreign firms after the policy change would cause one overestimate the impact of trade restrictions on aggregate productivity.

The fourth column presents the results from a counterfactual experiment where trade is allowed but foreign investment is not permitted. Average productivity drops by 18.1 percent without FDI. Although the fall in productivity is almost as large as that under autarky it is largely attributed to two features of the model. First, the fall is partly due the removal of the top 5% of the most productive firms, the foreign firms, in the industry.[78] Second, I construct average productivity by weighting plant level productivity by revenue shares. Thus, while foreign plants might only account for less than 5% of all plants, their productivity levels receive almost one quarter of the total weight in the average productivity calculation. Due to the direct impact that FDI restrictions have on the entry decision of foreign firms it is clear that FDI policy can have a much larger impact on aggregate productivity in Indonesia than trade. The estimates imply that the impact of FDI on aggregate productivity is 11 times that of international trade.

The welfare results are reported in the second row of Table 13. Welfare is measured as the change in the inverse price level since increases in prices reduce the purchasing power of consumers. The parameter δ captures the size of the textiles sector in the Indonesian economy. Blalock and Gertler (2005) estimate that manufacturing composes approximately one quarter of the Indonesian and I find that the textiles industry accounts for almost one quarter of manufacturing which implies $\delta \approx 0.055$. Although this will greatly reduce the size of the welfare impact it is clear from Table 13 that if similar changes occur across all Indonesian manufacturing sectors there would be significant drop in overall welfare.

Table 13 documents a relatively large fall in welfare under autarky, but very small changes to welfare when there are restrictions to trade or FDI. The intuition behind this result is that trade (FDI) flows partially "insure" FDI (trade) flows in the presence of FDI (trade) restrictions. For instance, a restriction to FDI is insured by the trade flows into Indonesia so that Indonesian consumers can continue to access foreign goods through trade. Similarly, trade restrictions are insured by foreign firms that enter and continue to produce in Indonesia. Since the foreign firms

[78] Note that when firms leave they take all of their knowledge and technology with them so their are no spillovers to the domestic industry.

tend to be much larger and more productive they tend to greatly reduce the fall in welfare.

In sum, the estimates imply that the model's predictions broadly match the features of the Indonesian manufacturing data. Moreover, the estimates confirm the ranking of productivity across plants with different ownership and export status as shown in section 2. The counterfactual experiments indicate that FDI restrictions have a much larger impact on aggregate productivity than international trade. The results for other industries and other estimation assumptions are reported in the Appendix. [79] The additional results document the same qualitative results across industries and very similar quantitative results across estimation assumptions. Last, the results suggest that policies which induce inwards flows of FDI will have a much larger impact on aggregate productivity relative to those that encourage exports

6 Conclusions and Extensions

This paper presents and estimates a model of foreign direct investment and exports with heterogeneous firms. I show that the model can generate productivity differences across plants with different ownership and export status which are consistent with the observed differences in the Indonesian manufacturing data. Using the theoretical model and a panel of Indonesian manufacturing plants, I develop and estimate a structural empirical model of exports and foreign direct investment.

The model's empirical predictions broadly match the features of the Indonesian manufacturing data. In particular, the model captures export decisions at the plant level and documents the differential export behaviour across foreign and domestic firms. Moreover, the estimates confirm the ranking of productivity across plants with different ownership and export status as shown in section 2. The model emphasizes that accounting for FDI flows is essential to recovering accurate estimates of the impact of trade on aggregate productivity. In particular, the counterfactual experiments imply that the impact of trade on productivity is greatly mitigated by FDI flows and that trade restrictions may even encourage FDI flows to Indonesia.

The counterfactual experiments imply that FDI restrictions can reduce aggregate produc-

[79] Tables 22-24 in the Appendix show that these results are quite robust to our assumption on fixed costs across countries. The magnitude of productivity and welfare changes induced by different policies across assumptions and industries not only has the same pattern across different assumptions and very similar implications for the change in aggregate productivity and welfare across industries.

tivity by 3 to 11 times more than trade restrictions across FDI-intensive industries in Indonesia. I find that the impact of FDI restrictions account for a fall in average total factor productivity between 8 and 27 percent across industries. Trade restrictions, in contrast, are estimated to have a smaller impact on average productivity. Across the food, manufactured metals and textiles industries average total factor productivity is estimated to fall by 1 to 4 percent.

The results suggest that policies which induce inwards flows of FDI will have a much larger impact on aggregate productivity relative to those that encourage exports. Moreover, the results imply that the differential impact international policies have on foreign and domestic firms can lead to drastically different results. These results are particularly important for policymakers in developing countries where the interaction between trade and foreign direct investment policy has been largely unexamined.

I also find that the welfare implications differ substantially across international integration policies. Autarky causes substantial reductions in welfare, while trade and FDI restrictions cause much smaller welfare impacts on an economy such as Indonesia. The model suggests that trade and FDI act as substitutes for each other and reduce the welfare impact of trade or FDI restrictions.

The results suggest a number of extensions and interesting questions for future work. There is growing evidence that entering foreign markets may require firms to pay both sunk costs and per-period fixed costs (see Das, S., M.J. Roberts, and J.R. Tybout (2007) and Kasahara and Lapham (2007) for examples). Additional sunk costs may also improve the model's ability to match the observed persistence export and ownership status. The data also demonstrates that manufacturing plants in Indonesia demonstrate substantial heterogeneity across export intensity and import behaviour. Extending the model to allow richer export and import patterns may uncover other dimensions of interacation across foreign direct investment, export decisions and import decisions. I intend to address these issues in my future research.

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Appendix

A Transition Probabilities

In this section I report the transition probabilities for the food and manufactured metals industries. Similar to the textiles industry, the model captures a substantial portion of the persistence in non-exporter status for both foreign and domestic firms, but cannot match the persistence in exporter status. As noted in the text, this may be indicative of the presence of sunk export costs.

Table 13: Distribution of Ownership/Export Status - Food

Actual	Dom. Non-Exporters	Dom. Exporters	For. Non-Exporters	For. Exporters	Exit
Dom. Non-Exporters at t	0.979	0.018	0.003	0.0005	0.094
Dom. Exporters at t	0.292	0.694	0.003	0.010	0.071
For. Non-Exporters at t	0.087	0	0.734	0.179	0.024
For. Exporters at t	0.022	0.034	0.225	0.719	0.033
Predicted					
Dom. Non-Exporters at t	0.974	0.026	—	—	0.105
Dom. Exporters at t	0.873	0.127	—	—	0.069
For. Non-Exporters at t	—	—	0.735	0.265	0.028
For. Exporters at t	—	—	0.732	0.268	0.029

Table 14: Distribution of Ownership/Export Status - Metals

Actual	Dom. Non-Exporters	Dom. Exporters	For. Non-Exporters	For. Exporters	Exit
Dom. Non-Exporters at t	0.956	0.033	0.007	0.005	0.062
Dom. Exporters at t	0.272	0.699	0.014	0.014	0.037
For. Non-Exporters at t	0.071	0.009	0.750	0.170	0.040
For. Exporters at t	0.022	0.017	0.191	0.774	0.041
Predicted					
Dom. Non-Exporters at t	0.968	0.032	—	—	0.134
Dom. Exporters at t	0.796	0.204	—	—	0.069
For. Non-Exporters at t	—	—	0.552	0.448	0.046
For. Exporters at t	—	—	0.551	0.449	0.046

Note: Metals refers to manufactured metals.

B Counterfactual Experiments

B.1 Counterfactual Results for the Food and Metals Industries

The results in the food and manufactured metals industries are similar to those in the textiles industry. Table 16 demonstrates that average productivity in the food industry falls by 16, 4 and 12 percent in the autarky, no trade and no FDI experiments. Also, the welfare impact is several times larger under autarky than the other experiments due to the lack of substitution of FDI for trade (or vice-versa).

Table 15: Counterfactual Experiments - Food

	Base	Autarky	No Trade	No FDI
Avg. Productivity[a]	2.804	2.357	2.697	2.473
$-(\varepsilon-1)\delta\Delta\ln P$	—	$-\delta 0.041$	$-\delta 0.00004$	0
Exit/Entry Rate of Foreign Firms in Indonesia	—	-1	0.210	-1
% of For. Non-Exporters	0.017	0	0.024	0
% of Dom. Exporters	0.028	0	0	0.028
%Δ in Exports	—	-1	-1	-0.395
Mkt. Shr. of Dom. Non-Exp.	0.703	1	0.773	0.894
Mkt. Shr. of Dom. Exp.	0.084	0	0	0.106
Mkt. Shr. of For. Non-Exp.	0.159	0	0.227	0
Mkt. Shr. of For. Exp.	0.055	0	0	0

Notes: a) Average productivity of all plants located in Indonesia in the steady state and is calculated using plant-level revenue shares as weights.

Table 17 demonstrates that average productivity in the manufactured metals industry falls by 30, 3 and 28 percent in the autarky, no trade and no FDI experiments. Again, the welfare impact is several times larger under autarky than the other experiments due to the lack of substitution of investment for trade (or vice-versa).

B.2 Price Indices

I denote the Indonesian aggregate price under the parameter vector θ by $P(\theta)$ and the foreign aggregate price by $P^*(\theta)$. Suppose that I am interested in a counterfactual Indonesian policy experiment with the parameter vector $\tilde{\theta}$ which is different from the estimated parameter vector $\hat{\theta}$. First, recall that the reduced form parameter φ_B is a function of the Indonesian price level

Table 16: Counterfactual Experiments - Metals[a]

	Base	Autarky	No Trade	No FDI
Avg. Productivity[b]	3.920	2.728	3.785	2.854
$-(\varepsilon-1)\delta\Delta\ln P$	—	$-\delta 0.022$	$-\delta 0.00002$	0
Exit/Entry Rate of Foreign Firms in Indonesia	—	-1	0.039	-1
% of For. Non-Exporters	0.058	0	0.109	0
% of Dom. Exporters	0.032	0	0	0.036
%Δ in Exports	—	-1	-1	-0.753
Dom. Mkt. Shr. of Dom. Non-Exp.	0.487	1	0.541	0.881
Dom. Mkt. Shr. of Dom. Exp.	0.066	0	0	0.119
Dom. Mkt. Shr. of For. Non-Exp.	0.248	0	0.459	0
Dom. Mkt. Shr. of For. Exp.	0.200	0	0	0

Notes: a) Metals refers to manufactured metals. b) Average productivity of all plants located in Indonesia in the steady state and is calculated using plant-level revenue shares as weights.

and the foreign price level:

$$\hat{\varphi}_B = \frac{E}{E^*}\left(\frac{P(\hat{\theta})}{P^*(\hat{\theta})}\right)^{\varepsilon-1}$$

where the aggregate price levels are written as a function of the estimated parameter vector $\hat{\theta}$. Writing the revenue functions in this fashion is equivalent to normalizing $E^*P^*(\hat{\theta}) = 1$ in the estimation routine. Denoting ϕ_B^* as

$$\varphi_B^* = \frac{E^*}{E^*}\left(\frac{P^*(\hat{\theta})}{P^*(\hat{\theta})}\right)^{\varepsilon-1} = 1$$

I can rewrite the firm level revenue functions as follows:

$$\begin{aligned} r_h(a_h, d_{ht}) &= \exp\Big(\ln\varphi_B(1-d_{ht}^X) + \ln[\varphi_B + \varphi_W\exp(\varphi_\tau)\varphi_B^*]d_{ht}^X - \ln a_h\Big) \\ r_f(a_f, d_{ft}) &= \exp\Big(\ln(\varphi_B^*)(1-d_{ft}^X)(1-d_{ft}^I) + \ln(\varphi_B^* + \varphi_B/\varphi_W\exp(\varphi_\tau))(1-d_{ft}^I)d_{ft}^X \\ &\quad + \ln(\varphi_B + \varphi_W\varphi_B^*\exp(\varphi_\tau))d_{ft}^I d_{ft}^X + \ln(\varphi_B^* + \varphi_B)d_{ft}^I(1-d_{ft}^X) - \ln a_f\Big) \end{aligned}$$

where $\bar{\varphi}_W$ is the calibrated level of intercountry wages and $\hat{\varphi}_\tau$ is the estimated transport cost.

At the counterfactual price $P(\tilde{\theta})$ and $P^*(\tilde{\theta})$, the reduced form coefficients φ_B and φ_B^* take the values

$$\begin{aligned}\tilde{\varphi}_B &= \frac{E}{E^*}\left(\frac{P(\tilde{\theta})}{P^*(\hat{\theta})}\right)^{\varepsilon-1} = \hat{\varphi}_B k(\tilde{\theta},\hat{\theta}) \\ \tilde{\varphi}_B^* &= \frac{E^*}{E^*}\left(\frac{P^*(\tilde{\theta})}{P^*(\hat{\theta})}\right)^{\varepsilon-1} = \hat{\varphi}_B^* k^*(\tilde{\theta},\hat{\theta}) \end{aligned} \tag{37}$$

where $k(\tilde{\theta},\hat{\theta}) = (P(\tilde{\theta})/P(\hat{\theta}))^{\varepsilon-1}$ and $k^*(\tilde{\theta},\hat{\theta}) = (P^*(\tilde{\theta})/P^*(\hat{\theta}))^{\varepsilon-1}$ represent the equilibrium price changes.

We can then evaluate the revenue functions using the counterfactual coefficients $\tilde{\varphi}_B$ and $\tilde{\varphi}_B^*$ which have been adjusted for the change in the counterfactual prices levels $P(\tilde{\theta})$ and $P^*(\tilde{\theta})$:

$$\begin{aligned} r_h(a_h, d_{ht}) &= \exp\Big(\ln\tilde{\varphi}_B(1-d_{ht}^X) + \ln[\tilde{\varphi}_B + \varphi_W\exp(\varphi_\tau)\tilde{\varphi}_B^*]d_{ht}^X - \ln a_h\Big) \\ r_f(a_f, d_{ft}) &= \exp\Big(\ln(\tilde{\varphi}_B^*)(1-d_{ft}^X)(1-d_{ft}^I) + \ln(\tilde{\varphi}_B^* + \tilde{\varphi}_B/\varphi_W\exp(\varphi_\tau))(1-d_{ft}^I)d_{ft}^X \\ &\quad + \ln(\tilde{\varphi}_B + \varphi_W\tilde{\varphi}_B^*\exp(\varphi_\tau))d_{ft}^I d_{ft}^X + \ln(\tilde{\varphi}_B^* + \tilde{\varphi}_B)d_{ft}^I(1-d_{ft}^X) - \ln a_f\Big) \end{aligned}$$

The equilibrium price change is determined so that the free entry conditions hold

$$\begin{aligned} \int V_h(a;\tilde{\theta},k(\tilde{\theta},\hat{\theta}))g_a(a)da &= f_E \\ \int V_f(a^*;\tilde{\theta},k(\tilde{\theta},\hat{\theta}))g_{a^*}(a^*)da^* &= f_E^* \end{aligned}$$

where $V_h(a;\tilde{\theta},k(\tilde{\theta},\hat{\theta}))$ and $V_f(a^*;\tilde{\theta},k(\tilde{\theta},\hat{\theta}))$ are the solutions to the Bellman equations (13)-(16) using the counterfactual adjusted revenue function and $g_a(a)$ and $g_{a^*}(a^*)$ are the normal probability density functions from which the initial productivity level are drawn.

B.3 Mass of Firms

The estimated model does not provide a prediction for the relative mass of foreign and domestic firms in Indonesia after the counterfactual change. This is important since the overall change in average productivity or welfare in Indonesia will depend not only on the probability of foreign firms investing in Indonesia, but also on the number of foreign firms relative to the size of the domestic economy. Recovering the mass of firms in Indonesia is difficult because the policy change in Indonesia may induce a change in the equilibrium mass of firms worldside (domestic or foreign) and the probability of entering Indonesia. Fortunately, we can use the equilibrium conditions (23) along with the assumption that any policy change in Indonesia does not affect the mass of "potential" foreign or domestic entrants to the economy so that we can calculate the mass of firms in the economy as:

$$\tilde{M}_j = \frac{\int \frac{\tilde{P}_j(\chi=1|a)}{\tilde{P}_j(\chi=0|a)} g_a(a)da}{\int \frac{\hat{P}_j(\chi=1|a)}{\hat{P}_j(\chi=0|a)} g_a(a)da} M_j$$

where $\hat{M}_j$ indicates the mass of firms calculated under the estimated model and the $\tilde{M}_j$ indicates counterfactual values. Starred variables replace unstarred variables when calculating the foreign mass of firms.

C Fixed Cost Bounds

If exporting multinationals are more productive than non-exporting multinationals than the following bounds on fixed costs must hold

$$f_D \left(\frac{\tau B}{B^*}\right)^{1-\varepsilon} < f_X \tag{C1a}$$

$$\left(\frac{w}{w^*\tau}\right)^{1-\varepsilon} < \frac{f_D + f_I}{f_X} \tag{C2a}$$

$$\frac{f_D + f_I - f_X}{f_X - f_D} < \left(\frac{w^{1-\varepsilon} - (w^*\tau)^{1-\varepsilon}}{(w\tau)^{1-\varepsilon} - w^{*1-\varepsilon}}\right) \frac{B}{B^*} \tag{C3a}$$

$$\tau w < w^* \tag{C4a}$$

D Additional Figures

D.1 Decision Trees

The following two figures outline the order of decisions in the empirical model for foreign and Indonesian firms:

Home firms first draw a cost shock associated with their decision to enter the market or to exit. Then, conditional on entering the market, each firm draws a cost shock associated with its export decision. Given the realized export cost shock each firm must then decide whether

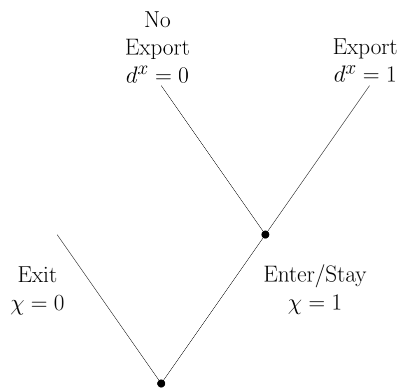

Figure 6: Indonesian Firms

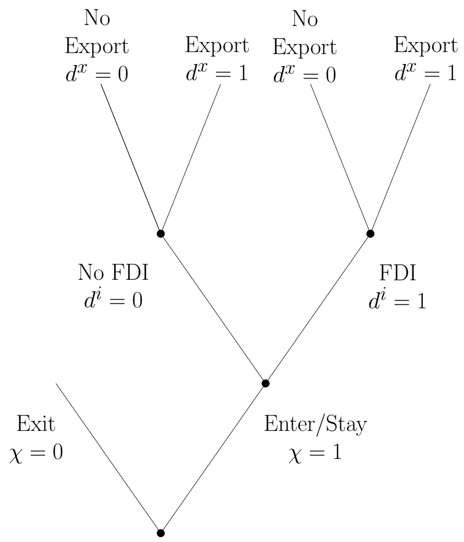

Figure 7: Foreign Firms

to export this period or not. Simiarly, foreign firms first draw a cost shock associated with their decision to enter the market or to exit. Conditional on entering the market they draw a cost shock associated with its FDI decision and decide whether to invest in Indonesia or not. Conditional on the investment decision they draw an export cost shock and make their export decision.

D.2 5-Digit Industry Differences Across Export Status

Here I report the distributions foreign exporters and foreign non-exporters across 5-digit industries (for selected 2-digit industries). Each dark column represents the percentage of all foreign non-exporters in a particular 5-digit industry. Similarly, each light column represents the percentage of all foreign exporters in a particular 5-digit industry.

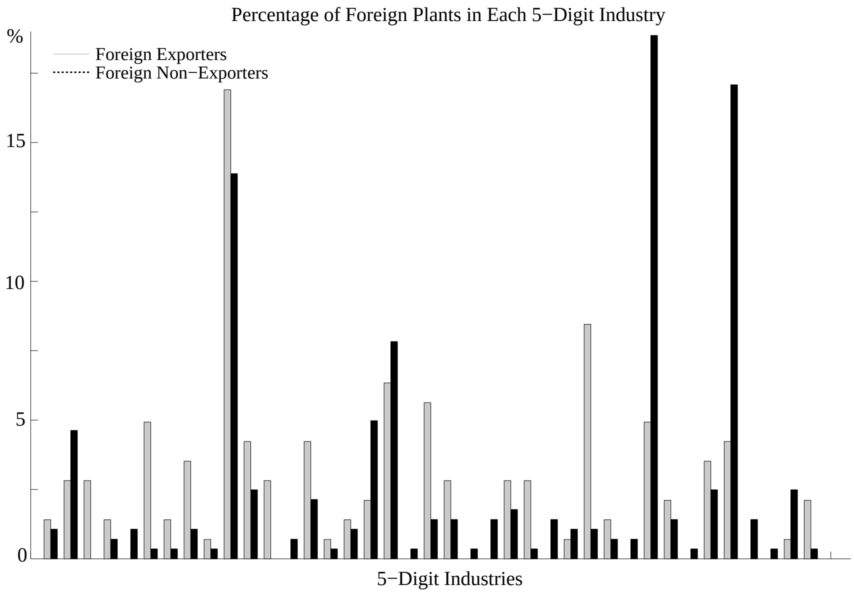

Figure 8: Food

Note: Each pair of columns along the x-axis represents a different 5-digit industry (ISIC codes).

Figure 9 shows the percentage of foreign exporters and non-exporters across 5-digit industries in the food industry. Across the large majority of industries it is evident that industries that have a higher percentage of all foreign exporters also tend to have a higher percentage of all foreign non-exporters. There are two notable exceptions at the right-side of the graph representing the soft drink and mineral water industry and the industry classified as “other food products n.e.c” where foreign non-exporters are notably more prevalent.

Figures 10 and 11 graph the same distributions for the manufactured metals and textiles industries, respectively. A similar pattern emerges from these diagrams: 5-digit industries that receive a higher percentage of the total number of foreign exporters and also tend to receive a higher percentage of the total number of foreign non-exporters. However, there are differences in both industries. We tend to see a slightly higher percentage of foreign non-exporters among industries that concentrate on spinning and weaving and a slightly higher percentage of foreign exporters among industries that fabricate clothing. Similarly, there is a higher number of foreign non-exporters in the transport industry. This is likely due to the Indonesian government’s

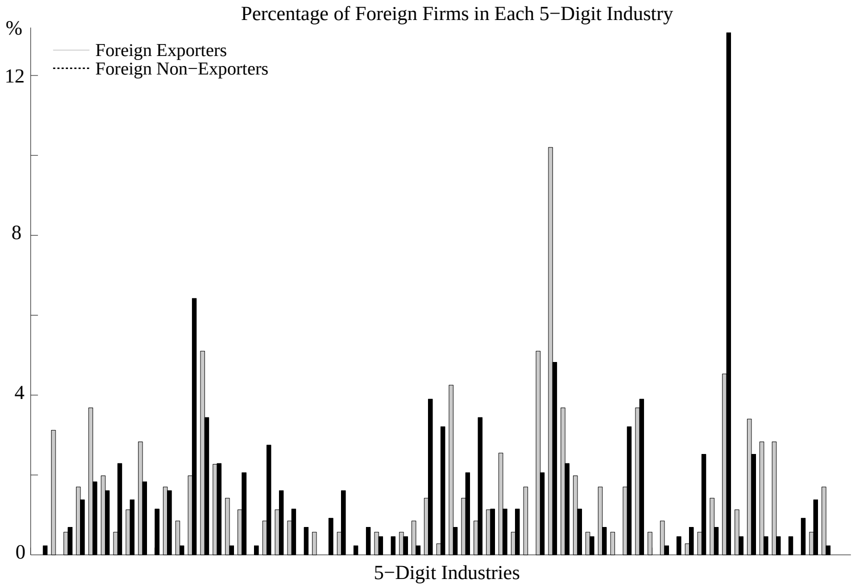

Figure 9: Metals

Note: Each pair of columns along the x-axis represents a different 5-digit industry (ISIC codes).

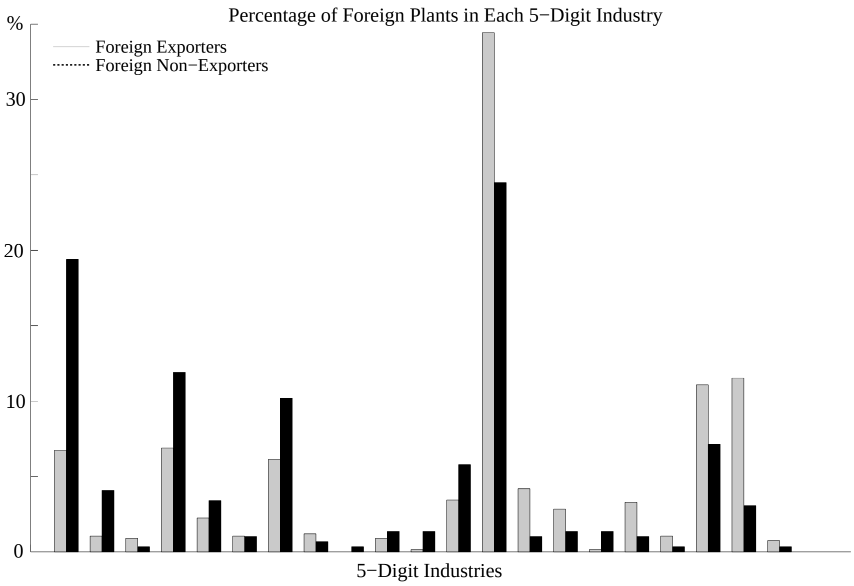

Figure 10: Textiles

Note: Each pair of columns along the x-axis represents a different 5-digit industry (ISIC codes).

sponsorship of foreign enterprises in the transport industry during this period. While these industrial differences may help explain some of the observed productivity differences across foreign exporters and non-exporters. However, as shown is section 2, there are still statistically and economically significant differences across foreign exporters and non-exporters even once we control for the industrial classification.

E Measurement of Aggregate Productivity and Welfare

E.1 Productivity

To calculate aggregate productivity I weight each plant's productivity level by its revenue share in the Indonesian market. I denote total revenue earned by plants located in Indonesia from Indonesian sales as

$$R_{IND} = \sum_i \hat{r}(a_i)$$

where $r(a_i) = (a_i w B)^{1-\varepsilon}$. The average productivity A is

$$A = \sum_i \frac{\hat{r}(a_i)}{R_{IND}} \frac{1}{a_i}$$

E.2 Welfare

Following Melitz (2003) I define welfare as $W = wL/P_F$ where P_F is the price index for the full Indonesian economy

$$P_F = w^{1-\delta} P^{\delta}.$$

I define P as the price index for the manufacturing sector alone

$$P = \left[\int_{v \in V} p(v)^{\varepsilon-1} dv \right]^{\frac{1}{\varepsilon-1}}.$$

F Export and Ownership Premia: Fixed Effects and the Chemicals Industry

In this section I report the estimated export and ownership premia estimated from fixed effects regressions for the entire sample excluding the chemicals industry and pooled OLS results for the chemicals industry alone. Although the estimates between foreign exporters and non-exporters in Table 3 are statistically significant, these differences could be driven by unobserved plant-specific differences. Fixed effects panel estimation is the most common regression used to control for plant-specific effects. However, there are two difficulties with implementing a fixed effects regression here. First, ownership and export status are very persistent over the short panel. Since the source of identification in a fixed effects regression comes from variation in ownership and export status within each firm, there is little variation from which to identify the coefficients. Second, because the identification is coming from plants which switch export status and/or ownership status, the definition used to identify these variables is particularly important. In general, the results are robust to changes in the percentage of equity held by foriegn investors, but sensitive to the definition of an exporter.

I observe in the data that plants that receive a relatively small percentage of total revenues from export sales can be broadly characterized much more like foreign non-exporters. If we define an exporter as one that has positive export sales then the plants that switch export status most often are going to plants that are in fact foreign non-exporters in some years and receive only a small amount of revenue from export sales. If most of the identification comes from these plants we would expect to observe very little difference between foreign non-exporters and exporters in a fixed effects regression. Suppose one changes the definition of an exporter so that exporters must receive at least a 25 percent of total revenues from export sales. In that case, most of the identification will come from exporting firms that cross the 25 percent threshold. A natural reason for arbitrarily increasing the percentage of export revenues required for export status is that export intensive firms are more likely to export to developed countries, while firms that export only a small percentage of revenues are more likely to emerging market countries near Indonesia. In fact, in Table 6 I show that industries where firms export intensively have a higher percentage of exports destined for Japan, the US and Western Europe. As such, I estimate equation (1) by both pooled OLS and fixed effects and report the results for the measure of output per worker as I vary percentage of export sales required for a foreign firm to have export status.[80]

Table 17 reports the results of the pooled OLS and fixed effects regressions. It shows that as we vary the defintion of a foreign non-exporter the differences in the output per worker premia

[80]Results are similar for other measures of export premia.

Table 17: Export & Ownership Premia: Output per Worker 1993-1996

	Pooled OLS			Fixed Effects		
Export Threshold	Domestic Exporters	Foreign Exporters	Foreign Non-Exporters	Domestic Exporters	Foreign Exporters	Foreign Non-Exporters
0	0.141	0.534	0.800	0.007	0.294	0.306
	(0.012)	(0.023)	(0.027)	(0.011)	(0.031)	(0.030)
25	0.176	0.490	0.869	0.028	0.253	0.288
	(0.014)	(0.028)	(0.028)	(0.012)	(0.037)	(0.035)
50	0.174	0.435	0.869	0.027	0.209	0.309
	(0.014)	(0.029)	(0.027)	(0.012)	(0.038)	(0.034)
No. of Obs.	57518			10801		

Notes: Standard errors are in parentheses. Plants in the chemicals industry are excluded from the estimation and results for the chemicals industry are reported in the Appendix.

grow.[81] Moreover, the differences are increasingly significant even when using a fixed effects estimator.[82]

I also report the pooled OLS results for the chemicals industry alone. While the results for export and ownership premia measured in terms of average wages, the ratio of non-production to total workers, capital per worker, domestic sales and total sales and employment are consistent with the results presented in Section 2, the output per worker measure is not consistent with the premia shown in other industries. In fact, in the chemicals industry, output per worker is highest for foreign exporters, rather than non-exporters. Part of the difference may be attributed to the fact that the mean difference total employment between foreign exporters and non-exporters is much smaller in the chemicals industry than in other industries. This may be indicative of increasing returns to scale in an industry that is largely influenced by the production of natural gas for export.

[81]Similar results are found for other measures of premia.

[82]A potential concern is that foreign exporters and foreign non-exporters produce very different products. While all pooled OLS regressions include 5-digit ISIC industry level dummies, it is possible that these dummies are not capturing fixed industry level differences for the foreign firms alone. Suppose that the foreign technology in one 5-digit industry is more productive that the foreign technology in another. If foreign non-exporters are more likely to be in the most highly productive industries then the output per worker premia will be biased upwards. Fortunately, using plant-level fixed effects will control for this possibility. Since the significance is much lower on the fixed effects regressions than it is on the pooled OLS regressions I also report the empirical distributions of foreign exporters and foreign non-exporters in the Appendix. As shown in the empirical distributions the mass of each type of plant in each 5-digit industry is highly correlated.

Table 18: Export & Ownership Premia: Chemicals

	Pooled OLS: 1993-1996		
Export/Ownership Status	Domestic Exporters	Foreign Exporters	Foreign Non-Exporters
Output per Worker	0.702	1.493	1.122
	(0.038)	(0.056)	(0.053)
Average Wage	0.122	0.776	0.900
	(0.022)	(0.033)	(0.031)
Non-Production/Total Workers	0.012	0.099	0.392
	(0.029)	(0.042)	(0.041)
Capital per Worker	0.381	0.814	1.055
	(0.034)	(0.049)	(0.047)
Domestic Sales	-0.462	0.521	1.060
	(0.045)	(0.068)	(0.060)
Total Sales	0.694	1.476	1.100
	(0.040)	(0.059)	(0.056)
Total Employment	1.034	1.000	0.717
	(0.031)	(0.047)	(0.046)
No. of Observations	8,478		

Notes: Standard errors are in parentheses.

G Mark-Ups & Productivity

A potential concern in the measurement of productivity in Section 2 is that firms that foreign exporters may charge lower mark-ups on average relative to foreign non-exporters. This may happen if firms that export back to Europe, Japan or the United States may charge a parent company a lower price than they would an arms-length buyer in order to claim higher profits in the parent's country (transfer pricing). Moreover, if the mark-up in export markets is lower than that in Indonesia due to higher competition we might observe lower mark-ups in export markets. If this is the case, our measurement of the productivity/output per worker of foreign exporters in section 2 would be downwards biased. It would not affect the other premia.

In contrast, if export markets are more profitable than Indonesian domestic markets, (e.g. due to pricing to market, for example), then the bias would operate in the opposite direction. In this case, the reported productivity differences between foreign exporters are non-exporters would be smaller than the actual productivity differences.

Table 19 reports the top corporate tax rates for Indonesia and the countries which are its main sources of foreign investment of the 1993-1996 period. It shows that Indonesia had, on average, the lowest corporate tax rates across this group of countries. As such, Table 19 suggests that foreign firms likely had more incentive to claim profits in Indonesia rather than abroad over this period.

Table 19: Top Corporate Tax Rate

	1993	1994	1995	1996	1993-96 Avg.
Indonesia	0.350	0.350	0.300	0.300	0.325
France	0.333	0.333	0.333	0.333	0.333
Germany	0.500	0.450	0.450	0.300	0.425
Japan	0.375	0.375	0.375	0.375	0.375
United Kingdom	0.330	0.330	0.330	0.330	0.330
United States	0.350	0.350	0.350	0.350	0.350

Notes: Taken from the World Tax Database at the University of Michigan. Data refer to the top marginal tax rate on *domestic* corporations. Wie (1994) reports that all restrictions to FDI had been removed before 1993 and in fact Indonesia offered tax incentives/holidays to many foreign firms over the 1993-1996 period. As such, the numbers presented in this table may be interpreted as an upper bound on the top corporate tax rate in Indonesia.

Similarly, if exporters were charging lower prices due to transfer pricing or highly competitive export markets, one might expect to be able to observe those differences in estimates of the firms mark-up behaviour. In particular, one can estimate the mark-up across firms as

$$\text{mark-up} = \frac{\text{revenues} - \text{variable costs}}{\text{revenues}}.$$

Using the sum of production labour, intermediate inputs, electricity and fuel expenses as a measure of variable costs, I estimate the average mark-up for each group of plants. Table 20 reports that foreign exporters tend to charge slightly higher mark-ups than foreign non-exporters in the food and manufactured metals industries and slightly lower mark-ups in the textiles industry, although the standard deviations are very high across all groups. Moreover, while Table 20 may suggest that the productivity difference between foreign exporters and non-exporters may be slightly smaller than suggested by the estimated premia in Section 2, there is little evidence to suggest that it is in fact due to mark-up heterogeneity across exporters and non-exporters.

H Robustness

In this section I present the structural estimates and the counterfactual results under different fixed cost assumptions. Specifically, I provide estimates for the model under the following sets of assumptions:

A1. $f_D^* = 0.510 f_D$ and $f_X^* = 0.380 f_X$;

Table 20: Mark-Ups Across Firms and Industries

	Domestic Non-Exporters	Domestic Exporters	Foreign Non-Exporters	Foreign Exporters	All Plants
Food	0.254	0.311	0.384	0.413	0.260
	(0.170)	(0.210)	(0.226)	(0.189)	(0.175)
Metals	0.315	0.410	0.401	0.425	0.332
	(0.182)	(0.213)	(0.208)	(0.213)	(0.191)
Textiles	0.253	0.275	0.317	0.300	0.257
	(0.159)	(0.169)	(0.185)	(0.194)	(0.162)

Standard deviations are in parentheses.

A2. $f_D^* = f_D$ and $f_X^* = f_X$;

A3. $f_D^* = 0.255 f_D$ and $f_X^* = 0.190 f_X$.

Assumption (A1) is the assumption used in the main text and the coefficients on the f_D and f_X terms are estimated from the World Bank Doing Business Report. Assumption (A2) considers the case where fixed costs are symmetric across countries while assumption (A3) estimates the model under the assumption that the fixed costs in the foreign country are one half of that assumed in the baseline estimation.

I Variation in Plant-Level Productivity

A potential concern with the model and estimation is that plant-level productivity is not persistent, but transitory, over time. If plant-level productivity displayed a great deal of variation over time, it would likely be reflected in variation in plant-level revenue. Tables (25) - (26) show that in fact both domestic and foriegn plants in Indonesia display substantial persistence in the revenues earned over time, even in a growing economy.

Table 21: Structural Estimates

Industry	Food			Metals			Textiles		
Assumption	A1	A2	A3	A1	A2	A3	A1	A2	A3
$\kappa\varrho_X$	52.416	39.774	55.199	31.780	40.1528	41.483	35.490	92.837	24.046
	(4.481)	(1.347)	(4.983)	(2.815)	(3.233)	(4.155)	(2.053)	(8.468)	(1.324)
$\kappa\varrho_{xh}$	10.287	13.725	15.063	4.897	7.7448	6.570	7.9016	8.842	11.480
	(0.587)	(0.353)	(0.828)	(0.373)	(0.2759)	(0.440)	(0.464)	(0.493)	(0.566)
$\kappa\varrho_{xf}$	3.428	0.00001	0.482	1.055	0.00005	0.502	0.455	1.729	0.507
	(6.545)	(0.0002)	(1.714)	(16.411)	(36.469)	(17.987)	(0.619)	(12.001)	(6.299)
$\kappa\varrho_{if}$	0.0001	0.001	0.0002	0.001	0.0009	0.0002	0.0001	0.001	0.001
	(1.423)	(0.020)	(1.458)	(4.421)	(28.567)	(4.103)	(1.667)	(3.295)	(3.642)
κf_{Dh}	2.379	5.884	4.630	3.567	4.5498	8.087	5.870	2.010	6.390
	(1.167)	(0.0003)	(1.255)	(0.830)	(0.8336)	(1.384)	(0.680)	(2.020)	(0.514)
κf_{Xh}	42.860	48.8470	57.304	21.923	26.808	27.933	23.513	26.507	39.071
	(2.307)	(1.069)	(2.966)	(1.548)	(0.7574)	(1.677)	(1.324)	(1.416)	(1.811)
κf_{Ih}	28.041	17.638	28.305	29.293	27.525	23.282	46.737	44.320	25.114
	(3.361)	(0.026)	5.783	(10.881)	(20.425)	(3.658)	(4.986)	(5.657)	(11.122)
ζ	0.078	0.120	0.011	0.088	0.117	0.075	0.0339	0.056	0.037
	(0.110)	(0.003)	(0.036)	(0.082)	(0.064)	(0.056)	(0.093)	(0.145)	(0.052)
ρ	-0.009	0.010	0.014	0.011	0.004	0.024	0.008	0.013	0.012
	(0.010)	(0.001)	(0.009)	(0.013)	(0.010)	(0.012)	(0.009)	(0.010)	(0.008)
φ_B	0.853	0.777	0.768	1.531	1.546	1.165	1.486	1.347	0.965
	(0.020)	(0.014)	(0.015)	(0.048)	(0.406)	(0.033)	(0.027)	(0.028)	(0.016)
φ_τ	-5.346	-5.312	-5.327	-3.799	-3.864	-3.796	-5.369	-5.320	-5.316
	(0.060)	(1e-07)	(0.056)	(0.078)	(0.004)	(0.068)	(0.060)	(0.057)	(0.0494)
σ_{ah}	1.041	1.097	0.961	0.996	0.947	0.996	1.011	1.300	0.982
	(0.007)	(0.008)	(0.007)	(0.008)	(0.006)	(0.008)	(0.003)	(0.006)	(0.004)
σ_{af}	1.139	1.364	1.239	0.971	0.795	1.062	0.941	1.399	0.946
	(0.010)	(0.014)	(0.010)	(0.009)	(0.006)	(0.009)	(0.007)	(0.014)	(0.007)
ξ	0.006	0.010	0.001	0.021	0.011	0.005	0.014	0.009	0.006
	(0.001)	(0.001)	(0.0001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.0004)
$\varepsilon = 1$/mark-up		3.8			3.0			3.8	
log-likelihood	-34,806	-34,803	-34,651	-16,820	-17,126	-16,612	31,866	-30,379	-31,918
No. of Obs.		17,786			7,549			13,287	

Notes: Standard errors are in parentheses. The parameters are evaluated in units of millions of Indonesian Rupiahs in 1983. Metals refers to manufactured metals.

Table 22: Counterfactual Experiments - Food

Experiment	Autarky			No Trade			No FDI		
Assumption	A1	A2	A3	A1	A2	A3	A1	A2	A3
% Δ Avg. Productivity[a]	-0.159	-0.138	-0.171	-0.038	-0.026	-0.027	-0.118	-0.087	-0.153
$-(\varepsilon-1)\Delta \ln P^b$	-0.041	-0.081	-0.085	-0.00004	-0.0005	-0.00006	0	0	-0.0002

Notes: a) The percentage change in average productivity for all plants in the steady state. Calculated using plant-level revenue shares as weights and evaluated relative to the estimated model. b) The welfare impact must be multiplied by industry share δ.

Table 23: Counterfactual Experiments - Metals[a]

Experiment	Autarky			No Trade			No FDI		
Assumption	A1	A2	A3	A1	A2	A3	A1	A2	A3
% Δ Avg. Productivity[b]	-0.304	-0.247	-0.247	-0.034	-0.016	-0.028	-0.272	-0.227	-0.201
$-(\varepsilon - 1)\Delta \ln P^c$	-0.022	-0.051	-0.035	-0.00002	0	0	0	0	0

Notes: a) Metals refers to manufactured metals. b) The percentage change in average productivity for all plants in the steady state. Calculated using plant-level revenue shares as weights and evaluated relative to the estimated model. c) The welfare impact must be multiplied by industry share δ.

Table 24: Counterfactual Experiments - Textiles

Experiment	Autarky			No Trade			No FDI		
Assumption	A1	A2	A3	A1	A2	A3	A1	A2	A3
% Δ Avg. Productivity[a]	-0.206	-0.172	-0.232	-0.016	-0.037	-0.016	-0.182	-0.111	-0.209
$-(\varepsilon - 1)\Delta \ln P^b$	-0.053	-0.068	-0.067	0	0	-0.000002	0	0	0

Notes: a) The percentage change in average productivity for all plants in the steady state. Calculated using plant-level revenue shares as weights and evaluated relative to the estimated model. b) The welfare impact must be multiplied by industry share δ.

Table 25: Revenue Bracket Transition Matrix - Domestic Plants

	Year $t+1$				
Year t	0 to 10	10 to 20	20 to 30	More than 30	Exit
0 to 10	0.967	0.024	0.004	0.005	0.091
10 to 20	0.246	0.503	0.139	0.066	0.049
20 to 30	0.092	0.215	0.391	0.302	0.037
More than 30	0.040	0.037	0.067	0.856	0.031

Notes: The revenue brackets are in millions of Indonesian Rupiahs. One million Indonesian Rupiahs was worth approximately 452.55 US dollars in 1983.

Table 26: Revenue Bracket Transition Matrix - Foreign Plants

	Year $t+1$				
Year t	0 to 10	10 to 20	20 to 30	More than 30	Exit
0 to 10	0.780	0.126	0.045	0.049	0.168
10 to 20	0.202	0.470	0.202	0.125	0.022
20 to 30	0.122	0.218	0.340	0.319	0.015
More than 30	0.023	0.034	0.061	0.882	0.013

Notes: The revenue brackets are in millions of Indonesian Rupiahs. One million Indonesian Rupiahs was worth approximately 452.55 US dollars in 1983.