Multinational Production, Exports and Aggregate Productivity

Joel Rodrigue*
Department of Economics, Vanderbilt University, Nashville, TN, United States

Abstract

This paper presents and estimates a dynamic model of multinational production (MP) and exports with heterogeneous firms. The model highlights the interaction between firms' location and export decisions and their effect on aggregate productivity. The model is structurally estimated using firm-level Indonesian manufacturing data. The results are broadly consistent with the pattern of productivity, exports and MP across firms. Counterfactual experiments suggest that there are substantial productivity gains due to international trade and MP. The implied changes in steady state real wages, however, are relatively small. The experiments emphasize that the nature of firm-level trade and MP interactions are crucial to determining the aggregate effects of trade and foreign direct investment policy.

KEYWORDS: exports; multinational production; foreign direct investment; firm heterogeneity; aggregate productivity; resource allocation; Indonesia

* Contact Information.
Mailing Address: Department of Economics, Vanderbilt University, VU Station B #351819, 2301 Vanderbilt Place, Nashville, TN 37235-1819; Tel.: +1 615 322 2871; fax: +1 615 343 8495.
E-mail address: joel.b.rodrigue@vanderbilt.edu

I am indebted to Beverly Lapham and Hiroyuki Kasahara for their guidance and advice. I have also greatly benefitted from invaluable comments from the associate editor, referees and various seminar participants. All errors are my own.

1. Introduction

It is well known that there are large differences in total factor productivity across developed and developing countries. Foreign direct investment (FDI) and export promotion are often encouraged to reduce these differences and, as such, both mechanisms represent key planks of development policy. Unfortunately, until very recently there has been relatively little quantitative research on the costs and benefits of these policies and their impact on policy relevant outcomes. We aim to fill this gap by rigorously examining the impact of trade and multinational production (MP) in Indonesia.

We begin by considering the impact of trade and MP on resource allocation across heterogeneous producers. We present a dynamic, empirical model of heterogenous producers with endogenous exit, entry and export decisions across international markets. The model is developed to emphasize how trade and multinational production (MP) interact to determine firm-level location and export decisions across heterogeneous producers. We structurally estimate the model using detailed plant-level Indonesian manufacturing data. A key contribution of our work is to rigorously fit a quantitative model of trade and MP using firm-level information from an economy where these two features play prominent roles in it's economic development. We find that our model broadly reproduces the pattern of productivity, exports and FDI across heterogeneous Indonesian producers. We then conduct a number of counterfactual experiments aimed at quantifying the impact of trade and MP on (a) resource allocation across heterogenous producers, (b) measures of aggregate productivity and (c) changes in steady state real wages.

Our counterfactual experiments suggest that existing international trade and MP relationships account for a large portion of aggregate productivity in Indonesia. We find that if Indonesia was cut off from MP, aggregate manufacturing productivity would fall by 19.6 percent. Likewise, if Indonesia was not able to trade with neighboring countries we would find a 8.5 percent decline in aggregate manufacturing productivity. These experiments emphasize that firm-level trade and MP interactions are crucial determinants of the aggregate effects of trade and MP policy across industries since the incentives for trade or MP greatly affect the likelihood of the other activity. Further, we document that endogenous entry and exit decisions play an important role in determining aggregate productivity in Indonesia.

Research by Restuccia and Rogerson (2008) and Hsieh and Klenow (2009) suggest that the misallocation of resources across firms can have important effects on aggregate productivity, particularly in developing economies. Pavcnik (2002) and Trefler (2004) similarly find that increasing trade openness has induced resource reallocation and productivity gains in Chile and Canada, respectively. Not surprisingly, a number of recent papers have studied the potential gains associated with trade in goods (e.g Eaton and Kortum, 2002; Alvarez and Lucas, 2007; Arkolakis, Costinot, and Rodríguez-Clare, 2010; Waugh, 2010; Fieler, 2011), multinational production (e.g. Burstein and Monge-Naranjo, 2009; McGrattan and Prescott, 2009; Ramondo,

2011) or both (e.g. Feinberg and Keane, 2006; Ramondo and Rodríguez-Clare, 2010; Irarrazabal, Moxnes, and Opromolla, 2010; and Arkolakis et al., 2011) across heterogeneous firms and countries.

We extend the international trade and MP framework of Helpman, Melitz and Yeaple (2004) by allowing firms to offshore production in a foreign country. In this 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.[1] Second, in our model, firms may also set up plants in a foreign country to export back to the country of origin.[2] This additional structure is motivated by the data; we often observe foreign owned plants Indonesia exporting heavily to markets from which most FDI is sourced. Thus, this paper constructs a parsimonious model that simultaneously allows firms to engage in MP for both market access and export-platform production. The model is used to empirically assess the influence of policy on firm-level decisions and provides a framework for evaluating the impact of economic policy on aggregate productivity, exports and MP.

Irarrazabal, Moxnes, and Opromolla, (2010) and Arkolakis et al. (2011) similarly study the interaction of trade and multinational production in closely related frameworks. Irarrazabal, Moxnes and Opromolla (2010) structurally estimate a model of multinational production and trade across OECD countries using multinational production decisions by Norwegian multinational firms. Their model also extends the Helpman, Melitz and Yeaple (2004) model to examine the nature of MP across a wide set of countries whereas our paper focusses on inward FDI within a developing country. In particular, Irarrazabal, Moxnes and Opromolla (2010) present a model that seeks to explain the gravity of FDI across geographically distant countries. Likewise, Arkolakis et al. (2011) develop a monopolistic competition model of trade and multinational production. In their model firms receive idiosyncratic productivity draws across locations and face a set of associated trade and investment costs. Their model is calibrated to match bilateral trade and FDI flows across countries. In contrast, we structurally estimate model parameters using individual firm-level decisions (rather than aggregate trade/FDI flows).

A key difference between our paper and similar papers which quantify the gains from openness to trade or MP, is that our paper provides rigorous estimates for a specific, developing country. Although Irarrazabal, Moxnes, and Opromolla (2010) and Arkolakis et al. (2011) provide insightful estimates for the importance of trade and FDI flows across countries, they do not distinguish the differential impact of these flows across industries as we do in this context. Our study is able to provide disaggregated responses to changes in MP or trade policy. We doc-

[1] Chor, Foley and Manova (2008) and Irarrazabal, Moxnes, and Opromolla (2010) report that the majority of multinational affliate sales are intended for the destination market and conclude that market access is a key motive for foreign direct investment. Earlier evidence can be found in Brainard (1997), Markusen and Maskus (2002) and Blonigen, Davies and Head (2003).

[2] See Antras and Helpman (2004), Grossman, Helpman and Szeidl (2006) and Garetto (2010) for examples.

ument that the observed differences in gains from trade or MP depend crucially on industrial differences in trade and MP costs across industries. Further, our data allows us to pin down the entry and exit responses across both foreign and domestic firms to changes in the economic environment, rather than studying the decisions of multinationals alone. This key difference allows us to quantify the impact of MP and trade policy, while accounting for endogenous entry and exit across all firms in the Indonesian manufacturing sector.

Our methodology is most similar to that taken in several recent studies of firm-level exporting; we approach the firm-level decision to enter international markets through MP and exports by fitting a structural model to detailed firm-level information in Indonesia. This approach is similar to that taken by Das, Roberts and Tybout (2007), Ruhl and Wills (2010), Eaton, Kortum and Kramarz (2011) and Kasahara and Lapham (2012) where model parameters are pinned down by capturing broad patterns in firm-level exporting in Columbia, France and Chile. Our objective, however, is to address a substantially different question. In particular, we are primarily interested in the trade-off between between foreign MP and exports and the impact that these activities have on aggregate outcomes. To this extent, our model draws heavily on the MP and trade literature.

Previous research studying the impact of MP and trade on aggregate outcomes is decidedly mixed. On one hand, a number of papers find that MP can induce large increases in aggregate productivity and welfare (e.g. McGrattan and Prescott, 2007 or Ramondo and Rodríguez-Clare, 2010). This is not surprising since a large amount of empirical evidence suggests that among firms producing in a given country, multinational firms are the most productive.[3] On the other hand, Arkolakis, Costinot, and Rodríguez-Clare (2010) and Atkeson and Burstein (2010) suggest that changes in firm-level decisions, such as endogenous entry into export markets, have a small effect on changes in real wages. We provide a quantitative counterpart to these findings in a country where trade and MP account for a substantial portion of total production.

Our work also relates to papers which investigate whether MP and trade are substitutes or complements at the firm-level. Again, the evidence here is mixed. Svensson (1996), Clausing (2000) and Head and Ries (2001) find that affiliate and domestic sales are complements. In contrast, using product-level data from the Japanese auto industry, Blonigen (2001) finds substantial evidence that affiliate production and exports can act as either substitutes or complements.

The next section presents the data and the key empirical moments which motivate our empirical structure. Section 3 and 4 develop our structural model and estimation strategy, respectively. The fifth section documents our results, while the sixth explores a number of counterfactual experiments. The last section concludes.

[3]Helpman, Melitz and Yeaple (2004) and Arnold and Javorcik (2009) compare multinationals, exporters and non-exporters. Roberts and Tybout (1997), Clerides, Lach and Tybout (1998), Bernard and Jensen (1999), Aw, Chung, and Roberts (2000), Bernard et. al. (2003) and Eaton, Kortum, and Kramarz (2004) compare exporters and non-exporters.

2. Data and Stylized Facts

The primary source of data is the Indonesian manufacturing census between 1993 and 1996. We focus on these years due to the fact that it is a period of relative calm in the Indonesian economic and policy environment.[4] Collected annually by the Central Bureau of Statistics, *Budan Pusat Statistik* (BPS), the survey covers the population of manufacturing plants in Indonesia with at least 20 employees. The data capture the formal manufacturing sector and record detailed plant-level information on over 100 variables covering industrial classification (5-digit ISIC), revenues, intermediate inputs, labour, capital, energy, trade and foreign ownership. Nominal values of total sales are converted to real values using the industry-level output, input, and export price deflators.[5]

We define a foreign plant as any plant where at least 10 percent of total equity is held by foreign investors. In over 66% of the foreign plants in the sample, foreign investors own at least 50% of the equity, while foreign investors own at least 25% of foreign plants in 95% of the sample. Similarly, exporters are identified as plants that receive any revenue from export sales.[6] Below we document a number of key differences across foreign and domestic firms in Indonesia that we use to motivate our model's structure.

Fact 1: Multinational firms account for a large percentage of aggregate output, exports and domestic market share.

Multinational firms are among the largest plants in the Indonesian manufacturing sector 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 each year. Multinational firms similarly account for a large percentage of domestic sales. One quarter of the Indonesian domestic market for manufactured goods in produced by multinational firms.

Fact 2: Some firms export while others do not. This is true of both foreign and domestic firms.

It is well known that even within narrowly defined industries only a small percentage of domestic firms export. This is true of the Indonesian manufacturing sector as well. Among domestic firms, only 14 percent of firms enter export markets. What is relatively unknown is

[4] There is substantial turmoil in the Indonesian economy at the onset of the Asian crisis. We do not extend the estimation to 1997 and 1998 where a number of shocks, not captured by our model, may affect the parameter estimates and model predictions. See Ito and Sato (2006), Agung et al. (2001) and Blalock and Gertler (2006) for a description of economic volatility, borrowing constraints and foreign ownership, respectively, during this period.

[5] Price deflators are constructed as closely as possible to Blalock and Gertler (2004). BPS Indonesia estimates that 95% of plants in our sample are single plant firms. Descriptive statistics are provided in the Appendix.

[6] Ramstetter and Sjoholm (2006) analyze the Indonesian data over a longer time period and indicate that foreign owned plants in Indonesia are typically part of multinational corporations. The data do not reveal the export destinations of each plant. In the Appendix we document that Indonesian industries which earn a higher percentage of revenues from exports are more likely to export to developed countries.

that multinational firms present a similar pattern; among foreign owned firms in Indonesia 59 percent export while 41 percent serve the Indonesian domestic market exclusively. Moreover, we are likely to find exporting and non-exporting multinational firms in the same narrowly defined industries. Across all 5-digit ISIC industries the correlation coefficient on the number of foreign exporters and non-exporters 0.53.[7]

Fact 3: There are large productivity differences across firms with different types of ownership and export status.

A common explanation for the observed differences in performance across firms is attributed to the fact that multinational firms are typically larger and more productive than their domestic counterparts. Following Bernard and Jensen (1999) we estimate export and ownership premia using a pooled ordinary least squares regression over the 1993-1996 period:

$$\ln X_{it} = \alpha_0 + \alpha_1 d^x_{it}(1 - d^m_{it}) + \alpha_2 d^x_{it} d^m_{it} + \alpha_3 (1 - d^x_{it}) d^m_{it} + Z_{it}\beta + \epsilon_{it}, \tag{1}$$

where X_{it} is a vector of plant attributes such as total employment, total sales, domestic sales, output per worker, and value-added per worker. A firm's export status is captured by the dummy variable d^x_{it}, while d^m_{it} is a dummy variable capturing whether the plant is part of a multinational firm. Last, Z_{it} is matrix of control variables including dummy variables for plant-age, year-dummies and plant-level fixed effects. The coefficient α_j where $j = \{1, 2, 3\}$ captures the average log point difference between the group of firms associated with α_j and domestic non-exporters (the excluded group).

The results in Table 1 confirm that domestic exporters tend to demonstrate higher premia than domestic non-exporters, and that multinational firms are generally more productive than their domestic counterparts. However, the ranking across export status is much less clear for foreign plants. The last two columns indicate that while foreign exporters exhibit higher employment, average labour productivity and value added per worker, foreign non-exporters tend to have larger total sales and have much higher domestic sales. Moreover, it appears that the mean differences are rarely statistically different.[8]

Fact 4: Export and ownership status is strongly persistent over time.

Export and ownership differences are strongly persistent over time. Among domestic firms, 72 percent of current exporters export in the next year, while 93 percent of non-exporters remain in the same state next year. A similar pattern presents itself among foreign firms. Among current

[7] Rodrigue (2008) provides additional, extensive evidence for the distribution of foreign exporters and non-exporters across highly disaggregated industries.

[8] See the Supplemental Appendix for a discussion on the possible impact of transfer pricing, differences in tax-rates across countries or markups across heterogeneous firms.

Table 1: Export & Ownership Premia

	Pooled OLS: 1993-1996		
Export/Ownership Status	Domestic Exporters	Foreign Non-Exporters	Foreign Exporters
Output per Worker	0.047	0.245	0.312
	(0.011)	(0.029)	(0.030)
Value-Added per Worker	0.090	0.177	0.197
	(0.014)	(0.035)	(0.036)
Domestic Sales	-0.736	0.386	-0.501
	(0.017)	(0.042)	(0.046)
Total Sales	0.151	0.402	0.494
	(0.014)	(0.036)	(0.036)
Total Employment	0.084	0.168	0.192
	(0.006)	(0.01)	(0.015)
No. of Observations		53808	

Notes: This table reports the results from a regression of firm-level characteristics on a set of dummy variables capturing plant export and ownership status. Domestic non-exporters are the omitted group. Additional control variables in each regression include plant age, year dummies and plant-level fixed effects. Robust standard errors are in parentheses.

foreign exporters 78 percent export in the next year, while 64 percent of non-exporters do not export in the next year. Finally, we observe very few changes between domestic and foreign ownership. That is, nearly all current domestic firms remain in domestic hands next year, while the same is true for approximately 90 percent of foreign firms.

Table 2: Export & MP Transition Matrix

Export/Ownership Status	Export/Ownership Status in Year $t+1$			
in Year $t+1$	Dom. Non-Exporters	Dom. Exporters	For. Non-Exporters	For. Exporters
Dom. Non-Exporters	93.4	5.5	0.5	0.6
Dom. Exporters	26.4	72.4	0.2	1.0
For. Non-Exporters	10.2	2.0	64.8	23.1
For. Exporters	5.6	4.8	12.0	77.6

Notes: This table reports the transition matrix across export and ownership status for all firms in the Indonesian manufacturing sector

3. A Model of MP and Exports

Given the above evidence, a model of MP and trade in Indonesia must reconcile the differential nature of exporting and MP across heterogeneous firms within the same industry. This section presents one possible model that captures these features of the Indonesian economy.

3.1. Consumers and Demand

Consider an economy with two countries, Home (h) and Foreign (f), which are endowed with non-depreciating stocks of labour, L^j, $j \in \{f, h\}$. Consumers supply labour inelastically.

Their preferences are defined by a Cobb-Douglas utility function over a homogeneous agricultural product z and a continuum of horizontally differentiated 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 $\varepsilon = 1/(1-\alpha) > 1$.

It is well known that the Dixit-Stiglitz (1977) framework generates a residual demand function $\delta R^j (P^j)^{1-\varepsilon}/p^j(v)^{\varepsilon}$ for each variety where R^j is the total manufacturing revenue earned in country j, P^j is an index of manufacturing prices in country j and $p^j(v)$ is the price chosen by an individual manufacturing producer for sales in country j.[9]

3.2. Production, Pricing and Revenue

The agricultural sector is characterized by a continuum of identical firms that can enter freely and produce a homogeneous agricultural product, z, with linear technology, $z = \phi_l^j l$. Producers hire labour on perfectly competitive markets which pins down the relative wage across countries. It is assumed that the foreign agricultural technology is more productive than the technology employed in the home country, $\phi_l^f > \phi_l^h$, so that wages in the foreign country are greater than those in the home country.

The manufacturing sector is the primary focus of this paper. It is characterized by a continuum of monopolistically competitive firms that produce horizontally differentiated goods. Individual manufacturing firms are indexed by i and the endogenous measure of manufacturing producers be denoted by M^j.

There exists an unbounded measure of ex-ante identical potential entrants. To enter the market each potential entrant must pay a sunk cost, c_e^j. Once the entry cost is paid, each firm draws its type, $\eta_i \equiv (a_i, \tau_i)'$, from the distribution $G_\eta(\eta)$. Here a_i captures the firm's productivity level and $\tau_i > 1$ represents an iceberg export transport cost. A large literature has established that exporting firms with similar productivity levels generally report very different levels of export revenues. Our model accounts for this feature of the data by allowing τ_i to vary across firms. We assume that a firm's productivity and transport costs are constant over the life of the firm.

At the beginning of each period the firm draws an extreme cost shock with constant probability ξ. If the firm suffers the extreme cost shock it is forced to exit the industry. Conditional on survival, each firm decides whether to exit, the location of production and in which countries to sell their good. In either country output is determined by the linear production function $q_i = l_i/a_i$ where l is labour hired on competitive markets within that country.[10] Since demand

[9] For simplicity, we restrict attention to a two-sector economy here. However, we will later allow for an arbitrary number of manufacturing sectors indexed by ℓ, each of which will enter preferences in Cobb-Douglas fashion, $U = z^{1-\bar{\delta}}\prod_\ell Q_\ell^{\delta_\ell}$, where $Q_\ell = [\int_{v\in V} q(v)^{\alpha}dv]^{1/\alpha}$ and $\bar{\delta} = \sum_\ell \delta_\ell$. The price index in sector ℓ and country j is $P_\ell^j = [\int_{V_\ell^j} p^j(v)^{1-\varepsilon}dv]^{1/(1-\varepsilon)}$.

[10] We assume that the firm's productivity does not vary with the location of production. Numerous studies

is exogenous to each individual producer the optimal pricing rule for each firm is a mark-up over marginal costs in each market.

This implies that if a home firm decides to locate a plant in country h, the optimal price for sales to country h is simply $p(a_i) = \frac{a_i w^h}{\alpha}$ where w^j represents the wages in country h. Alternatively, if the firm decides to serve country h consumers through exports from country f, the export price, p^X, is written $p^X(a_i) = \frac{a_i w^f \tau_i}{\alpha}$. Our structure further implies that we can write the net revenue of a firm serving market h from a plant located in country h as $r_i^j = (a_i w^h B^h/\alpha)^{1-\varepsilon}$. If they alternatively choose to serve country h through exports from country f, net revenue is then written $r_i^{Xf} = (a_i w^f \tau_i B^h/\alpha)^{1-\varepsilon}$ where $B^h = [(1-\alpha)\delta w^h L^h]^{1/(1-\varepsilon)}/(\alpha P^h)$ captures the size of country j. Analogous equations, with the country superscripts reversed, hold for firms choosing to sell to consumers in country f.

3.3. Static Costs and Profits

Following a rich literature studying heterogeneous firms and trade we assume MP and exporting are subject in fixed costs (see, for example, Melitz (2003) or Helpman, Melitz and Yeaple (2004)). Specifically, a firm interested in entering and maintaining a presence in any market is assumed to bear fixed costs specific to its chosen mode of entry (exports vs. MP) and the country which it serves (home vs. foreign). In line with the empirical literature studying firm-level entry into international markets we allow for the magnitude of these costs to vary with firm-level export and MP histories (see Das, Roberts and Tybout (2007) or Aw, Roberts and Xu (2011) for examples of export sunk and fixed costs).

To produce, each firm must pay a fixed overhead cost c^j in all countries where the firm locates a plant. We assume that these costs are sufficient to not only maintain a plant in the market where it is located, but also to sell to consumers in that market.[11] Regardless of the magnitude of these fixed costs, it is necessary to allow for stochastic fixed cost shocks associated with the firm's entry. As noted by Rust (1987) this stochastic element of the empirical model is necessary in order to generate a positive likelihood for some of the observed behaviour in the data. For example, without these shocks the model would be inconsistent with the large number of small firms observed in the data. We interpret these shocks as capturing differences

suggest that firms located in developing countries experience dramatic increases in productivity when acquired by foreign investors. See Arnold and Javorcik (2009) for detailed evidence in Indonesia. The paper otherwise abstracts from the notion of knowledge or productivity spillovers from foreign to unaffiliated domestic firms. Due to the short time period we examine it is unlikely that we will be able to identify significant knowledge spillovers across firms. Moreover, among studies that have examined this feature of micro-data there is little empirical evidence for within-industry spillovers; see Rodrik (1999), Aitken and Harrison (1999), Javorcik (2004), Ramondo (2009) and the references therein. Blalock and Gertler (2008) examine horizontal productivity spillovers using the same data and conclude that "none of [their] models provide any evidence of horizontal technology transfer" between foreign and domestic firms. Downstream spillovers from MP, as investigated by Javorcik (2004) and Blalock and Gertler (2008), require a model of inter-industry production which is beyond the scope of this paper.

[11] Empirically we observe that almost all firms, foreign and domestic, serve the Indonesian market.

in the fixed costs across firms and write the total fixed production cost incurred by any firm as $c^j = \bar{c}^j + \epsilon_{it}^{\chi}$ where $\bar{c}^j$ is the average fixed production in country j and ϵ_{it}^{χ} is the fixed cost shock drawn by firm i in year t. We assume that the cost shock is independently drawn from an extreme-value distribution with the scale parameter ϱ_{χ}.[12]

Should the firm decide to produce, it will also draw costs associated with exporting and MP. Specifically, exporters pay a per-period fixed cost $c_x^j = \bar{c}_x^j + \epsilon_{it}^x$. We expect that entering a foreign market for the first time is likely to require additional costs associated first-time entry. We allow for this possibility by including a one-time sunk cost $s_x^j = \bar{s}_x^j + \epsilon_{it}^x$. The sunk and fixed export costs are interpreted as forming and maintaining distribution and service networks in export markets. 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 export costs, s_x^j and c_x^j, and on the transport costs, τ_i, by choosing to produce abroad, we assume that it incurs the an additional fixed overhead cost, $c_m^j = \bar{c}_m^j + \epsilon_{it}^m$, and a one-time sunk cost, $s_m^j = \bar{s}_m^j + \epsilon_{it}^m$, associated with the initial multinational set-up abroad. Again, $\bar{c}_x^j$ and $\bar{s}_x^j$ represent the mean fixed and sunk export cost shocks, while $\bar{c}_m^j$ and $\bar{s}_m^j$ capture the mean MP sunk and fixed costs. The cost shocks associated with MP and exporting are denoted by ϵ_{it}^m and ϵ_{it}^x. Again, the export and MP cost shocks are assumed to be independently drawn from extreme-value distributions with the respective scale parameters ϱ_m and ϱ_x, respectively.

Firms may choose not to produce domestically at all. Suppose a foreign firm sets up a plant in country h and exports back to its country of origin. The firm then incurs the fixed costs c^h, c_x^h and c_m^h and along with the sunk costs s_x^h and s_m^h in the initial period. Since $s_m^h > 0$ and $c_m^h > 0$, any firm that produces abroad to export back home incurs higher fixed and sunk 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 wages across countries.

We assume that in each case the fixed and sunk costs are incurred in labor terms. For example, the fixed cost of exporting in country j captures the wages paid to labor hired to cover these overhead export costs, $c_x^j = w_j \tilde{c}_x^j$ where $\tilde{c}_x^j$ captures the number of workers required allocated to covering the fixed export activities.[13] The relative magnitude of these costs, along with differences in firm-level state variables, will determine how firms sort across modes of production and markets.

Let d_{it} capture a firm's export and MP decisions $d_{it} \equiv (d_{it}^m, d_{it}^x) \in \{(0,0),(0,1),(1,0),(1,1)\}$ where d_{it}^m captures the firm's decision to maintain a plant abroad and d_{it}^x is the firm's decision to export. If a firm decides to engage in MP or exporting that decision takes a value of 1, and is 0 otherwise. We then collect a home country firm's current set of fixed and sunk costs, conditional

[12] Assuming that the cost shocks are drawn from an extreme-value distribution will be a useful feature in the structural estimation of the model discussed below.

[13] In keeping with the convention in the empirical trade literature we only report the overall sunk or fixed costs.

on its current and past MP and export decisions, as

$$C^h(d_{it}, d_{i,t-1}) = \begin{cases} c^h & \text{for } (d^m_{it}, d^x_{it}) = (0,0) \\ c^h + c^h_x + s^h_x(1 - d^x_{i,t-1}) & \text{for } (d^m_{it}, d^x_{it}) = (0,1) \\ c^h + c^f + c^f_m + s^f_m(1 - d^m_{i,t-1}) & \text{for } (d^m_{it}, d^x_{it}) = (1,0) \\ c^f + \zeta_c c^f_x + c^f_m + [\zeta_s s^f_x(1 - d^x_{i,t-1}) + s^f_m](1 - d^m_{i,t-1}) & \text{for } (d^m_{it}, d^x_{it}) = (1,1) \end{cases}$$

where we denote the analogous and symmetric costs paid by firms originating in country f as $C^f(d_{it}, d_{i,t-1})$. Finally, it is important to note that firms must pay fixed export costs even if they are exporting back to their country of origin. We expect that there is generally some complementarity between foreign ownership and exporting to foreign markets; for instance, multinational exporters in Indonesia are likely to be able to access foreign distribution networks more cheaply that Indonesian exporters. We capture the fact that the fixed and sunk costs may be reduced through the parameters ζ_c and ζ_s, respectively.

We can then determine the static profit of firms originating in the home country as

$$\pi^h_{it}(\eta_i, d_{it}, d_{i,t-1}) = \tilde{r}^h(\eta_i, d_{it}) - C^h(d_{it}, d_{i,t-1}) \tag{2}$$

where

$$\tilde{r}^h(\eta_i, d_{it}) = \begin{cases} r^h_i(\eta_i) & \text{for } (d^m_{it}, d^x_{it}) = (0,0), \text{ Domestic Non-Exporters} \\ r^h_i(\eta_i) + r^{Xh}_i(\eta_i) & \text{for } (d^m_{it}, d^x_{it}) = (0,1), \text{ Domestic Exporters} \\ r^h_i(\eta_i) + r^f_i(\eta_i) & \text{for } (d^m_{it}, d^x_{it}) = (1,0), \text{ Multinational Non-Exporters} \\ r^f_i(\eta_i) + r^{Xf}_i(\eta_i) & \text{for } (d^m_{it}, d^x_{it}) = (1,1), \text{ Multinational Exporters} \end{cases}$$

As in Melitz (2003) we impose conditions on the relative size of fixed and sunk costs in order match the observed pattern of firms in the data. The first condition implies that all domestic exporters will also serve the domestic market, $c^h_x/c^h > (\tau_i B^f/B^h)^{1-\varepsilon}$. The second condition rules out that foreign investors may open plants in Indonesia exclusively for sales to the Indonesian consumers without serving consumers in any other country. A sufficient, though not necessary condition, for this to hold in our model is that $(w_h B_h)^{1-\epsilon} - (w_f B_f)^{1-\epsilon} < a_i^{1-\epsilon}(c^h + c^h_m - c^f)$. Last, we assume that the cost of entering the foreign country as a multinational for an Indonesian firm, c^f_m, is sufficiently large that all Indonesian producers which choose to serve foreign markets do so through export sales.[14]

MP and export decisions will depend on both firm-specific characteristics (productivity and transport costs) and differences across countries (wages, fixed/sunk costs, size). There are a

[14]The second condition implies that the wage differences across countries cannot be too big. The third condition is motivated by the observation that Indonesia had little outward FDI over the 1993-1996 period. See the appendix for further details.

number of intuitive implications that arise from our simple structure. First, due to the fixed export cost, firms that export will be more productive than domestic non-exporters. Second, if it is more costly to maintain a plant abroad than at home, multinational firms will be more productive than their domestic counterparts. The decision to become a non-exporting, rather than an export-platform oriented multinational is more complex.

Consider the export and MP 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. Even if transport costs are equal there will be substantial differences in these two production and export decisions. Abstracting from differences in country size and transport costs, the advantage to exporting from the foreign country is that the foreign firm incurs lower fixed and/or sunk overhead costs. The disadvantage is that labour costs are high. Thus, foreign firms that produce in the home country must be productive enough to afford the higher fixed and sunk costs.

Similarly, multinational firms must decide whether to produce all units abroad and export back to the foreign country or open 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.

3.4. Dynamic MP and Export Decisions

Consider the dynamic structure of a manufacturer's decision problem. At the beginning of each period, a producer's state is given by their type η_i and their previous MP and export decisions, $d_{i,t-1}$. The Bellman equations for a producer originating in country j are written as follows:

$$V^j(\eta_i, d_{i,t-1}, \epsilon^{\chi}_{it}) = \max\left\{\epsilon^{\chi}_{it}(0), \epsilon^{\chi}_{it}(1) + \int V^j_m(\eta_i, d_{i,t-1}, \epsilon^m) dH^m(\epsilon^m)\right\}, \tag{3}$$

$$\begin{aligned} V^j_m(\eta_i, d_{i,t-1}, \epsilon^m_{it}) = \max_{d^{m\prime}} \Big\{ & \epsilon^m_{it}(0) + \int V^j_{x0}(\eta_i, d_{i,t-1}, \epsilon^{x0}) dH^{x0}(\epsilon^{x0}), \\ & \epsilon^m_{it}(1) + \int V^j_{x1}(\eta_i, d_{i,t-1}, \epsilon^{x1}) dH^{x1}(\epsilon^{x1}) \Big\}, \end{aligned} \tag{4}$$

$$V^j_{x0}(\eta_i, d_{i,t-1}, \epsilon^{x0}_{it}) = \max_{d^{x\prime}}\left\{\epsilon^{x0}_{it}(d^{x\prime}) + \bar{\pi}^j(\eta_i, d_{i,t-1}, d^{m\prime} = 0, d^{x\prime}) + \tilde{\beta}\bar{V}^j\right\} \tag{5}$$

$$V^j_{x1}(\eta_i, d_{i,t-1}, \epsilon^{x1}_{it}) = \max_{d^{x\prime}}\left\{\epsilon^{x1}_{it}(d^{x\prime}) + \bar{\pi}^j(\eta_i, d_{i,t-1}, d^{m\prime} = 1, d^{x\prime}) + \tilde{\beta}\bar{V}^j\right\} \tag{6}$$

where $\bar{\pi}(\cdot) = E[\pi^j(\cdot)]$ is the expected value of equation (2), $\bar{V}^j = \int V^j(\eta_i, d', \epsilon^{\chi}) dH^{\chi}(\epsilon^{\chi})$ and $\tilde{\beta} = \beta(1-\xi) \in (0,1)$ is the discount factor. To allow for systematic heterogeneity in the fixed export costs across ownership, we assume that fixed export costs among foreign firms ϵ^{x1}_{it} are drawn from a separate distribution than those from domestic firms ϵ^{x0}_{it}. Specifically, H^k represents the cumulative distribution of ϵ^k, $k \in \{\chi, m, x0, x1\}$.

The value function $V^j(\cdot)$ characterizes the firm's exit decision. In equation (3) the firm compares the value of exiting $\epsilon^{\chi}(0)$ with the value of continued operation $\epsilon^{\chi}_{it}(1)+\int V^j_m(\cdot,\epsilon^m)dH^m(\epsilon^m)$. This decision depends on the difference in cost shocks $\epsilon^{\chi}(1)-\epsilon^{\chi}(0)$. Although in expectation, this difference is 0, low values of $\epsilon^{\chi}(0)$ or high values of $\epsilon^{\chi}(1)$ allow us to explain the presence of otherwise unprofitable firms. Likewise, $V^j_m(\cdot)$ describes the firm's decision whether to engage in MP. If the firm decides not to engage in MP, it receives the value associated with production, and possibly export from the country of origin, $\epsilon^m_{it}(0)+\int V^j_{x0}(\cdot,\epsilon^{x0})dH^{x0}(\epsilon^{x0})$. The firm compares this with the value associated with production, and possibly export platform sales abroad, $\epsilon^m_{it}(1)+\int V^j_{x1}(\cdot,\epsilon^{x1})dH^{x1}(\epsilon^{x1})$, and proceeds to make its optimal MP decision. The continuation values of firms which have decided to engage in MP or not, $V^j_{x0}(\cdot,\epsilon^{x0}_{it})$ and $V^j_{x1}(\cdot,\epsilon^{x1}_{it})$, also depend on the firm's later export decision. An advantage of this decision structure is that it allows for natural separation between foreign and domestic export decisions. A potential drawback is that firms make an MP decision before realizing their export shock.[15]

3.5. Equilibrium

We focus on a stationary equilibrium where aggregate variables and the distribution of productivity are constant over time. In the presence of discounting, there are aggregate profits. For simplicity, we assume that all profits are redistributed to consumers so that aggregate expenditure equals aggregate revenue, $w^jL^j+\bar{\Pi}^j=\bar{R}^j$, where $\bar{\Pi}^j$ and $\bar{R}_j$ represent the sum of aggregate profits and revenues, respectively, over all industries in country j. We denote the stationary distribution of incumbent firms by $\phi^j(\eta,d)$. Although firms exit home and foreign markets over time, these changes are exactly offset by new entrants of each type in equilibrium. For convenience, the time subscript is dropped and the firm's state is denoted as (η_i,d_i).

Under free entry the expected value of the firm must be equal to the fixed entry cost c^j_e,

$$\int V^j(a,(0,0))g^j_\eta(\eta)d\eta=c^j_e \tag{7}$$

where $g^j_\eta(\eta)$ is the joint distribution of initial productivity and transport cost draws in country j. A stationary equilibrium requires that the number of exiting firms must equal the number of successful new entrants:

$$M^j\int\left(\sum_d P^j_\chi(\chi=0|\eta,d)\phi^j(\eta,d)\right)d\eta=M^j_e\int P^j_\chi(\chi=1|\eta,(0,0))g^j_\eta(a)g^j_\tau(\tau)d\eta, \tag{8}$$

where M^j is the mass of incumbents, M^j_e is the total mass of entrants that attempt to enter the market, $P^j_\chi(\chi=0|\eta,d)$ is the probability of a firm of type (η,d) exiting the market.

[15]Similar empirical results are found using alternative timing structures.

In what follows, it is useful to define *expected* value functions as:

$$\bar{V}^j_m = \int V^j_m(\eta_i, d_{i,t-1}, \epsilon^m) dH^m(\epsilon^m) \tag{9}$$

$$\bar{V}^j_{x0} = \int V^j_{x0}(\eta_i, d_{i,t-1}, \epsilon^{x0}) dH^m(\epsilon^{x0}) \tag{10}$$

$$\bar{V}^j_{x1} = \int V^j_{x1}(\eta_i, d_{i,t-1}, \epsilon^{x1}) dH^m(\epsilon^{x1}) \tag{11}$$

The properties of extreme-value distributed random variables imply that the probability of producing this period is:

$$P^j_\chi(\chi = 1|\eta, d) = (1 - \xi) \left(\frac{\exp(\bar{V}^j_m(\eta, d)/\varrho^\chi)}{\exp(0) + \exp(\bar{V}^j_m(\eta, d)/\varrho^\chi)} \right) \tag{12}$$

where ξ is the exogenous probability of exit. The conditional choice probabilities for all MP and export decisions follow the nested logit formula (See McFadden (1978)). Conditional on operating, the probability of maintaining a plant abroad is given by

$$P^j_m(d^{m'} = 1|\eta, d, \chi = 1) = \frac{\exp(\bar{V}^j_{x1}(\eta, d)/\varrho^m)}{(\exp(\bar{V}^j_{x0}(\eta, d)) + \exp(\bar{V}^j_{x1}(\eta, d)))/\varrho^m)}. \tag{13}$$

Similarly, conditional on choosing to maintain a plant abroad, the firm's export probability is

$$P^j_x(d^{x'}|\eta, d, \chi = 1, d^{m'} = 1) = \frac{\exp([\bar{\pi}^j(\eta, d, d^{m'} = 1) + \tilde{\beta}\bar{V}^j(\eta, d')]/\varrho^x_1)}{\sum_{d^{x'}} \exp([\bar{\pi}^j(\eta, d, d^{m'} = 1) + \tilde{\beta}\bar{V}^j(\eta, d')]/\varrho^x_1)}. \tag{14}$$

The export probability conditional on *not* engaging in MP is analogous to (14) where the foreign scale parameters are replaced with their home country counterparts. Importantly, the conditional choice probabilities depend on the average sunk and fixed costs through $\bar{\pi}(\cdot)$, while the scale parameters, (ϱ_χ, ϱ^0_x, ϱ^1_x, ϱ_m), account for the effect of the fixed and sunk cost shocks to each decision.

The final condition required for a stationary equilibrium is that the measure of firms with state (η, d) is constant over time. Define the probability of MP and export as $P^j_d(d_{it}|\eta_i, d_{i,t-1}) = P^j_m(d^m_{it}|\eta_i, d_{i,t-1})P^j_x(d^x_{it}|\eta_i, d_{i,t-1})$. The equilibrium condition can therefore be written as

$$\begin{aligned} M^j \phi(\eta, d) &= M^j P^j_\chi(\chi = 1|\eta, d) \sum_{d'} P^j_d(d|\eta, d', \chi = 1)\phi^j(\eta, d) \\ &\quad + M^j_e P^j_\chi(\chi = 1|\eta, (0, 0))P^j_d(d|\eta, (0, 0), \chi = 1)g^j_\eta(\eta) \end{aligned} \tag{15}$$

The first term on the right-hand side of (15) is the measure of continuing producers with state (η, d) in the current period. The second term is the measure of entrants with the same state.

4. Structural Estimation

We begin by outlining the distributional assumptions that determine each firm's idiosyncratic productivity and transport cost draws. We assume that firm-level productivity, a_i, is drawn from a log normal distribution with mean 0 and variance σ_a^2.[16] Let φ_τ be a function of iceberg shipping costs, $\varphi_\tau \equiv (1-\varepsilon)\ln\tau$. We also assume that, conditional on a_i, φ_τ is drawn from a normal distribution with mean μ_τ and variance σ_τ^2.

By modifying the profit functions to include measurement error, we can write the logarithm of *observed* revenue for any plant i, r_{it}^o, as

$$\ln r_{it}^o = \ln\varphi_b(1-d_{it}^x) + \ln[\varphi_b + \varphi_w \exp(\varphi_\tau)]d_{it}^x - \ln a_i + \nu_{1,it} \tag{16}$$

where φ_w measures the ratio of wages across countries $(w^*/w)^{1-\varepsilon}$, φ_b is a function of the country sizes $(B^*/B)^{1-\varepsilon}$ and $\nu_{1,it}$ is the associated measurement error. Given a guess of the revenue function parameters, the model returns an estimate of firm-level log productivity up to a normally distributed error term. Equation (16) highlights an important limitation of the data: the data only documents the revenue, exports and ownership from plants located in Indonesia. Estimating the model requires imposing some consistency across plants located in different countries. In particular, we assume that foreign non-exporting plants also produce in a separate plant located in the foreign country with the same firm-specific productivity level as the Indonesian plant.

The ratio of export to total sales (among exporters) can be written as

$$\ln\left(\frac{r_{it}^{Xh}}{r_{it}^h + r_{it}^{Xh}}\right) = \left(\frac{\exp(\varphi_\tau)\varphi_b}{1+\exp(\varphi_\tau)\varphi_b}\right) + \nu_{2,it} \tag{17}$$

where $\nu_{2,it}$ is measurement error in export intensity. We assume that $\nu_{it} \equiv (\nu_{1,it}, \nu_{2,it})$ is randomly drawn from a mean zero normal distribution with covariance matrix Σ_ν. The density function is given by $g_\nu(\cdot)$ and we parameterize Σ_ν using the unique Cholesky decomposition as $\Sigma_\nu = \Lambda_\nu\Lambda_\nu'$. Let $\lambda_{j,k}$ represent the (j,k)-th element of Λ_ν.

We use maximum likelihood to estimate the vector of model parameters θ:

$$\theta = (\varphi_b, c, c_x, c_m, s_x, s_m, \zeta_c, \zeta_s, \xi, \varepsilon, \varrho_\chi, \varrho_m, \varrho_{x0}, \varrho_{x1}, \mu_\tau, \sigma_\tau, \sigma_a^h, \sigma_a^f, \lambda_{11}, \lambda_{21}, \lambda_{22}).$$

[16] We allow foreign and domestically owned firms to draw their initial productivity level from different distributions. The shape of the log normal distribution is very similar to the Pareto distributed productivity (as in Chaney (2008)) or the Fréchet distributed (as in Eaton and Kortum (2003)) which are common assumptions for the distribution of productivity across heterogeneous firms. However, well-known quadrature methods allow for straightforward and fast numerical integration under the log normal assumption. Variation in transport costs are modeled similarly, with the additional restriction that the distribution of transport costs does not vary across countries. We have estimated the model while allowing the distribution transport costs to vary across foreign and domestic plants. It made little difference to the final results.

Note that the discount factor, β, is not estimated and is set to 0.96.[17] Given a value of θ the model is solved on a finite number of grid points which approximate the continuous state space of a and τ. The state space of log productivity $\ln(a)$ and transport costs φ_τ are approximated by n_a and n_τ grid points, respectively. Thus, the continuous state space of η is approximated by $n_\eta = n_a \times n_\tau$ grid points. In practice, we set $n_a = n_\tau = 25$.

For any θ and η^k, we can calculate firm-level profits in (2) and determine the fixed point of the Bellman equations. Specifically, we start from an initial guess of $V^j(\eta, d) = 0$ for all values of d and iterate on (3)-(6) until convergence. Once convergence is reached we calculate the exit, exporting and MP conditional choice probabilities in each year and for each firm. Using the conditional choice probabilities we construct the likelihood function.[18] The full vector of parameters is separately estimated for three FDI and export oriented industries (food, metals and textiles) and one aggregated industry capturing the remaining manufacturing industries.[19] We focus on the food, metal and textile industries since they represent large, distinct industries which are among the most FDI-intensive Indonesian manufacturing sectors.

4.1. Identification

It is not possible to identify all of the model's parameters. Equation (16) is a reduced-form specification where the reduced-form parameters represent the following structural parameters:

$$\varphi_b = \left(\frac{w^h B^h}{w^f B^f}\right)^{1-\varepsilon} \qquad \varphi_w = \left(\frac{w^h}{w^f}\right)^{1-\varepsilon}.$$

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 level P^j will lead to a change in $B^j = [(1-\alpha)\delta w^j L^j]^{1/(1-\varepsilon)}/(\alpha P^j)$ and thus φ_b. The counterfactual experiments in this paper explicitly account for equilibrium price changes on the reduced-form coefficients using the relationship between the reduced-form coefficients and the aggregate prices. Likewise, 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, the profit function is normalized by $\kappa = \varepsilon/(w^f B^f)^{1-\varepsilon}$.[20]

The identification of the revenue function (16) parameters follows from the within-plant variation in revenue and export status. The fixed cost and scale parameters are similarly identified

[17] It is difficult to identify the discount factor in dynamic discrete choice models (Rust, 1987).

[18] The joint distribution of η_i and export/MP status $d_{i,t-1}$ depends on whether entering plants are observed in the initial year of the sample (Heckman (1981)). In the initial year of the sample it is assumed that the pair $(\eta_i, d_{i,t-1})$ are drawn from the stationary distribution $\phi(\eta, d)$ since we cannot distinguish new and incumbent firms. In subsequent years, η_i assumed to be drawn from the productivity distribution conditional upon successful entry into Indonesia. See Appendix D for full details.

[19] The model is estimated for 2-digit ISIC manufacturing industries.

[20] Specifically, the parameters κc, κc_x, κc_m, $\kappa \varrho_\chi$, $\kappa \varrho_m$ $\kappa \varrho_{x0}$ and $\kappa \varrho_{x1}$ are estimated instead of c, c_m, c_x, c_x^1, ϱ_χ, ϱ_m, ϱ_{x0} and ϱ_{x1}.

by relating the variation in productivity to the variation in export and MP probabilities. The sunk export cost is identified from the differences in export frequencies across plants with similar productivity levels but different export histories. The sunk MP costs are identified by the entry and exit dynamics of foreign firms, given the parametric assumption on the distribution of productivity. Specifically, a model without sunk costs cannot match the distribution of productivity among foreign firms in Indonesia. This is because high fixed costs and low cost shocks are both required to match the higher productivity and low exit rates across foreign owned plants. This results in too few low productivity, foreign firms. A model with sunk costs improves the model's fit along these dimensions since previous sunk investment in Indonesia will encourage low productivity foreign plants to stay in Indonesia despite the presence of large cost shocks.

Due to data limitations it is not possible to identify the parameters φ_w, c^f, c_x^f, and s_x^f. The parameter φ_w represents differences in wages across countries and is calibrated using cross-country manufacturing wages from the International Labour Organization. The last three parameters capture fixed and sunk cost parameters in the foreign country and are calibrated using data from the World Bank's *Doing Business Report* as $c^f = 0.51c^h$, $c_x^f = 0.38c_x^h$ and $s_x^f = 0.38s_x^h$. The calibrated parameters are constructed by comparing Indonesia's foreign wage, index of business rigidity and required export processing days to the average value for the rest of the world where the share of FDI in Indonesia are used as weights. To test for possible misspecification around the fixed cost parameters, we re-estimate under various alternative fixed and sunk cost assumptions. First, the model is re-estimated assuming that the fixed operation costs are equal across countries. Second, we consider an alternative where the ratio of Indonesian to foreign fixed and sunk costs are doubled. These robustness results are presented in the Appendix.

5. Estimation Results

Table 3 presents the maximum likelihood estimates of model parameters and the asymptotic standard errors. The standard errors are computed using the outer product of gradients estimator. The parameters are evaluated in millions of 1983 Indonesian rupiahs. The implications and interpretation of the estimated parameters are discussed in the following subsections.

5.1. Productivity

The model predicts that only productive domestic firms are able to produce profitably in Indonesia. Table 4 confirms that domestic incumbents are on average 11 to 27 percent more productive than domestic entrants across industries. This pattern is even more striking among foreign firms where incumbents are 18 to 49 percent more productive than foreign incumbents across industries. Although we separately estimate the distribution of initial productivity draws, the estimates σ_a^h and σ_a^f suggest that foreign firms are not receiving systematically higher productivity draws than domestic firms. Rather, this pattern is determined by the endogenous selection of firms into MP.

Table 3: Structural Estimates

	Food		Metals		Textiles	
σ_a^h (s.d. of dom. prod. dist.)	0.563	(0.012)	1.197	(0.013)	1.349	(0.023)
σ_a^f (s.d. of for. prod. dist.)	0.427	(0.012)	1.305	(0.025)	0.592	(0.025)
μ_τ (mean of export cost dist.)	-5.280	(0.097)	-5.097	(0.194)	-5.706	(0.178)
σ_τ (s.d. of export cost dist.)	0.127	(0.036)	0.817	(0.074)	0.320	(0.039)
c (fixed production cost)	4.220	(0.233)	0.549	(2.593)	1.889	(1.267)
c_x (fixed export cost)	1.611	(0.415)	0.665	(0.819)	1.042	(0.570)
s_x (sunk export cost)	11.156	(0.987)	25.318	(5.652)	16.010	(2.791)
c_m (fixed MP cost)	1.639	(10.905)	0.070	(7.728)	0.922	(1.700)
s_m (sunk MP cost)	42.925	(4.042)	22.591	(7.629)	64.998	(31.519)
ζ_c (MP-exp. fixed cost complement.)	0.501	(2.224)	0.027	(6.433)	0.220	(0.932)
ζ_s (MP-exp. sunk cost complement.)	0.020	(0.181)	0.003	(0.211)	0.051	(0.190)
φ_b (country size parameter)	1.564	(0.035)	2.278	(0.064)	1.173	(0.058)
ξ (exogenous exit shock prob)	0.002	(0.001)	0.001	(0.0003)	0.017	(0.003)
ϱ_χ (exit cost shock scale)	23.563	(2.142)	327.833	(24.357)	110.000	(24.970)
ϱ_m (MP cost shock scale)	0.898	(0.089)	28.658	(5.578)	2.264	(0.404)
ϱ_{x0} (dom. export cost shock scale)	3.242	(0.297)	7.565	(1.741)	5.987	(1.071)
ϱ_{x1} (MP export cost shock scale)	8.951	(13.495)	2.973	(1.803)	15.010	(3.201)
$\varepsilon = 1/\text{mark-up}$	3.8		3.0		3.8	
log-likelihood	-34048		-16531		-30813	
No. of Obs.	17,786		7,549		13,287	

Notes: This table presents the estimates of the model's structural parameters. Standard errors are in parentheses. The parameters are evaluated in units of millions of Indonesian Rupiahs in 1983. Metals refers to manufactured metals.

Table 4: Average Productivity

	Food		Metals		Textiles	
	Indonesian	Foreign	Indonesian	Foreign	Indonesian	Foreign
Mean at successful entry in Indonesia	1.007	1.754	1.006	1.494	1.009	1.182
Mean at steady state in Indonesia	1.117	2.068	1.275	2.066	1.224	1.763
Non-Exporters	1.087	2.071	1.153	2.268	1.039	1.479
Exporters	1.457	2.073	2.719	1.836	2.065	1.949

Note: This table reports the average productivity level across foreign and domestic plants in Indonesia. The first row reports the average productivity among domestic and foreign firms who have successfully entered Indonesia for the first time. The second row reports the average productivity among all domestic and foreign firms, while the third row decomposes the average steady state productivity into exporting and non-exporting firms. Metals refers to manufactured metals.

As shown in Section 2, domestic exporters tend to have higher productivity than domestic non-exporters, and foreign plants are more productive than domestic plants. This pattern is confirmed in each of the three industries documented in Table 6. Similarly, as in the data, there is no consistent productivity ranking of exporters and non-exporters within foreign plants.[21]

Our theory suggests that industries where shipping costs may be higher (or with smaller export markets), we might expect to find the most productive firms engaging in horizontal FDI.

[21] Moreover, in the food and metals industries we see that foreign exporters are less productive than domestic non-exporters. Lu (2010) also reports that highly export-intensive firms are often found to much less productive in similar setting.

In contrast, industries with low transport costs, τ, we expect to find the opposite pattern. In our model, the parameters μ_τ and ϵ jointly imply that, on average, iceberg export costs are largest in the metals industry and smallest in the food industry.

5.2. Sunk and Fixed Costs

Table 3 reports the average fixed and sunk export and MP cost across firms. In each industry we find that sunk export and MP costs are large. These represent key barriers to entry into international markets. The average sunk export cost drawn by a domestic firm ranges from 17 thousand 1983 US dollars in the metals industry to 32 and 152 thousand US dollars in the textiles and food industries, respectively. Across industries, the average sunk export cost is greater than one year's worth of export revenue for the median exporter. As such, it is unlikely that many non-exporting firms will optimally choose to enter export markets in any year. Further, our model implies that most new exporters have received beneficial sunk export cost shocks which reduce the cost of entry.[22] In contrast, the MP-export complementarity parameters ζ_m implies that foreign plants are estimated to pay 5% or less of the sunk export costs faced by their domestic counterparts.

Sunk MP costs are also estimated to be very large. Across industries the sunk MP cost for the average firm are as much as 584 thousand 1983 US dollars. These costs also account for a substantial percentage of total revenue; across industries the sunk MP costs account for more than 1 year's worth of revenue from the median foreign plant in Indonesia. Fixed costs are typically much smaller than the estimated sunk costs. The average fixed cost of operation in Indonesia ranges from 1 to 4 thousand 1983 US dollars in the manufactured metals industries and textiles, while it is 57 thousand dollars in food industry. The average fixed export cost ranges from 1 thousand 1983 US dollars in the manufactured metals industry to 22 thousand 1983 US dollars in the food industry. As with the sunk costs, foreign firms are estimated to only pay a small percentage of the fixed export costs (3 to 50% across industries). The fixed MP costs range from less than 1 thousand dollars in the manufactured metals industry, to 2 thousand dollars in the textiles industry and 22 thousand 1983 US dollars in the food industry. It is important to note that there exists substantial uncertainty in the estimates of most fixed costs since the standard errors are usually large and the estimates are often insignificant.

5.3. Exports and FDI

The parameters μ_τ and φ_b jointly capture the impact of exporting at the plant-level. The estimates imply that on average 19 percent of a domestic exporters' revenues are from export

[22]The extreme value distribution from which the cost shocks are drawn implies that the average cost shock is 0. However, among firms which endogenously choose to select into exporting, these firms tend to have received beneficial cost draws. As such, the average sunk cost *incurred* by the average exporter is substantially lower since the estimated model predicts many domestic plants only export or invest abroad when they receive beneficial cost shocks, ϵ_{x0}.

Table 5: 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	0.889	0.090	0.014	0.010
Metals	0.791	0.105	0.058	0.047
Textiles	0.725	0.228	0.017	0.030

Note: This table presents the percentage of firms with each type of ownership and export status in the data and the percentages predicted by the estimated model. The estimated model does not provide a prediction of the total number of foreign firms relative to the total number of domestic firms. As such, the initial percentage of foreign firms in the data is taken as given. Metals refers to manufactured metals.

Table 6: Export/Domestic Market Share by Ownership/Export Status

	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	0.761	0.239	0.724	0.182	0.053	0.041
Metals	0.878	0.122	0.443	0.372	0.122	0.063
Textiles	0.782	0.218	0.292	0.641	0.016	0.052

Note: This table reports the share of total industry exports from foreign and domestic firms in the data and shares predicted by the estimated model. It also reports the domestic market share across ownership and export status in the data and those predicted by the estimated model. Metals refers to manufactured metals.

sales in the food industry, while exporters in the food and textiles industries receive 38 and 40 percent of revenues from export sales, respectively. Table 5 documents the predicted distribution of plant-level export and ownership status across industries. The model's predictions match the distribution of plants across export and ownership status very closely in each industry. Table 6 reports the model's predicted domestic market and export shares across export and ownership status. The model also matches the empirical distribution of sales relatively well.

5.4. Dynamics

Table 7 documents the actual and predicted transition probabilities of MP, export and exit in the manufactured metals industry. 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 across MP and export status. Although the model generally captures the persistence in export and ownership status well, it does slightly underpredict the degree of persistence for foreign non-exporters. We note that without large sunk costs to MP or exporting, the model

Table 7: Transition Probabilities - 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	0.943	0.058	—	—	0.082
Dom. Exporters at t	0.417	0.584	—	—	0.042
For. Non-Exporters at t	—	—	0.576	0.424	0.039
For. Exporters at t	—	—	0.542	0.458	0.041

Note: This table reports the transition matrix across ownership and export status in the Indonesian manufactured metals industry and the transition matrix predicted by the estimated model. Each row represents the probability of moving from each firm's initial status (in the leftmost column) to next year's status (columns 2-5).

cannot replicate the persistence either MP or exporting.[23]

6. Counterfactual Experiments

In this section we conduct a series of counterfactual experiments intended to examine the effect of trade and MP barriers in the Indonesia. The experiments are chosen to highlight the interaction of MP and trade at the firm-level and its implications for policy change. Specifically, to determine the quantitative implications of barriers to trade and MP in our model, the following three counterfactual experiments are conducted by manipulating three parameters:

1. Autarky: $c_x^h, c_x^f, c_m^h \to \infty$,
2. No Trade: $c_x^h, c_x^f \to \infty$,
3. No MP in Indonesia: $c_m^h \to \infty$,

We decompose the Indonesian sector into 4 industries: food, metals, textiles and a composite industry capturing the remaining manufacturing industries (hereafter, ROM). We emphasize that in order to determine the full impact of trade or MP barriers on the Indonesian economy it is important to consider the effect policy changes have on the equilibrium price level. This, in turn, influences firm-level entry, exit, export and MP decisions. The experiments explicitly solve for the new price levels in Indonesia and the rest of the world which satisfy the free entry conditions (7) under the policy change.[24]

[23] Similar tables can be found in the Supplemental Appendix for the food and textiles industries. Das, Roberts and Tybout (2007), Kasahara and Lapham (2012) and Ruhl and Willis (2007) all find that sunk costs are necessary in order to capture the dynamic behaviour of entry and exit in international trade markets.

[24] Parameter estimates for the composite industry can be found in the Supplemental Appendix. See the Supplemental Appendix for a detailed description of the counterfactual experiments.

Table 8: The Impact of Policy Change on MP and Trade Outcomes

	Food				Metals				Textiles			
	Bench	Aut.	No Trade	No MP	Bench	Aut.	No Trade	No MP	Bench	Aut.	No Trade	No MP
Exit Rate of MP	—	-100	-97.9	-100	—	-100	-57.7	-100	—	-100	-17.5	-100
% of For. Non-Exp.	1.0	0	0.1	0	5.8	0	4.8	0	1.7	0	4.1	0
% of Dom. Exp.	9.0	0	0	9.3	10.5	0	0	11.7	22.8	0	0	23.9
%Δ in Exports	—	-100	-100	-23.9	—	-100	-100	-12.2	—	-100	-100	-21.8

Notes: The Exit Rate of MP captures the predicted percentage change in the number of multinational firms operating in each Indonesian manufacturing industry. The % of For. Non-Exp and the % of Dom. Exp refer to the percentage of all firms operating in Indonesia which are foreign non-exporters or domestic exporters, respectively. The percentage of foreign exporters is not reported since it is 0 in each case (by construction). The line item %Δ in Exports captures the percentage change in industry level exports after the change in policy. Metals refers to manufactured metals.

Tables 8 and 9 examine the impact of the policy change on a set of industry level outcomes. Specifically, Table 8 examines the impact of MP and trade restrictions on flow of foreign firms into Indonesia, the propensity of foreign or domestic exporting and the impact on industry exports from Indonesia. This last measure is of particular interest since many developing countries, including Indonesia, have export promotion play a key role in their development strategy.

Our results can be best understood by comparing the the results for any experiment in any industry (e.g. columns 2-4) with that the of the benchmark, estimated model (e.g. column 1). It is not surprising that increasing MP costs discourages multinationals from entering Indonesia. Rather, the first interesting finding from Table 8 is that increases in trade costs have a similar effect. In particular, we observe that across industries at least 18 percent of all multinational firms would optimally choose to leave Indonesia if they were to lose the ability to use Indonesia as an export platform. This effect is particularly strong in the food industry which is characterized by relatively low trade costs and high initial export intensity among foreign firms.

Similarly, we also find that changes in MP costs have a large impact on trade outcomes. By discouraging the presence of multinational firms, many of the most productive exporting firms located in Indonesia are forced to vacate the country. Domestic firms respond to trade restrictions, and the less competitive environment, by growing into export markets. However, this second effect is small, and overall industry level exports fall substantially in response to the policy change. There is, however, a wide difference in outcomes across industries. Although the food and textiles industries observe industry export declines of over 20 percent, the food industry only suffers a 12 percent fall in total industry exports. Of the three industries we study, the metals industry is the least "export intensive" in the sense that the average exporter receives the smallest percentage of total revenues from export sales (19 percent). In comparison, the average exporter in the food and textiles industries receives 38-40 percent of revenues from export sales.

Table 9: The Impact of Policy Change on Domestic Market Share

	Food				Metals				Textiles			
	Bench	Aut.	No Trade	No FDI	Bench	Aut.	No Trade	No FDI	Bench	Aut.	No Trade	No FDI
Dom. Non-Exp.	72.4	100	99.8	79.9	44.3	100	80.3	54.4	29.2	100	89.9	31.3
Dom. Exp.	18.2	0	0	20.1	37.1	0	0	45.6	29.2	0	0	68.7
For. Non-Exp.	5.3	0	0.02	0	12.2	0	19.7	0	1.6	0	10.1	0
For. Exp.	4.1	0	0	0	6.3	0	0	0	5.2	0	0	0

Notes: This table presents the share of domestic revenues captured by each type of firm under the benchmark parameters and the counterfactual experiments. Metals refers to manufactured metals.

Changes to firm-level performance on the domestic, Indonesian market serve as a second, useful metric of the impact of policy change. This measure is particularly revealing because it allows us to examine changes on a common market of interest to all firms. Table 9 documents again that changes in trade policy have a large impact on the share of revenue held by foreign firms, particularly in trade intensive industries. Likewise, increases in MP costs encourage the growth of existing and new Indonesian firms into the domestic Indonesian market.

Following Burstein and Cravino (2012) we compute industry productivity as industry revenue relative to the industry price index.[25] We compute this measure of aggregate manufacturing productivity under each counterfactual exercise and compare it to the benchmark. Table 10 presents the percentage changes in steady state aggregate productivity after accounting for entry, exit and the changes in firm structure induced by the policy changes. Note that, in each case, our productivity measures account for the changes in trade and MP across the three industries we study in detail (food, metals, textiles) and our composite industry (ROM) which captures the remaining manufacturing industries.

As expected, eliminating both trade and MP induces the largest reduction aggregate productivity. Aggregate manufacturing productivity falls by 44.1 percent, when both trade and MP are eliminated. When trade or MP are eliminated individually, the impact of policy change on aggregate productivity is substantially smaller. Restricting trade causes aggregate productivity to fall by 39 percent, while it falls by 22 percent when MP alone is eliminated. The difference across experiments is attributable to the differential response of foreign firms. As shown in Tables 8 and 9, many producers choose to leave Indonesia in response to the restrictions on trade. As such, trade restrictions have a similar effect to autarky: they sharply reduce domestic trade *and* discourage foreign direct investment. When MP is restricted, but trade is allowed the fall

[25]We aggregate the industry-specific changes using the industry-specific expenditure share parameters are pinned down by the expenditure share on each industry in Indonesia, consistent with the Cobb-Douglas utility function presented in Section 3.

Table 10: Aggregate Productivity and Wages

	Autarky	No Trade	No FDI
% Δ in Steady State Aggregate Manufacturing Productivity	-44.1	-39.0	-22.0
% Δ in the Steady State Real Wage	-1.1	-1.1	-0.1

Notes: This table documents the steady state changes in aggregate manufacturing productivity and real wages under the counterfactual experiments. Industry productivity is calculated we as industry revenue relative to the industry price index. We aggregate the industry-specific changes using the industry-specific expenditure share parameters are pinned down by the expenditure share on each industry in Indonesia, consistent with the Cobb-Douglas utility function presented in Section 3. Real wages are calculated as the prevailing nominal wages divided by the equilibrium price index. Metals refers to manufactured metals.

in productivity is also quite large, but substantially smaller. This result is largely due to the fact that few firms in any Indonesian industry are foreign owned and highly productive domestic exporters do not contract as in the second experiment. The counterfactual results indicate that due to the complementarity between trade and MP, particularly in a labor-rich country like Indonesia, trade restrictions are likely to have large productivity effects by affecting both export and MP location decisions.

We also report the predicted change in the real wage in the second row of Table 10.[26] We find that the changes in the steady state real wages are relatively small across all three experiments. The explanation for this finding is two-fold. First, Indonesian consumers purchase most goods from Indonesian firms both before and after the change in policy limiting the scope for gains from trade or MP. As such, it it is not surprising that when examining steady state differences across policy experiments the changes in real wages are likely to be modest since the change in consumer expenditures is relatively small. Second, varieties which are lost to Indonesian consumers by policy restrictions are compensated by the entry of new domestic firms. Nonetheless, the *relative* magnitude of the changes in real wages reveal subtle differences in the impact of our counterfactual experiments on Indonesian consumers.

In autarky steady state real wages fall by almost 1.1 percent. The fall in real wages when trade was restricted is nearly as large, while under MP restrictions it is only 0.1 percent. The intuition behind this result is simple. Trade flows partially “insure” MP flows in the presence

[26] The real wage is calculated as the nominal wage divided by the aggregate price level. Although the change in steady state real wages are modest, they are comparable to those found in similar models. As shown in Arkolakis, Costinot and Rodríguez-Clare (2010, ACR hereafter), the aggregate budget constraint $P^C Q^C = wL + \bar{\Pi}$ implies that aggregate utility $U = (wL+\bar{\Pi})/P^C$ where P^C and Q^C are the aggregate price and quantity indices over both the heterogeneous and homogeneous good. Since L and w are constant (due to the presence of the homogeneous good), changes in aggregate consumption are a function of changes in aggregate profits and changes in the aggregate price index. We observe slightly larger changes in this context since (1) foreign firms capture a large share (25%) of total domestic manufacturing market share, (2) the import penetration ratio in in Indonesia is 19%, which is larger than the US ratio of 7% and (3) in presence of discounting aggregate profits are positive.

of MP restrictions. For instance, a productive multinational firm which exits Indonesia under MP restrictions will become an exporting firm from the foreign country to Indonesia. Because of this, Indonesian consumers can continue to access foreign goods through trade and access to new domestic goods through domestic entry.

Similarly, trade restrictions are partially insured by multinational firms that maintain a firm in Indonesia in response to trade restrictions. As documented in Table 8, however, export-intensive foreign producers are likely to exit Indonesia in response the change in policy. Moreover, trade restrictions prevent Indonesian consumers from accessing these goods. This causes a fall in the varieties consumed and a larger increase in the price level (relative to MP restrictions).[27]

Finally, it is natural to question the degree to which our results depend on the model's assumptions. To examine this issue we test the extent to which the calibration of fixed export and MP costs across countries affect the quantitative results. In particular, to test for possible misspecification around the fixed or sunk cost parameters we re-estimate the model under various alternative fixed and sunk cost assumptions. The results from these exercises are presented in the Appendix and document that the qualitative and quantitative findings from our experiments are robust across estimation assumptions.

7. Conclusion

This paper presents and estimates a model of multinational production and exports with heterogeneous firms. The model is structurally estimated using a panel of Indonesian manufacturing plants. Counterfactual policy experiments are employed to assess the impact of a change in MP or trade policy on aggregate productivity.

The model's empirical predictions broadly match the features of the Indonesian manufacturing data. The model captures firm-level export decisions and documents the differential export behaviour across foreign and domestic firms. We find that accounting for MP flows is essential for recovering accurate estimates of the impact of trade on aggregate productivity and real wages in a developing country. The counterfactual experiments show that trade and MP restrictions result in large reductions in aggregate productivity through the reallocation of resources from highly productive foreign plants to less productive domestic plants. Restricting MP from Indonesia causes 22 percent decline in manufacturing productivity, while trade barriers similarly reduce manufacturing productivity by 39 percent. The impact on real wages, in contrast, is relatively modest. We find that our MP or trade restrictions cause real wages to fall 1.1 percent or less across experiments. The reason for this is that trade flows (MP flows) partially protect consumers against unilateral MP (trade) restrictions.

[27]We have also computed changes in aggregate consumption, accounting for changes in aggregate profits, across policy experiments. Since this pattern follows the changes in real wages closely we have relegated the discussion to Appendix C.

Appendix A

Due to data limitations we rule out the possibility 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. A sufficient, though not necessary, condition for this to hold in our model is that $(w^h B^h)^{1-\epsilon} - (w^f B^f)^{1-\epsilon} < a_i^{\epsilon-1}(c^h + c_m^h - c^f)$. This result implies that if it is profitable for a firm to operate a firm abroad, it must also be profitable to operate a plant at home. To see the intuition behind this result we impose symmetry on country sizes, $B^h = B^f = B$, and fixed operation costs, $c^h = c^f = c$. This condition can then be written as $(w^h)^{1-\epsilon} - (w^f)^{1-\epsilon} < c_m/(a_i B)^{1-\epsilon}$ which implies that given the distribution of a_i and the fixed cost of maintaining a firm abroad, c_m, the difference in cross-country wages w_f and w_h must be sufficiently small so that no unprofitable firm in country f would be profitable in country h.

Appendix B

This appendix reports two results. Tables 11 and 12 present descriptive statistics across export and ownership status and the destinations of Indonesian exports, respectively.

Table 11: Descriptive Statistics

	Total Sales[a]	Labor	Capital	Export Intensity[a,b]	Output/ Worker	V-A/ Worker[c]	No. of Obs.
Foreign	169.79	704.81	30.46	0.70	0.34	0.12	2,444
Exporters	(388.76)	(1,057.50)	(47.23)	(0.34)	(0.57)	(0.23)	—
Foreign	170.54	402.59	29.27	—	0.46	0.17	1,736
Non-Exporters	(366.30)	(637.71)	(49.24)	—	(0.82)	(0.36)	—
Domestic	87.89	477.64	15.56	0.69	0.16	0.05	9,796
Exporters	(518.86)	(1,242.39)	(38.90)	(0.33)	(0.38)	(0.12)	—
Domestic	21.77	128.42	3.29	—	0.09	0.03	43,438
Non-Exporters	(191.92)	(378.73)	(11.32)	—	(0.31)	(0.13)	—

Notes: This table reports the sample means of key firm-level characteristics across different types of firms in our sample. Standard deviations are in parentheses. (*a*) In millions of Indonesian Rupiahs. (*b*) Computed using the sample of exporting plants. (*c*) The ratio of skilled to total workers. (*c*) Value-added per worker.

Appendix C

Table 13 documents our counterfactual robustness results. Assumption A1 presents the benchmark results. Under assumption A2 the model is re-estimated assuming that the fixed operation costs are equal across countries. Alternatively, under assumption A3 the benchmark ratio of Indonesian to foreign fixed and sunk costs are doubled.

To calculate the change in consumption we first compute the number of workers in each sector L_m using the equilibrium relationship between aggregate revenues, aggregate profits and

Table 12: Indonesian Export Destinations

Industry	Export Intensity[a]	% of Industry Exports to Developed Nations	No. of Obs.
Wood	0.67	58%	1,860
Textiles	0.60	75%	1,816
Food	0.52	64%	956
Manufactured Metals	0.43	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) Firms in the petroleum industry are omitted as they were large outliers. This resulted in the removal of twelve plant-year observations.

Table 13: Counterfactual Experiments - Robustness

		Assumption		
Experiment		A1	A2	A3
Autarky	% Δ in Steady State Aggregate Manufacturing Productivity	-44.1	-26.5	-60.46
	% Δ in the Steady State Real Wage	-1.1	-1.3	-0.7
	% Δ in the Steady State Consumption	-1.6	-0.5	-5.8
No Trade	% Δ in Steady State Aggregate Manufacturing Productivity	-39.0	-16.9	-37.88
	% Δ in the Steady State Real Wage	-1.1	-0.4	-0.7
	% Δ in the Steady State Consumption	-1.6	-0.3	-5.8
No FDI	% Δ in Steady State Aggregate Manufacturing Productivity	-22.0	-9.7	-23.78
	% Δ in the Steady State Real Wage	-0.01	-0.2	-0.05
	% Δ in the Steady State Consumption	-0.02	-0.03	-0.1

Notes: This table presents the changes aggregate productivity and real wages arising from our counterfactual experiments across three separate sets of identification assumptions. The parameter estimates that generated these results are available in the Supplemental Appendix.

the mass of firms in Indonesia: $L_m^j = M^j(\bar{r}^j - \bar{\pi}^j)/w^j$. Given the number of workers employed in each sector by foreign and domestic firms we compute the implied number of workers in the outside sector so that average share of manufacturing workers in total employment is 12 percent.[28] We then recompute manufacturing employment share and aggregate manufacturing profits under each counterfactual to determine the change in total expenditure. In combination with the computed changes in real wages we determine the change in aggregate consumption by dividing aggregate expenditure by the aggregate price index.

[28] This is consistent with employment data from the International Labor Organization (2013). The percentage of manufacturing employment varies by less than 1 percentage point over the 1993-1996 period we study.

Appendix D

This appendix describes the construction of the likelihood function used in the structural estimation exercise. Allow the variable $\bar{\chi}_{it}$ to take a value of 0 if a plant exits the data and 1 otherwise. Thus, the probability of $\bar{\chi} = 1$ for domestic plants is simply the probability of exit ($\chi = 0$): $P^h_{\bar{\chi}}(\bar{\chi}_{it} = 0|\eta_i, d_{i,t-1}) = P^h_{\chi}(\chi_{it} = 0|\eta_i, d_{i,t-1})$. However, a foreign plant may exit because of a shock that causes the firm to die entirely or because it chooses to produce in its country of origin instead:

$$P^f_{\bar{\chi}}(\bar{\chi}_{it} = 0|\eta_i, d_{i,t-1}) = P^f_{\chi}(\chi_{it} = 0|\eta_i, d_{i,t-1}) + P^f_{\chi}(\chi_{it} = 1|\eta_i, d_{i,t-1})P^f_m(d^m_{it} = 0|\eta_i, d_{i,t-1}).$$

Likewise, the conditional choice probabilities for MP and exporting are computed by equations (13)-(14) and the stationary distribution is determined using (8) and (15).

Define η^k and ω^k to respectively be the grid points and weights associated with the multinomial distribution. The joint distribution of η_i and export/MP status $d_{i,t-1}$ depends on whether entering plants are observed in the initial year of the sample (Heckman (1981)). In the initial year of the sample it is assumed that the pair $(\eta_i, d_{i,t-1})$ are drawn from the stationary distribution $\phi(\eta, d)$ since we cannot distinguish new and incumbent firms. In subsequent years, η_i assumed to be drawn from the productivity distribution conditional upon successful entry into Indonesia

$$g^j_{\eta e}(\eta^k) = \frac{\omega^k P^j_{\bar{\chi}}(\bar{\chi} = 1|\eta, d_{t-1})}{\sum_{\tilde{k}=1}^{n_\eta} \omega^{\tilde{k}} P^j_{\bar{\chi}}(\bar{\chi} = 1|\eta', d_{t-1})}. \tag{18}$$

where $d_{t-1} = (0, 0)$ in the plant's initial year of entry for all domestic plants. Last, we derive the conditional density function for the observed components of ν_{it}, conditional on (η_i, d_{it}). Using equations (16)-(17) we derive the conditional density function for firms originating in country j:

$$g^j_\nu(\nu_{it}|\eta_i, d_{it}) = \begin{cases} g^j_{\nu_1}(\nu_{1,it}(\eta_i)) & \text{for country } j \text{ non-exporters} \\ g^j_{\nu_1}(\nu_{1,it}(\eta_i))g^j_{\nu_{2,it}|\nu_{1,it}}(\nu_{2,it}(\eta_i)|\nu_{1,it}(\eta_i)) & \text{for country } j \text{ exporters} \end{cases}$$

where $g^j_{\nu_1}(\cdot)$ is the marginal distribution of $\nu_{1,it}$ and $g^j_{\nu_2|\nu_1}(\cdot)$ is the conditional distribution of ν_2 given ν_1.

We now turn our attention to constructing the likelihood function. Denote $T_{i,0}$ as the first year the firm appears in the data. Then, conditional on η_i and $d_{i,t-1}$ the likelihood contribution of plant i in year $t > T_{i,0}$ is

$$L_{it}(\theta|\eta_i, d_{i,t-1}) = \begin{cases} P^j_{\bar{\chi}}(\bar{\chi}_{it} = 0|\eta_i, d_{i,t-1}) & \text{for } \bar{\chi}_{it} = 0 \\ \underbrace{P^j_{\bar{\chi}}(\bar{\chi}_{it} = 1|\eta_i, d_{i,t-1})}_{\text{Stay/Exit}} \underbrace{P^j_d(d_{it}|\eta_i, d_{i,t-1}, \chi_{it} = 1)}_{\text{MP/Export}} \quad \underbrace{g^j_\nu(\nu_{it}(\eta_i))}_{\text{Rev./Exp. Intensity}} & \text{for } \bar{\chi}_{it} = 1 \end{cases}$$

Note that the endogeneity of the export, MP and exiting decisions are controlled by simultaneously considering the likelihood contribution from each decision. Since only plants that chose to stay in the market are observed, the likelihood contribution of these plants in the initial year is calculated conditional on $\chi_{it} = 1$, $L_{it}(\theta|\eta_i, d_{i,t-1}) = P_d(d_{it}|\eta_i, d_{i,t-1}, \chi_{it} = 1)g_\nu(\nu_{it}(\eta_i))$.

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

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

The likelihood contribution from each plant i is calculated by numerically integrating out η_i as

$$L_i(\theta) = \begin{cases} \int L_i(\theta|\eta', d_{i,T_{i,0}})\phi^j(\eta', d_{i,T_{i,0}})d\eta' & \text{for } T_{i,0} = 1993, \\ \int L_i(\theta|\eta', d_{i,T_{i,0}})P_d^j(d_{i,T_{i,0}}|\eta', d_{i,T_{i,0}-1})g^j_{\eta e}(\eta')d\eta' & \text{for } T_{i,0} > 1993, \end{cases}$$

where the stationary distribution of foreign plants is conditional upon entering Indonesia, $\phi^f(\eta', d_{i,T_{i,0}}|d^m_{i,T_{i,0}} = 1)$. The parameter vector θ is estimated by maximizing the logarithm of the likelihood function

$$\mathcal{L}(\theta) = \sum_{i=1}^{N} \ln L_i(\theta). \tag{19}$$

For each candidate parameter vector, we evaluate the log-likelihood function (19). Searching over the parameter space of θ, the estimates are found by maximizing (19).

References

[1] Agung, J., B. Kusmiarso, B. Pramono, E.G. Hutapea, A. Prasmuko, N. Joko Prastowo, "Credit Crunch In Indonesia In the Aftermath of the Crisis: Facts, Causes and Policy Implications," Directorate of Economic Research and Monetary Policy. (2007) Bank Indonesia.

[2] Aitken, B. and A. Harrison, "Do domestic firms benefit from direct foreign investment? Evidence from Venezuela," *American Economic Review*, 89(1999) 605-618.

[3] Alvarez, F., and R.E. Lucas, "General Equilibrium Analysis of the Eaton-Kortum Model of International Trade," *Journal of Monetary Economics,* 54(2007) 1726-1768.

[4] Antras, P. and E. Helpman, "Global Sourcing," *Journal of Political Economy*, 112(2004) 552-580.

[5] Arkolakis, C., A. Costinot, and A. Rodríguez-Clare, "New Trade Models, Same Old Gains?" *American Economic Review*, (2010) forthcoming.

[6] Arnold, J.M. and B.S. Javorcik, "Gifted Kids or Pushy Parents? Foreign Acquisitions and Plant Performance in Indonesia," *Journal of International Economics*, 79(2009) 42-53.

[7] Atkeson, A. and A. Burstein. 2010. "Innovation, Firm Dynamics, and International Trade," *Journal of Political Economy*, 118(3): 433-484.

[8] Aw, B.Y., S. Chung, and M.J. Roberts, "Productivity and Turnover in the Export Market: Micro-level Evidence from the Republic of Korea and Taiwan (China)," *World Bank Economic Review*, 14(2000) 65-90.

[9] Bernard, A.B. and J.B. Jensen, "Exceptional Exporter Performance: Cause, Effect, and or Both?" *Journal of International Economics*, 47(1999) 1-25.

[10] Bernard, A.B., J. Eaton, J.B. Jensen, and S. Kortum, "Plants and Productivity in International Trade," *American Economic Review*, 93(1999) 1268-1290.

[11] Blalock, G. and P.J. Gertler, "Learning from Exporting Revisited in a Less Developed Setting," *Journal of Development Economics*, 75(2005) 397-416.

[12] Blalock, G. and P.J. Gertler, "Welfare gains from Foreign Direct Investment through technology transfer to local suppliers," *Journal of International Economics*, 74(2008) 402-421.

[13] Blonigen, B.A., "In search of substitution between foreign production and exports," *Journal of International Economics*, 53(2001) 81-104.

[14] Blonigen, B.A., R.B. Davies, and K. Head, "Estimating the Knowledge-Capital Model of the Multinational Enterprise: Comment," *American Economic Review*, 93(2003) 980-994.

[15] Brainard, S.L., "An Empirical Assessment of the Proximity-Concentration Trade-off Between Multinational Sales and Trade," *American Economic Review*, 87(1997) 520-544.

[16] Burstein, A. and J. Cravino, "Measured Aggregate Gains from International Trade," (2012) NBER Working Paper 17767.

[17] Burstein, A., and A. Monge-Naranjo, "Foreign Know-How, Firm Control, and the Income of Developing Countries," *Quarterly Journal of Economics*, 124(2009) 149-195.

[18] Chor, D., F. Foley, and K. Manova, "Host Country Financial Development adn MNC Activity," Working Paper Stanford University.

[19] Clausing, K.A., "Does multinational activity displace trade?" *Economic Inquiry*, 38(2000) 190-205.

[20] Clerides, S., S. Lach, and J.R. Tybout, "Is Learning by Exporting Important? Micro-Dynamic Evidence from Columbia, Mexico and Morocco," *Quarterly Journal of Economics*, 113(1998) 903-947.

[21] Doing Business: Comparing Business Regulations, World Bank. (2006). http://www.doingbusiness.org/.

[22] Das, S., M.J. Roberts, and J.R. Tybout, "Market Entry Costs, Producer Heterogeneity, and Export Dynamics," *Econometrica*, 75(2007) 837-873.

[23] Eaton, J. and S. Kortum, "Technology, Geography and Trade," *Econometrica,* 70(2002) 1741-1779.

[24] Eaton, J., S. Kortum and F. Kramarz, "Dissecting Trade: Firms, Industries, and Export Destinations," *American Economic Review, Papers and Proceedings*, 94(2004a) 150-154.

[25] —–, "An Anatomy of International Trade: Evidence from French Firms," *Econometrica*, 79(2011) 1453-1498

[26] Fieler, A.C., "Non-Homotheticity and Bilateral Trade: Evidence and a Quantitative Explanation," *Econometrica*, 79(2011): 1069-1101.

[27] Feinberg, S.E., and M.P. Keane, "Accounting for the Growth of MNC-Based Trade Using a Structural Model of U.S. MNCs," *American Economic Review,* 96(2006) 1515-1558.

[28] Garetto, S. "Input Sourcing and Multinational Production," mimeo, (2010) Boston University.

[29] Heckman, J.J., "The Incidental Parameters Problem and the Problem of Initial Conditions in Estimating A Discrete Time-Discrete Data Stochastic Process and Some Monte Carlo Evidence," in: C.F. Manski and D.L. McFadden (Eds.), Structural Analysis of Discrete Data With Econometric Applications, M.I.T. Press, 1981.

[30] Grossman, G.M., E. Helpman and A. Szeidl, "Optimal Integration Strategies for the Multinational Firm," *Journal of International Economics,* 70(2006) 216-238.

[31] Head, K. and J. Ries, "Overseas Investment and Firm Exports," *Review of International Economics,* 9(2001) 108-122.

[32] Helpman, E., M.J. Melitz and S.R. Yeaple, "Export versus FDI with Heterogeneous Firms," *American Economic Review*, 94(2004) 300-316.

[33] Hsieh, Chang-Tai and Peter J. Klenow. "Misallocation and Manufacturing TFP in China and India," *Quarterly Journal of Economics*, 124(2009) 1403-1448.

[34] International Labour Organization Bureau of Statistics. (2007). http://ilo.laborsta.org/.

[35] Irarrazabal, A., A. Moxnes and L.D. Opromolla, "The Margins of Multinational Production and the Role of Inter-firm Trade," (2010) Working Paper.

[36] Ito, T. and K. Sato, "Exchange Rate Changes and Inflation in Post-Crisis Asian Economies: VAR Analysis of the Exchange Rate Pass-through," NBER Working Paper 12395, (2006).

[37] Javorcik, B.S. "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages," *American Economic Review*, 93(2006) 605-627.

[38] Kasahara, H. and B. Lapham, "Productivity and the Decision to Import and Export: Theory and Evidence," *Journal of International Economics*, (2012), forthcoming.

[39] Lu, D., "Exceptional Exporter Performance? Evidence from Chinese Manufacturing Firms," University of Chicago, (2010).

[40] Markusen, J.R. and K.E. Maskus, "Discriminating Among Alternative Theories of the Multinational Enterprise," *Review of International Economics*, 10(2002) 694-707.

[41] McFadden, D., "Modeling the Choice of Residential Location," in: A. Karlquist et al. (Eds.), Spatial Interaction Theory and Residential Location, North- Holland, Amsterdam, 1978.

[42] McGrattan, E.R., and E.C. Prescott, "Openness, Technology Capital, and Development," *Journal of Economic Theory,* 144(2007) 2454-2476.

[43] Melitz, M.J., "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica,* 71(2003) 1695-1725.

[44] International Direct Investment Statistics Online Database, OECD. (2006) http://www.sourceoecd.org/.

[45] Pavcnik, N. "Trade Liberalization, Exit, and Productivity Improvements: Evidence From Chilean Plants," *Review of Economic Studies,* 69(2002) 245-276.

[46] Ramondo, N. "A Quantitative Approach to Multinational Production," mimeo. (2011). https://sites.google.com/site/nataliaramondo/home/research.

[47] Ramondo, N. "Foreign Plants and Industry Productivity: Evidence from Chile," *Scandanavian Journal of Economics*. 111(2009): 789-809.

[48] Ramondo, N. and A. Rodríguez-Clare, "Trade, Multinational Production, and the Gains from Openness," mimeo. (2010) http://www.econ.psu.edu/∼aur10/research.htm.

[49] Ramstetter, E.D., and F. Sjoholm, "The Issues: Multinationals and the questions they raise," in: E.D. Ramstetter and F. Sjoholm (Eds.), Multinational Corporations in Indonesia and Thailand, Palgrave MacMillan, New York, 2006.

[50] Restuccia, Diego and Richard Rogerson, "Policy Distortions and Aggregate Productivity with Heterogeneous Plants," *Review of Economic Dynamics*, 11(2008), 707-720.

[51] Roberts, M.J. and J.R. Tybout, "Decision to Export in Columbia: An Empirical Model of Entry with Sunk Costs," *American Economic Review*, 87(1997) 545-564.

[52] Rodrigue, J. *International Trade, Foreign Direct Investment and Productivity: An Empirical Investigation*, PhD Dissertation, Queen's University (Canada), 2008. NR44602.

[53] Rodrik, D., "The new global economy and developing countries: making openness work," Policy Essay 24, Overseas Development Council. Johns Hopkins University Press, Washington, DC.

[54] Ruhl, K.J., and J.L. Willis, "Convexities, Nonconvexities, and Firm Export Behaviour," mimeo. (2007). http://www.vanderbilt.edu/econ/sempapers/Ruhl.pdf

[55] Rust, J., "Optimal replacement of GMC bus engines: an empirical model of Harold Zurcher," *Econometrica,* 55(2006) 999-1033.

[56] Svensson, R., "Effects of overseas production on home country exports: Evidence based on Swedish multinationals," *Review of World Economics,* 132(1996) 304-329.

[57] Trefler, D., "The Long and Short of the Canada-U.S. Free Trade Agreement," *American Economic Review*, 94(2004) 870-895.

[58] United Nations, Commodity Trade Statistics 1994, United Nations Publishing Division, New York, 1995.

[59] Waugh, M., "International Trade and Income Differences," *American Economic Review*, 100(2010) 2093 - 2124.