Firm-Level Investment and Export Dynamics

Young-Woo Rho[†] Joel Rodrigue[‡]

Department of Economics, Vanderbilt University, Nashville, TN, United States

Abstract

This paper characterizes the complementarity between exporting and investment in physical capital. We argue that new investment allows young exporters to grow faster and survive longer in export markets, while reducing their vulnerability to productivity or demand shocks across markets. We structurally estimate our model using detailed firm-level data. We find that the choice of cost structure has large impact on model performance and the estimated costs of exporting or investment. Using detailed capital and output tariff rates we quantify the impact of policy change on aggregate export and investment growth.

Keywords: Productivity, Export Demand, Investment, Exports, Indonesia
JEL Classification Numbers: F14, O33

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 addresses: [†]young-woo.rho@vanderbilt.edu; [‡]joel.b.rodrigue@vanderbilt.edu.

This paper studies the impact of investment in physical capital on firm-level entry, growth and duration in export markets. We show that new investment allows young exporters to grow faster and survive longer in export markets, while reducing their vulnerability to productivity or demand shocks across markets. Consistent with these facts, we develop a model which emphasizes that firm-level investment and export decisions evolve endogenously with firm-specific productivity and export demand shocks. We find that capital adjustment frictions slow down the firms ability to make profits in the export market, which, with mean reverting shocks, decreases the value of being an exporter. The model is estimated in two-steps. First, we estimate a model-consistent measure of firm-level productivity which accounts for the role of quasi-fixed factors of production, such as capital stock, in a context where firms endogenously respond differential demand shocks domestic and export markets. Accounting for this bias, the productivity estimates among new Indonesian exporters increase by as much as 15 percent across industries. Second, we estimate the model's remaining structural parameters using firm-level export and investment data. Allowing firms to endogenously accumulate capital substantially alters the performance of comparable heterogeneous firms and trade models. For instance, the estimated fixed export costs are reduced by 90 percent and have a much smaller impact on export decisions. Finally, using detailed capital and output tariff rates we quantify the impact of policy change on aggregate export growth.

Exporting firms are almost universally found to be larger, more productive, capital-intensive and pay higher wages than their non-exporting counterparts. Not surprisingly, numerous countries have pursued development strategies that emphasize export promotion with the purpose of creating and expanding firms with these desirable characteristics. Although it is natural to expect new exporters to increase capital holdings as they expand into export markets, little is known about the nature of firm-level investment dynamics in relation to changes in export behavior. For instance, how much does investment in new capital affect firm duration and revenue growth in export markets? Likewise, do capital constrained firms forgo sales on domestic markets in order to enter new markets abroad? What impact do investment costs have on the decision to export? Our aim is to develop a model and estimation strategy to answer these questions within one coherent framework.

It is well-known that firm-level investment in physical capital varies dramatically within narrowly defined industries and this differential behavior has important implications for aggregate performance.[1] Similarly, accounting for investment dynamics have proven particularly important for capturing firm exit and asset accumulation in a developing country (Bond, Tybout and Utar, 2014). While these papers focus exclusively on the domestic market, our model highlights the role that exports have on encouraging investment and, likewise, the impact of costly investment on deterring firms from entering and maintaining their presence in export markets.

[1] See Doms and Dunne (1994), Caballero, Engel and Haltiwanger (1995), Cooper, Haltiwanger and Power (1999) and Cooper and Haltiwanger (2006), among others.

We find that new exporters vary systematically in their investment behaviour and export outcomes. Using detailed firm-level data from Indonesia, we document that new exporters invest systematically faster than similar non-exporting firms. Further, differences in investment behaviour and capital holdings among new exporters are strongly correlated with survival in export markets, export revenue growth and domestic market performance. Specifically, the endogenous capital adjustment model rationalizes why many new exporters are small (under-investment prior to exporting), why export revenues grow rapidly over the first few years of initial exporting (rapid new investment upon initial entry), why domestic revenue grows more slowly among new exporters (capital-constraints) and why there is strong firm-level persistence in export status (irreversible investment in capital holdings).

Recent contributions by Luttmer (2007) and Arkolakis (2013) argue that firm-level selection across markets and productivity growth can account for exit, entry and revenue dynamics in domestic markets, exports markets or both. Our model provides an alternative explanation for firm-level selection and growth in new markets, costly investment and the gradual accumulation of capital. Riano (2011) and Alessandria and Choi (2013) develop calibrated models of firm-level investment and exporting in Columbia and US, respectively. Riano (2011) focusses on the impact of exporting on firm-level volatility, while the latter paper studies the effects of tariffs and transport cost reductions in a two-sector dynamic variant of the Melitz (2003) model. Although closely related, our work specifically targets capturing the frictions associated with investment in a developing country and the impact that convex and non-convex investment costs have on the performance of heterogeneous firms and trade models. Further, our model and counterfactual experiments emphasize the impact that allowing for capital accumulation has important export and investment growth implications over time.[2]

We follow a rich literature studying the impact of firm-level decisions on export dynamics. Constantini and Melitz (2008), Ederington and McCalman (2008), Atkeson and Burstein (2010), Lileeva and Trefler (2010), Aw, Roberts and Xu (2011) and Bustos (2011) study the impact of firm-level innovation on productivity evolution and exporting over time. Similarly, a number of recent papers recognize the role of increasing marginal costs, often justified by a fixed capital input, in determining firm-level trade outcomes. For example, Ruhl and Willis (2008), Nguyen and Schaur (2011), Cosar, Gunar and Tybout (2014), Vannoorenberghe (2012) and Ahn and McQuoid (2012) suggest that allowing for increasing marginal costs are key to capturing sales correlation across markets or export dynamics.[3]

Our model links exporting and investment through three mechanisms. First, the return to

[2]Moreover, in contrast to Riano (2011) our work highlights the role convex and non-convex for capital adjustment costs on investment and exporting, the impact the export demand shocks have on firm-level productivity estimation, and differences in firm-level outcomes across markets. Alessandria and Choi (2007) argue that "lags in expanding trade flows are potentially more important for net export dynamics than the costs of entering and continuing exporting." We study this aspect of heterogeneous firm trade directly.

[3]Similarly, Soderbery (2014) presents a model with constant marginal costs and a constant firm-level production capacity to capture the sales correlation across markets.

investment depends on the firm's current decision to export. Second, we allow that marginal costs may depend on the firm's capital stock and, as such, previous investment decisions. Third, in an environment where firms incur one-time sunk export costs, current export and investment decisions depend on the firm's export history. Investment in capital holdings expands firm capacity and allows for complex intertemporal trade-offs between endogenous investment and export decisions. A key distinction between our model and those that precede it is we allow firms to make a continuous investment decision rather than simply a binary choice between investing and non-investing. Further, our model includes both convex and non-convex investment costs and allows us to characterize the extent to which investment frictions deter entry into export markets.

We structurally estimate the model in two-steps. First, we develop a method to consistently estimate firm-level productivity in this context which can be applied to most firm-level manufacturing data sets. Our method emphasizes that ignoring the impact of export market shocks on domestic performance across firms and time can substantial bias productivity estimates. A key insight of our method is that we are able to exploit differential export behavior over time to simultaneously identify firm-level productivity and the shape of the marginal cost function. We find that new exporters, who are often small, and build capital holdings slowly over time, and are often mistakingly characterized as unproductive. Our findings suggest that standard estimates of firm-level productivity are downwards biased for new exporters by as much as 15 percent.[4] In the second step, we structurally estimate the model's dynamic parameters using detailed information on firm-level investment and export decisions among Indonesian manufacturing firms. The model's parameters are estimated using indirect inference and the estimated model matches average investment and export behavior across heterogeneous firms. We find that allowing for investment costs drastically reduces the estimated size of export entry costs by 90 percent.

Finally, we use the estimated model to study the impact of trade liberalization on aggregate export and investment behavior. In our first experiment we use detailed data on the tariff rates faced by Indonesian exporters in destination markets to evaluate the impact on unilateral tariff reductions in export markets on firm-level export and investment behaviour. We find that eliminating tariffs in destination markets leads to a 18-39 percent increase in aggregate exports relative to the benchmark model after 10 years. Further, our simulations suggest that the contribution of new exporters, or the extensive margin of export growth, is very sensitive to model specification.[5] In contrast, we find that trade liberalization has a relatively small impact

[4]In line with Demidova, Kee and Krishna (2012), we argue that failing to account for heterogeneous demand shocks across markets will likely lead to biased productivity estimates in export-oriented industries. While numerous papers find that most new exporters are small and unproductive (e.g. Arkolakis 2010), we conclude that largely new exporters are small, but very productive.

[5]The contribution of the extensive margin to aggregate exports is studied in Evenett and Venables (2002), Hummels and Klenow (2005), Ruhl (2004), Alelssandria and Choi (2007), Kehoe and Ruhl (2013), Arkolakis (2010), and Alessandria and Choi (2013).

on aggregate investment since only a relatively small number of large firms export in both the benchmark and counterfactual experiments.

We also study the impact of reducing tariffs on capital imports. Under the assumption of a competitive capital market, we find that eliminating tariffs on imported capital has a small impact on aggregate exports initially, but after 10 years the aggregate export growth rates are 14-16 percentage points higher than the benchmark model. Consistent with the evidence in Manova (2013) we find that this effect is particularly strong in industries where capital-constraints are most severe. Moreover, after the reduction in investment costs, exporters account as much as a 5 percent of the annual investment growth.

The next section describes the data used in this study and documents the key features of the data upon which we will base our model. Section 2 presents our model of investment and exporting, while sections 3 and 4 describe the estimation methodology and present the results, respectively. The fifth section discusses the policy implications of our work and the sixth section concludes.

1 Data

The first source of data is the Indonesian manufacturing census between 1990 and 1995. 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 captures the formal manufacturing sector and records detailed plant-level information covering industrial classification, revenues, capital holdings, new investment in physical capital, intermediate inputs, and export sales. Data on revenues and inputs are deflated with wholesale price indices.[6]

Key to our analysis the data also include annual observations of the estimated replacement value of fixed capital, purchases of new investment and capital sales across five type types of capital: land, buildings, vehicles, machinery and equipment, and other capital not classified elsewhere. The capital stock and investment series are created by aggregating data across types. Following Blalock and Gertler (2004) we deflate capital using wholesale price indices for construction, imported electrical and non-electrical equipment, and imported transportation equipment. In years following 1990 we use the perpetual inventory method to construct a measure of capital holdings as

$$k_{jt+1} = (1 - \bar{\delta})k_{jt} + i_{jt} \tag{1}$$

where $\bar{\delta}$ is the industry-specific, average depreciation rate reported in the data.[7]

[6]Price deflators are constructed as closely as possible to Blalock and Gertler (2004) and include separate deflators (1) output and domestic intermediates, (2) energy, (3) imported intermediates and (4) export sales. Further details can be found in the Supplemental Appendix available at https://my.vanderbilt.edu/joelrodrigue.

[7]To construct the capital stock deflator we weight each price index by the average reported shares of buildings

The second source of data is detailed tariff rates retrieved from the World Trade Organization (WTO). We first focus on the import tariffs charged by the Indonesian government on capital imports to develop a measure of the tariff imposed on capital in Indonesia. Specifically, we retrieve the tariffs on construction, imported machinery, and vehicles. We weight each individual tariff rate proportionally to the average amount of each type of capital used across firms industry-by-industry. The tariff rate on land is set to 0. Aggregating over capital types we construct a single measure of capital import tariffs.

We also examine the the tariff rates which Indonesian exporters face in export markets. Although our firm-level data do not reveal the destination of any given exporter's products we augment our data set by examining industry-level export flows from the UN Comtrade database. In combination with the WTO tariff rates we construct a industry-level trade-weighted measure of the tariffs faced by exporters across export destinations worldwide.

The Indonesian manufacturing sector covers a wide scope of industries which face a very broadly very different tariffs across markets. We choose to focus on two specific industries so that industrial differences do not contaminate our estimates. Specifically, we estimate the structural model using data from the plastic products (ISIC code 356) and fabricated metals (ISIC code 381) industries. We choose these two industries as they represent typical industries in a developing country, but have very different capital-intensity. An second advantage of these industries is that both capital import tariffs and the tariffs faced by these firms in export markets are roughly constant over time, which simplifies the empirical analysis below.

In each industry we follow a balanced panel of continuing firms over time.[8] Our data includes information on export status, inputs and revenues in 1996 which allows us to characterize the

and land, machinery and equipment and fixed vehicle assets, respectively. The depreciation rate, $\bar{\delta}$, varies between 0.117 and 0.118 over the industries we study. These estimates are very close to those reported in Schündeln (2012) who studies depreciation rates among Indonesian manufacturers over a similar period. Our data do contain annual estimates of the firm's holdings of capital stock. However, since these estimates are determined by asking firm managers for the estimated replacement value of existing capital, year to year variation in this capital measure will potentially suffer from severe measurement error over time. To examine this issue we construct a measure for the log error in the capital evolution process

$$\epsilon_{jt}^{k} = \ln(\tilde{k}_{jt+1} - (1-\bar{\delta})\tilde{k}_{jt} - i_{jt}) \tag{2}$$

where $\bar{\delta}$ is the industry-specific average reported depreciation rate reported in the data and $\tilde{k}$ is the year-to-year reported market value of capital. We find that the variance of this error process is often large even within narrowly-defined industries. For example, in the plastics industry the standard deviation of ϵ_{jt}^{k} is 25 percent of the mean value of log capital. Similarly, the standard deviation of ϵ_{jt}^{k} is 31 percent of the mean value of log capital in the fabricated metals industry. Investment data, in contrast, is likely to be measured precisely since the market value of new investment can be obtained directly from purchase receipts. After constructing our series by the perpetual inventory method we compare the constructed distribution of capital with that from the survey data. We find that these are nearly identical in each year.

[8]The plastics industry includes plastic dinnerware, mats, containers, tubes and similar products. The fabricated metals industry includes cutlery, hand tools, hardware, metal furniture, fixtures and like products. Our main samples follow 343 and 302 firms in the plastics and fabricated metals industries between 1990 and 1995, respectively. We stop our sample in 1995 for two reasons. First, the Indonesian manufacturing survey does not report physical investment in 1996. Second, in 1997-1998 the Asian crisis hits Indonesia which greatly altered the nature and composition of exporting and investment in Indonesia.

impact of 1995 decisions on economic outcomes in the following year. 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: Exporting firms invest at a much higher rate relative to non-exporting firms. In particular, new exporters are among the most investment-intensive firms in an industry.

Figure 1 presents the firm-level distribution of investment rates, new investment divided capital stock, in both industries and across export status. In each case the investment rate distributions have a substantial mass at zero, fat tails, and are highly skewed to the right. As in Riano (2011), it is clear that the percentage of exporting firms which are actively investing and the average size of the capital increases are much larger among exporting firms relative to non-exporters. The main features of the investment distributions are summarized in Table 1. In either industry we observe sharp differences between exporters and non-exporters. Consistent with the evidence presented in Rho and Rodrigue (2014) we find that exporters are almost twice as likely to invest in new capital than the average firm and, among those that invest, exporting firms are increasing the size of their capital holdings more than twice as fast. Across first time exporters and incumbent exporters, we observe that new exporters are increasing capital particularly quickly and that export sales are most strongly correlated with investment among new explorers. Notably, we do not observe differences in size, existing capital stock, labour productivity across new and incumbent exporters which are particularly different.[9]

Fact 2: Exit rates among new exporters are very high in the first year after entry, but relatively low in subsequent years.

Table 2 reports the survival rates of exporting firms over time. The first column documents the percentage of period t entrants which continue to export in period $t+1$. Likewise, columns 2, 3 and 4 document the percentage of period t entrants which continue to export in subsequent years. It well known that a large percentage of new exporters exit after 1 year of exporting; in our data, 47 percent of new plastics exporters and 38 percent of new fabricated metals exit after only 1 year. As noted by Ruhl and Willis (2007), standard heterogeneous firm trade models are often characterized by large sunk entry costs. Due to this feature of these models too many new entrants are generally predicted to survive after the first period.

The reason why sunk export costs are estimated to be high can also be rationalized in Table 2. Specifically, while survival is low in the first year after entry, it is much higher in later years. Table 2 shows that while 62 percent of new exporters survive their first year of exporting, among the firms that export in a second consecutive, 83 percent will continue to survive into their third year of exporting. Further, the conditional probability of survival continues to remain high in

[9]A expanded set of summary statistics and documentation of macroeconomic trends are available in the Supplemental Appendix available at: https://my.vanderbilt.edu/joelrodrigue.

every subsequent year. This feature of the data creates internal tension in the model. While incumbent exporters are very likely to survive in export markets (driving estimated sunk costs up), new exporters are not (which should drive estimated sunk costs down).

Models that do not allow firms to become engrained in export markets over time are likely to have difficulty matching this feature of the data. In particular, large (small) sunk costs will allow the model to match the persistence of incumbents exporters are the expense of the persistence of new exporters. A model where firms invest in the to export capacity, however, potentially provides a natural explanation for this observed pattern. Due to costly investment many new exporters will optimally choose to exit export markets after one year due to capacity constraints, while surviving exporters will be firms that invest heavily in new physical capacity and over time become increasingly able to produce for both domestic and foreign consumers.

Fact 3: Domestic revenue growth is relatively low among new exporters. This effect is particularly strong among firms with little growth in existing capital stock.

A series of recent papers document that new exporters demonstrate systematically lower revenue growth relative to comparable non-exporters.[10] We document that this pattern is present in our data as well. However, we add a key caveat: among new exporters who have a large existing capital stock this relationship is significantly weaker. That is, new, capital-intensive exporters face smaller trade-offs across markets. We investigate the role of exporting on domestic revenues by considering a simple OLS regression of log domestic revenues, $\ln r_{jt}^D$, on export status, d_{jt}^X, in first differences

$$\Delta \ln r_{jt}^D = \beta_0 + \beta_1 \Delta d_{jt}^X + \beta_2 \Delta \ln k_{jt} + \beta_3 \Delta (d_{jt}^X \cdot \ln k_{jt}) + \gamma X_{jt} + \epsilon_{jt}$$

where $\ln k_{jt}$ is a measure of the firm's current capital stock, X_{jt} is a matrix of control variables and ϵ_{jt} represents *iid* measurement error. While the coefficient β_1 captures the log point difference between exporting and non-exporting firms, β_3 captures any additional differences across new exporters with large and small capital growth.

Table 3 collects the results from the OLS regression. We find, not surprisingly, that the coefficient on export status is always negative and strongly significant. However, when we interact the change in export status with firm capital, we consistently recover a large, positive and significant coefficient. Our estimates imply that a new exporter in the 90^{th} percentage of the capital growth distribution should expect to observe a 17-19 percent decline in domestic sales upon entry into export markets. For comparison, a new exporter in the 10^{th} percentile of the capital growth distribution should expect domestic sales to fall by 45-55 percent.

Our findings suggest that while new exporters may generally suffer declines in domestic revenue, the magnitude of these declines can lessened through actively expanding firm-level capital

[10] See Soderbery (2014), Vannoorenberghe (2012) and Ahn and McQuoid (2012) for examples.

stock prior to initial entry.[11] Moreover, models without quasi-fixed fixed factors and constant marginal costs, as commonly assumed, will not be able to capture the implicit loss of domestic sales from entering export markets.

Fact 4: Export revenues grow quickly among new exporters if they have sufficient capacity.

It is well-known that export revenues grow quickly among surviving exporters (see Eaton et al., 2014). We find similar patterns in our context; The first row of Table 4 documents annual export sales growth. Specifically, each column documents the average growth in export sales between year $t = 2, 3, 4, 5$ and the benchmark year, $t = 1$, the year of initial entry. We find that export sales grow quickly among surviving exporters. In our data export revenues grow by 73-84 percent on average between the first and second year of exporting. By the fifth year of exporting, the sales of surviving exporters were approximately 250 percent higher than the sales listed by the same firms in their first year of entry into export markets.

Our data suggests that how firms grow into export markets depends both on the evolution of their productivity and capital stock. To demonstrate these differences we first classify firms as having high or low labour productivity and high or low capital at the time of entry into export markets.[12] The second through fifth rows of Table 4 document two key facts. First, within each productivity class, the rate of initial growth is stronger among firms with large capital stocks. This is true despite the fact that firms with larger capital stocks consistently make larger initial entries into export markets and are more likely to survive to the next period. A natural, potential explanation for this finding is that entrants with a small initial capital stock are constrained in their entries into export markets if the capital stock cannot adjust quickly. Five years after entry, this pattern tends to reverse itself. Firms that were initially small are generally found to have grown faster which is consistent with the firm-size and growth literature.[13]

We have argued that adding capital and investment to a standard heterogeneous firms and trade model potentially provides a natural and intuitive explanation for facts 1-4. However, it is unclear how well a quantitative model can replicate these features of the data, which investment frictions are most important for export behaviour, or how the relationship between exporting and investment influence the conclusions drawn from policy experiments. We next develop a model for the express purpose of answering these questions.

[11] Lopez (2009) documents complementary evidence that exporting firms are actively investing prior to entry into export markets.

[12] Specifically, a highly productive new exporter is a firm with labour productivity (revenue per worker) above the median labour productivity among all new exporters. Similarly, a high capital new exporter is a firm with a capital stock which is above the median capital stock among all new exporters.

[13] See Evans (1987) or Hall (1987) for evidence on the relationship between firm size and growth.

2 The Model

We first consider the production and investment environment for each firm. Each firm produces according to a Cobb-Douglas production function $q_{jt} = e^{\omega_{jt}} k_{jt}^{\alpha_k} l_{jt}^{\alpha_l}$ where q is the firm's total production, ω is firm-specific productivity and k and l are firm j's current holdings of capital and variable inputs, respectively. We assume that variable inputs can be freely adjusted each period, but investment in physical capital only becomes productive the year after the initial investment. The "time-to-build" assumption is common in micro-models of firm-level investment (see Caballero, Engel and Haltiwanger (1995) or Cooper and Haltiwanger (2006) for examples), but will be particularly important for firms in our context since they will not be able to immediately adjust to within-period shocks to productivity or demand. We discuss the firm's investment decision in more detail below.

We can write firm j's short-run marginal cost function as:

$$\ln c_{jt} = -\ln \alpha_l - \frac{\alpha_k}{\alpha_l} \ln k_{jt} - \frac{1}{\alpha_l}\omega_{jt} + \ln w_t + \frac{1-\alpha_l}{\alpha_l} \ln q^*_{jt} \tag{3}$$

where w_t is a set of relevant variable input prices and q^*_{jt} is the target, profit-maximizing level of output. Note that if $\alpha_l = 1$ the model exhibits short-run constant marginal costs and the marginal cost function does not depend on target output.[14] Equation (3) implies that firms with larger capital stocks incur lower marginal costs, *ceteris paribus*. Across two equally productive firms, the firm with the larger capital stock will produce at a lower cost and, as such, the firm with the larger capital stock to be more likely to export.

Firms also incur costs when they choose to invest. We write the firm's investment cost function, $C(i_{jt}, k_{jt})$, as

$$C(i_{jt}, k_{jt}) = \psi_0(1+\tau^k)i_{jt} + \psi_1 \left(\frac{i_{jt}}{k_{jt}}\right)^2 k_{jt} + \psi_2 1[i_{jt} > 0] \tag{4}$$

where i_{jt} is the firm-level choice of investment, and ψ_0 and ψ_1 are investment cost parameters capture the convex adjustment costs of investment in Indonesia, and τ^k is the tariff imposed on imported capital in Indonesia. We abstract from changes in tariffs over time since they are nearly constant over the period we study.[15] Last, the indicator function $1[\cdot]$ and ψ_2, which is drawn from the distribution G^{ψ}, capture fixed costs incurred whenever the firm choose to invest. Fixed investment costs represent the need for firm restructuring and are intended to capture indivisibilities in capital, increasing returns to the installation of new capital and increasing

[14] This assumption is common in both theoretical models of heterogeneous firms and trade and empirical applications. See Melitz (2003), Atkeson and Burstein (2010) and Manova (2013) for theoretical models with constant marginal costs and Kasahara and Lapham (2013), Aw, Roberts and Xu (2011), Rodrigue and Soumonni (2011) for examples of empirical models with constant marginal costs.

[15] Tariffs faced in export markets and import tariffs on capital equipment are documented in the Appendix.

returns to retraining and restructuring of production activity. Both convex and non-convex parameters have been found to be important for capturing firm-level investment dynamics in the US (c.f. Cooper and Haltiwanger (2006), Cooper, Haltiwanger and Willis (2010)). However, we are not aware of any work that has attempted to capture the nature of these costs in a developing country context.

We maintain standard assumptions regarding the structure of domestic and export markets (see Melitz (2003) for an example). Both markets are assumed to be monopolistically competitive, but segmented from each other so that firms will not interact strategically across markets. Firm j faces the domestic demand curve q_{jt}^D at home and export demand curve q_{jt}^X abroad:

$$q_{jt}^D = Q_t^D (p_{jt}^D / P_t^D)^\eta = \Phi_t^D (p_{jt}^D)^\eta \qquad q_{jt}^X = Q_t^X (p_{jt}^X / P_t^X)^\eta e^{z_{jt}} = \Phi_t^X (p_{jt}^X)^\eta e^{z_{jt}} \tag{5}$$

where Q_t^D, Q_t^X, P_t^D and P_t^X are the industry aggregate output and price indices, Φ_t^D and Φ_t^X are demand aggregates, η is the (constant) elasticity of demand, p_{jt}^D and p_{jt}^X are the prices chosen in each market and z_{jt} is a shock to firm j's export demand in year t.[16]

Data limitations require a number of assumptions. First, we assume that each firm is a separate organizational entity and that each firm produces a single output which can be sold at home or abroad.[17] Second, there are two sources of short-run cost heterogeneity: differences in firm-level capital stocks and productivity. We allow marginal costs to vary with firm-level output and, as such, demand shocks in one market will affect the static output decision in the other market (and requires us to model revenue and profits in each market jointly).

Firm j decides whether or not to export and sets the price for its output in each market to maximize the discounted sum of domestic and export profits. The optimal domestic market price p_{jt}^D implies that the log of domestic market revenue r_{jt}^D is:

$$\ln r_{jt}^D \quad = \quad -(\eta+1)\lambda[\Gamma_t + \alpha_k \ln k_{jt} - (1-\alpha_l)\ln(1 + (1+\tau^X)^{\eta+1}\Lambda_t^X e^{z_{jt}})d_{jt} + \omega_{jt}] \tag{6}$$

where τ^X is the tariff faced by Indonesian exporters in export markets and λ is a function of the elasticity of substitution and the variable input share parameter, $\lambda = [(\eta+1)\alpha_l - \eta]^{-1}$. The parameters Γ_t and Λ_t^X capture all of the terms which do not vary across firms,

$$\Gamma_t = \alpha_l \ln\left(\frac{\alpha_l \eta w_t}{\eta+1}\right) + \frac{\ln \Phi_t^D}{\eta+1} \qquad \Lambda_t^X = \frac{\Phi_t^X}{\Phi_t^D},$$

where w_t and Λ_t^X capture variable input prices and the relative size of the home and foreign markets, respectively.[18] We define d_{jt} to be a binary choice variable that takes a value of 1

[16]The assumption of firm specific export demand shocks are is common in this literature. This feature allows the model to capture heterogeneity in export intensity across firms.

[17]The first part of this assumption will not be too restrictive. Blalock, Gertler and Levine (2008) report that 95% of the plants in the Indonesian manufacturing census are separate organizational entities.

[18]The coefficient Λ_t^X captures industry-wide variation in export demand.

if the firm exports and zero otherwise. In contrast to standard heterogeneous firms and trade models with constant marginal costs the last term in equation (6) implies that domestic revenue is a function of the firms decision to export if $\alpha_l \neq 1$. Examining this term we see that the assumption of constant marginal costs will be most damaging when firms charge low mark-ups (η is large in absolute value), foreign markets are relatively big (Λ_t^X and z_{jt} are large) and when the absolute value of α_l is far from 1.

Firms that choose to export also earn the revenue from export sales

$$\ln r_{jt}^X = \ln r_{jt}^D + (\eta + 1)\ln(1 + \tau^X) + \ln \Lambda_t^X + z_{jt} \tag{7}$$

which is the export counterpart to the domestic revenue function (6). The export specific demand shock z_{jt} captures the difference in export intensities across exporting firms with similar productivity levels.

Firm-specific productivity captures various sources of heterogeneity, and as such, it is important to interpret their effects cautiously. Specifically, ω_{jt} captures any source of firm-level heterogeneity that affects the firm's revenue in both markets; this may be product quality, for example, but we will refer to it as productivity. Similarly, the export shock captures any sources of firm heterogeneity specific to the export market.[19]

The structure of the model allows us to calculate gross short-run operating profit for both exporters and non-exporters before investment costs are paid as

$$\pi_{jt} \quad = \quad -\left(\frac{1}{\lambda\eta}\right) r_{jt}^D(\Phi_t^D, \Lambda_t^X, \tau^X, k_{jt}, d_{jt}, \omega_{jt}, z_{jt}) \tag{8}$$

Short-run operating profits are implicitly observable with data on revenue in each market and will be important for determining the export and investment decisions developed in the dynamic model below.

2.1 Transition of the State Variables

Consider the evolution of capital stock, productivity, export demand shocks and the state variables Φ_t^D and Λ_t^X over time. The model's "time-to-build" assumption is embedded in the evolution of the firm's capital stock

$$k_{jt} = (1 - \delta)k_{jt-1} + i_{jt-1} \tag{9}$$

[19]Without the export shock the model predicts that all firms with the same productivity level should export the same amount. This prediction is easily rejected in the data. Demidova, Kee and Krishna (2012) and Rodrigue and Soumonni (2011) demonstrate that export demand shocks vary widely across firms and are important determinants of firm-level behaviour. As in the preceding literature we include the export shock to capture this feature of the data.

where i_{jt-1} is the firm's total investment in physical capital in period $t-1$ and δ is the per-period depreciation rate on physical capital.

We assume that productivity evolves over time as a Markov processf:

$$\begin{aligned} \omega_{jt} &= g(\omega_{jt-1}) + \xi_{jt} \\ &= \alpha_0 + \alpha_1 \omega_{jt-1} + \xi_{jt} \end{aligned} \tag{10}$$

The stochastic element of productivity evolution is captured by $\xi_{jt} \sim N(0, \sigma_\xi^2)$. Note that the stochastic element of productivity is carried forward into future periods.[20] We also assume that the export demand shock evolves according to the following first-order Markov-process:

$$z_{jt} = \rho z_{jt-1} + \mu_{jt}$$

where $\mu_{jt} \sim N(0, \sigma_\mu^2)$. The persistence in z captures factors such as the nature of the firm's product, the set of countries they export to, long-term contractual or reputation effects that lead to persistence in the demand for its exports over time. Last, we treat the aggregate state variables $\ln \Phi_t^D$ and $\ln \Lambda_t^X$ as exogenous first-order Markov processes.

2.2 Dynamic Export and Investment Decisions

We next consider the firm's dynamic decisions to export and invest. We assume that the firm first observes the fixed and sunk costs of exporting, γ_{jt}^F and γ_{jt}^S, and decides whether or not to export in the current year. The export costs are assumed to be *iid* draws from the joint distribution G^γ. As documented in Das, Roberts and Tybout (2007), Alessandria and Choi (2013) and Aw, Roberts and Xu (2011) export fixed and sunk cost parameters are often estimated to be large in magnitude and important determinants of firm-level export behavior. After making its export decision, the firm observes the fixed cost of investment this period, ψ_{2jt}, and decides how much to invest in the current year.[21]

Denote the value of firm j in year t before it observes fixed or sunk costs by V_{jt}:

$$\begin{aligned} V_{jt}(s_{jt}) = & \int \max_{d_{jt}} \{ \pi_{jt}(s_{jt}, d_{jt} = 1) - d_{jt-1}\gamma_{jt}^F - (1 - d_{jt-1})\gamma_{jt}^S + V_{jt}^E(s_{jt}), \\ & \pi_{jt}(s_{jt}, d_{jt} = 0) + V_{jt}^N(s_{jt}) \} dG^\gamma \end{aligned} \tag{11}$$

where $s_{jt} = (\omega_{jt}, z_{jt}, k_{jt}, d_{jt-1}, \Phi_t^D, \Lambda_t^X, \tau^k, \tau^X)$ is a vector of state variables, and V_{jt}^E and V_{jt}^N are the value of an exporting or non-exporting firm, respectively, after it makes its optimal investment decision. Note that if the firm chooses to export, we allow for the possibility that

[20] We have also tried including a learning-by-exporting term in this equation. However, since it was never estimated to be significantly different from zero, we chose to remove it from the model.

[21] An alternative assumption is that the export and investment decisions are made simultaneously. While this leads to a similar model, the computational difficulty of estimating this model is substantially greater.

fixed cost associated with initial entry γ_{jt}^S may be drawn from a different distribution than those for subsequent entries, γ_{jt}^F.

The value of investment can in turn be characterized as:

$$V_{jt}^E(s_{jt}) = \int \max_{i_{jt}} \{\beta E_t V_{jt+1}(s_{jt+1}|d_{jt} = 1, i_{jt}) - C(i_{jt}, k_{jt})\} dG^{\psi}$$

for exporting firms and

$$V_{jt}^N(s_{jt}) = \int \max_{i_{jt}} \{\beta E_t V_{jt+1}(s_{jt+1}|d_{jt} = 0, i_{jt}) - C(i_{jt}, k_{jt})\} dG^{\psi}$$

for non-exporting firms where β is the discount factor, $C(i_{jt}, k_{jt})$ captures both the convex and non-convex costs of capital adjustment in (4), and the firm's expected value is

$$E_t V_{jt+1}(s_{jt+1}|d_{jt}, i_{jt}) = \int_{\Phi^{D\prime}} \int_{\Lambda^{X\prime}} \int_{z'} \int_{\omega'} V_{jt+1}(s') dF(\omega'|\omega_{jt}, d_{jt}) dF(z'|z_{jt}) \\ dG(\Lambda^{X\prime}|\Lambda_t^X) dG(\Phi^{D\prime}|\Phi_t^D)$$

If the firm does not choose to invest ($i_{jt} = 0$) we would expect the firm's capital stock to fall and the firm's marginal costs of production to rise next period. Conversely, if the firm invests enough to increase its capital stock in period $t + 1$ the firm's marginal costs will fall. The first-order condition for the investment decisions for either exporters or non-exporters can be written as

$$\psi_0(1 + \tau^k) + 2\psi_1 \left(\frac{i_{jt}}{k_{jt}}\right) = \beta E_t \frac{\partial V_{jt+1}(s_{jt+1}|d_{jt}, i_{jt})}{\partial i_{jt}} \tag{12}$$

The left side of (12) is the marginal cost of adjustment and is independent of the firm's export decision or history.[22] The right side is the expected marginal gain and includes the effects on both the intensive (the amount of investment) and extensive margins (whether to invest or not).[23] The expected marginal gain from investment clearly depends on the firm's export decision. By entering export markets, firms raise the marginal value of capital and in turn encourage greater investment. Note, however, that if the firm initially carried a small capital stock, as many new exporters do, it is unlikely that they will optimally choose to jump immediately to a new larger capital stock due to convex adjustment costs.[24] Rather we would expect that small exporters

[22] While it is conceivable that firms with longer export histories may be able to secure cheaper credit for investment we do not consider this possibility here.

[23] The RHS of (12) ignores the effects of i_{jt} on the probability of adjustment since the effect of capital adjustment on the probability of adjustment is evaluated just at a point of indifference between adjusting and not adjusting. For each i_{jt} there are values of ω_{jt} which bound adjustment and non-adjustment. Variation in i_{jt} does influence these boundaries, but since the boundaries are points of indifference between adjustment and non-adjustment, there is no further effect on the value of the objective function. See Cooper, Haltiwanger and Willis (2010) for further discussion.

[24] While it is beyond the scope of this paper to detail all of these patterns across heterogeneous firms and

will optimally choose to expand their capital holdings over several years.

Similarly, the net benefit to exporting, conditional on investment, can be described by the value functions. We can write the marginal benefit from starting to export, MBE, for any firm as:

$$\begin{aligned} MBE_{jt} &= \underbrace{\pi_{jt}(s_{jt}, d_{jt}=1) - \pi_{jt}(s_{jt}, d_{jt}=0) - d_{jt-1}\gamma_{jt}^{F} - (1-d_{jt-1})\gamma_{jt}^{S}}_{\text{Initial Gain/Loss}} \\ &\quad + \underbrace{V_{jt}^{E}(s_{jt}) - V_{jt}^{D}(s_{jt})}_{\text{Future Gain/Loss}} \end{aligned} \tag{13}$$

It is often assumed that firms incur initial losses on export decisions due to large sunk costs associated with entering those markets. These decisions are nonetheless justified by a large enough stream of future export sales. Here, we allow that the export decision may affect the initial gain (or loss) through sunk costs, investment costs and forgone domestic sales. Conversely, equation (13) suggests that firms with large capital stocks that suffer a fall in demand on the domestic market (measured as a fall in productivity here), may find it optimal to enter export markets given their excess capacity.

3 Structural Estimation

3.1 Firm-Level Productivity and Marginal Costs

It is well-known that firm-level productivity is an important determinant of export and investment decisions and, as such, it is important that we recover reliable estimates of each firm's productivity series. We begin by first estimating the relationship between total revenues and total variable costs. Since optimal prices in this environment can be expressed as a mark-up over the firm's marginal cost we can multiply both sides of the pricing equation by total quantity sold to reveal the following relationship between revenues, r_{jt}, and total variable costs, v_{jt}:

$$\begin{aligned} v_{jt} &= \alpha_l q_{jt} c_{jt} \\ &= \alpha_l \left(1 + \frac{1}{\eta}\right) r_{jt} + \varepsilon_{jt} = \beta r_{jt} + \varepsilon_{jt} \end{aligned} \tag{14}$$

where the error term ε_{it} captures measurement error in total variable cost and α_l captures the share of variable inputs in production. In our data we use the sum of total wages, intermediate material costs and energy expenditures as a measure of total variable costs.

With this estimate in hand, we proceed to estimate firm-level productivity. Recall that the

industries, we refer the interested reader to Rho and Rodrigue (2014) for further broad, reduced-form evidence on the nature of capital holdings among new exporters over time.

domestic revenue function is

$$\ln r_{jt}^D \;=\; -(\eta+1)\lambda[\Gamma_t + \alpha_k \ln k_{jt} - (1-\alpha_l)\ln(1+(1+\tau^X)^{\eta+1}\Lambda_t^X e^{z_{jt}})d_{jt} + \omega_{jt}] + u_{jt}$$

where we have added an *iid* error term to equation (6). Using our definition of λ and the estimate of β from equation (14) we can rewrite the composite error term as[25]

$$-\frac{1}{\alpha_l}\left(\frac{\beta}{\beta-1}\right)\left(\omega_{jt} - \left(1-\alpha_l\right)\ln(1+(1+\tau^X)^{\eta+1}\Lambda_t^X e^{z_{jt}})d_{jt}\right) + u_{jt}$$

Here the composite error includes both an *iid* component and two firm-specific, time varying components: productivity and export-demand. As in Olley and Pakes (1996) and Levinsohn and Petrin (2003) we note that input demand is an increasing function of either unobservable and rewrite unobserved productivity and export demand components as a non-parametric function of observables that are correlated with them. A key difference, and challenge, in our context is that we have two unobserved components to separately identify. We use firm-level material, m_{jt}, and electricity, n_{jt}, demand as proxies for productivity and export demand and rewrite domestic revenue as

$$\begin{aligned}\ln r_{jt}^D &= \varrho_0 + \sum_{t=1}^{T}\varrho_t D_t - \frac{1}{\alpha_l}\left(\frac{\beta}{\beta-1}\right)\Big[\alpha_k \ln k_{jt} - (1-\alpha_l)\ln(1+(1+\tau^X)^{\eta+1}\Lambda_t^X e^{z_{jt}})d_{jt} \\ &\quad +\omega_{jt}\Big] + u_{jt} \\ &= \varrho_0 + \sum_{t=1}^{T}\varrho_t D_t + f(k_{jt}, m_{jt}, n_{jt}) + v_{it} \qquad (15)\end{aligned}$$

where ϱ_0 is a constant, D_t is a set of year dummies and we approximate $f(\cdot)$ by a fourth order polynomial of its arguments. The essence of the above method is that the function $f(\cdot)$ captures the combined effects of capital, productivity and export demand on domestic revenue.

We first estimate (15) by OLS, recover an estimate of the composite term, $\hat{\varphi}_{jt}$ and construct a productivity series for each firm. Specifically, fitted value of the $f(\cdot)$, $\hat{\varphi}_{it}$, captures

$$\frac{1}{\alpha_l}\left(\frac{\beta}{\beta-1}\right)\left(\left(1-\alpha_l\right)\ln(1+(1+\tau^X)^{\eta+1}\Lambda_t^X e^{z_{jt}})d_{jt} - \omega_{jt} - a_k \ln k_{jt}\right) \qquad (16)$$

which is a function of capital, productivity and export demand. Inserting φ_{jt} into (10) we can

[25] To see this recall that $\eta = \alpha_l/(\beta-\alpha_l)$ and insert this into $(\eta+1)\lambda = (\eta+1)/[(\eta+1)\alpha_l - \eta]$.

write the following equation of the capital, export demand and the composite residual

$$\begin{aligned}\hat{\varphi}^*_{jt} &= \frac{\alpha_0}{\alpha_l} + \frac{\alpha_k}{\alpha_l}\ln k_{jt} - \frac{1-\alpha_l}{\alpha_l}\ln(1+(1+\tau^X)^{\eta+1}\Lambda^X_t e^{z_{jt}})d_{jt} \\ &+\alpha_1\left(\hat{\varphi}^*_{jt-1} - \frac{\alpha_k}{\alpha_l}\ln k_{jt-1} - \frac{1-\alpha_l}{\alpha_l}\ln(1+(1+\tau^X)^{\eta+1}\Lambda^X_t e^{z_{jt-1}})d_{jt-1}\right) + \xi_{jt} \quad (17)\end{aligned}$$

where the asterisk indicates that the variable is scaled by $\beta/(\beta-1)$.

We cannot yet take equation (17) to the data since we will not be able to identify the parameters of the productivity process without knowledge of the unobservable z_{jt} or the parameters Λ^X_t and η whenever the firm chooses to export. Fortunately, equation (7) suggests that we can rewrite the unobserved export demand shock as of the observed firm-level export intensity in years the firm chooses to export

$$z_{jt} = \ln\left(\frac{r^X_{jt}}{r^D_{jt}}\right) - \ln\Lambda^X_t - (\eta+1)\ln(1+\tau^X) \Rightarrow \hat{z}_{jt} \equiv \ln(1+(1+\tau^X)^{\eta+1}\Lambda^X_t e^{z_{jt}})d_{jt} = \ln\left(\frac{r^T_{jt}}{r^D_{jt}}\right) \quad (18)$$

where $r^T_{jt} = r^D_{jt} + r^X_{jt}$. An advantage of our method is that we can construct $\hat{z}_{jt}$ for both exporters and non-exporters since the theoretical export intensity term in the productivity equation, $\ln(1+(1+\tau^X)^{\eta+1}\Lambda^X_t e^{z_{jt}})d_{jt}$, always takes a value of 0 whenever the firm does not export (regardless of the value of z_{jt}). A second concern may arise from the fact that $\hat{z}_{jt}$ is a function of the error term u_{jt} in equation (15). However, our data reports the total value of sales r^T_{jt} and percentage of sales from exports, θ_X from which we construct domestic and export revenues. As such, any log linear measurement error is total sales will be proportional to the measurement error in domestic sales.[26] Substituting equation (18) into equation (17) we can then write the estimating equation as

$$\begin{aligned}\hat{\varphi}^*_{jt} &= \frac{\alpha_0}{\alpha_l} + \frac{\alpha_k}{\alpha_l}\ln k_{jt} - \frac{1-\alpha_l}{\alpha_l}\hat{z}_{jt} + \alpha_1\left(\hat{\varphi}^*_{jt-1} - \frac{\alpha_k}{\alpha_l}\ln k_{jt-1} - \frac{1-\alpha_l}{\alpha_l}\ \hat{z}_{jt-1}\right) \\ &+\xi_{jt} \quad (19)\end{aligned}$$

To estimate the productivity process we will also need the following relatively mild assumptions:

Assumption 1

The firm makes its export decision before hiring variable inputs.

Assumption 2

There are no period-to-period adjustment costs in variable inputs.

[26] Specifically, let $\tilde{r}^T_{jt}$ represent the true value of total sales so that our observed value is then $r^T_{jt} = \tilde{r}^T_{jt}e^{\tilde{u}_{jt}}$ and $\tilde{u}_{jt}$ is an *iid* error term. Since $r^D_{jt} = \theta_X r^T_{jt} = \theta_X \tilde{r}^T_{jt}e^{\tilde{u}_{jt}}$ (or alternatively since $u_{jt} = \ln(\theta_X) + \tilde{u}_{jt}$), it follows that the ratio of $r^T_{jt}/r^X_{jt} = \theta_X^{-1}$ and $\hat{z}_{jt}$ is independent of $\tilde{u}_{jt}$.

Under these conditions we can write the input demand function for materials or electricity as

$$\begin{aligned} m_{jt} &= m_t(k_{jt}, \omega_{jt}, \hat{z}_{jt}) \\ n_{jt} &= n_t(k_{jt}, \omega_{jt}, \hat{z}_{jt}) \end{aligned} \tag{20}$$

where the appropriate value for $\hat{z}_{jt}$ is always zero among non-exporters. This is a key feature of our method since we do not observe any information on export revenues, or export shocks, in years when the firm does not export. Among non-exporters relative variation in *static* inputs will reflect differences in productivity and dynamic inputs, such as capital. Because of this the inverted input demand among non-exporters is a bijection in productivity. It is generally not true that input demand is a bijection in productivity alone among exporting firms and, as such, we need to condition on the size of export demand shock in order to isolate productivity.[27]

Our approach is similar to that in Demidova, Kee and Krishna (2012) who use an investment proxy combined with measurements of export intensity to control for export demand shocks when estimating a productivity series among Bangledeshi garment manufacturers. In their model (as in ours) the investment policy function will depend on the export demand shock, even among non-exporters.[28] Unfortunately, most firms in our data do not export and their method is invalid if we do not observe export sales for all firms in the data.[29] Since static input demand should only reflect the firm's current export decision, our approach, though similar, is much less demanding of the firm-level data and more appropriate to our economic environment.[30]

Clearly, estimating equation (19) by non-linear least squares will potentially suffer from endogeneity bias since the current decision to export and $\hat{z}_{jt}$ are functions of firm-level productivity. As such, we follow Ackerberg, Caves and Frazer (2006) and form the twelve moments to obtain our estimates of the production function and productivity process. In particular, we assume that $E[\xi_{jt}|X_{jt}] = 0$ where $X_{jt} = [k_{jt}, k_{jt}^2, k_{jt}^3, k_{jt-1}, k_{jt-1}^2, k_{jt-1}^3, \hat{z}_{jt-1}, \hat{z}_{jt-1}^2, \hat{z}_{jt-1}^3, \hat{\varphi}_{jt-1}^*, \hat{\varphi}_{jt-1}^{*2}, \hat{\varphi}_{jt-1}^{*3}]$.

We estimate equation (19) by GMM and recover the parameters governing the evolution of productivity and the shape of the marginal cost function. Using these parameters we construct

[27] As in cited papers above we are implicitly assuming that firms can observe, or reliably forecast, the export demand shock.

[28] Intuitively, the investment policy function will reflect the firm's export prospects over time and is a function of z_{jt}.

[29] As noted in Demidova, Kee and Krishna (2012) productivity series cannot be determined if there are zero values in investment or export sales. While these observations are rarely zero in their data, our data is similar to many other firm-level data sets where we often observe zero values. For example, approximately 10 percent of firms report positive export sales in either industry. See Levinsohn and Petrin (2003) for further discussion of the role of zero values in a similar context.

[30] A second interesting feature of our method relates to the fact that we identify the shape of the marginal cost function off of firm-level entry behavior into export markets. This is in sharp contrast to much of the preceding literature which estimates production or cost functions using data on firm inputs and total output alone. Our method, though closely related to preceding control-function exercises, provides an alternative identification strategy relative to the current literature.

an estimated productivity series for each firm $\omega_j = (\omega_{j0}, ...\omega_{jT})$ where

$$\omega_{jt} = \frac{(1-\beta)\alpha_l}{\beta}\hat{\varphi}^*_{jt} + (1-\alpha_l)\hat{z}_{jt} - \alpha_k \ln k_{jt}. \tag{21}$$

Note the productivity measure is increasing in measured export intensity, $\hat{z}_{jt}$, and decreasing in capital stock, k. The implication is that if two firms have the same level of domestic sales and the same capital stock (export sales), but one has larger export sales (capital stock), then this firm must be more (less) productive.

3.2 Investment and Export Parameters

We estimate the remaining 8 model parameters by the indirect inference method of Gourieroux et al. (1993) and Smith (1993). Our objective is to estimate the vector of structural parameters, $\theta = (\psi_0, \psi_1, \psi_2, \gamma^F, \gamma^S, \Lambda^X, \rho, \sigma_\mu)$, by matching a set of simulated statistics, μ_s, with a corresponding set of statistics derived from the data, μ_d. The remaining structural parameters correspond to the investment cost function parameters, the export cost parameters, the export market size parameter and the parameters governing the evolution of the firm-specific export demand shocks. Since Φ_t^D and Λ_t^X were almost always nearly constant over years we restricted these parameters to be the same in all years, $\Phi_t^D = \Phi^D$ and $\Lambda_t^X = \Lambda^X$, so as to simplify the estimation routines. We also set the discount factor in the Bellman's equation $\tilde{\beta}$ to 0.95 and omit it from the estimation routine.

The estimated structural parameters are those that minimize the weighted average distance between the simulated statistics and the statistics from the data. Intuitively, since the set of simulated statistics rely on the underlying structural parameters, minimizing the distance between the simulated and actual statistics provides consistent estimates of the structural parameters under mild conditions. The indirect estimator θ is defined as the solution to the minimization of

$$\hat{\theta} = \arg\min_{\theta} \, [\mu_d - \bar{\mu}_s(\theta)]'\hat{W}[\mu_d - \bar{\mu}_s(\theta)]$$

where $\bar{\mu}_s(\theta) = \frac{1}{S}\sum_{n=1}^{S} \mu_{sn}(\theta)$, $n = 1, ..., S$ is an index of simulations and W is a weighting matrix. We use the inverse of the covariance matrix of the data moments for the weighting matrix where the covariance matrix is computed by bootstrapping over firms (with replacement) in 1000 separate bootstrap samples. Since $\bar{\mu}_s(\theta)$ is not analytically tractable the minimization is performed using numerical techniques. Given the discretization of the state space and the potential for discontinuities in the model, we use a simulated annealing algorithm to perform the optimization.[31]

The statistics we match are listed in Tables 7 and 8. They include both OLS regression coefficients and summary statistics from the data. The first four moments are chosen to capture

[31] We follow An and Liu (2000) to control for initial conditions in the panel data.

basic features of investment and export behavior in the data. In particular, the first moment captures the average number of firms which actively invest in any year while the second is the mean investment rate in the data. Analogously, moments three to six include the mean frequency of exporting, the fraction of current exporters who exported in the previous year, the mean level of export sales among firms who export and the variance of log export intensity among exporting firms.[32]

The second set of statistics are comprised of regression coefficients from 3 separate OLS regressions:

$$\frac{i_{jt}}{k_{jt}} = \varrho_0 + \varrho_1 \omega_{jt} + \varrho_2 d_{jt} + \nu_{jt}^k \tag{22}$$

$$\omega_{jt} = \varsigma_0 + \varsigma_1 d_{jt} + \nu_{jt}^x \tag{23}$$

$$\tilde{z}_{jt} = \vartheta_0 + \vartheta_1 z_{jt-1} + \nu_{jt}^z \tag{24}$$

where $\tilde{z}_{jt} = \ln(r_{jt}^T / r_{jt}^D)$.[33] The variable $\tilde{z}_{jt}$ captures export intensity at the firm-level and corresponds to export intensity term in the firm's revenue equations $\tilde{z} \equiv \ln(1+(1+\tau^X)^{\eta+1}\Lambda_t^X e^{z_{jt}})d_{jt}$.

The first equation (22) captures the relationship between investment, productivity and exporting. The second equation (23) captures the average productivity level in the data and the mean productivity difference between exporters and non-exporters in the data. Even though we have already estimated the parameters of the productivity process, this regression is useful in disciplining the model's export and investment behaviour. In particular, the magnitude of the export and investment costs determine the distribution of exporters and, thereby, the observed productivity difference between exporters and non-exporters in any period. The third equation (24) captures the persistence in export intensity which is inherently tied to the persistence export demand in the model. Our model suggests that each firm will receive an export shock in each year, regardless of its export decision. Naturally, we only observe information on export shocks in years when a firm chooses to export. However, given a set of parameter estimates it is straightforward to simulate export demand shocks for each firm. We then use these shocks in simulating the model, constructing the simulated $\tilde{z}_{jt}$ measures for each firm and evaluating equation (24) on the simulated data.

As noted above, the frequency of investment and the investment rate and among investing firms is higher in the fabricated metals industry. Most of the export statistics are very similar across industries with the exceptions of the persistence in export status and the level of export intensity which are slightly higher in the plastic products industry. In both industries exporting firms are associated with higher investment and productivity.

[32]Export intensity is measured as the ratio of export sales to domestic sales.

[33]Recall that r_{jt}^T is the firm's total revenues, $r_{jt}^T = r_{jt}^D + r_{jt}^X$. Also, we originally included a second order productivity term, ω_{jt}^2, in equation (22). Since it was always imprecisely estimated we dropped it from our specification.

Estimating the model requires the discretization of the state space. We follow Rust (1997) to discretize the state space for the unobserved state variables ω_{jt} and z_{jt} using a 100 (low-descrepancy) random grid points. We discretize capital stock with 50 fixed grid points over the distribution of capital.[34]

4 Results

4.1 Mark-Ups, Productivity and Marginal Costs

The first-stage parameter estimates governing mark-ups, the shape of the marginal cost function and the evolution of productivity are reported in Table 5. Both industries are estimated to have nearly long-run constant returns to scale in production; the *sum* of the share parameters α_k and α_l ranges between 0.86 and 0.87 across industries. Nonetheless, if capital is a quasi-fixed factor in the short-run the estimates suggest that we should expect both industries to treat shocks in a manner that reflects strongly increasing marginal costs in the short-run. This is particularly true in the plastics industry where the capital share, α_k, is relatively large and the variable input share, α_l, is relatively small.

The estimated parameter $\hat{\beta}$ is a function of both the market elasticity and the variable input share. Together they imply that the elasticity of demand in the fabricated metals industry $\eta = \alpha_l/(\beta - \alpha_l) = -14.64$ while the mark-up is estimated to be $-1/(\eta+1) = 0.07$. Similarly, the implied elasticity parameter and mark-up are -5.8 and 0.21 in the plastic products industries.[35] In both industries productivity is estimated to be highly persistent across firms. As such, we expect that highly productive firms are able to gain substantially from export sales and will have a strong incentive to invest in new physical capital as they expand into export markets.

For comparison, we fix $\alpha_l = 1$ and repeat estimation exercise described in Section 3.1 under the assumption that marginal costs are constant in the short-run.[36] Many model parameters are different; the capital share parameter and the estimated variance of the productivity shock process are much larger than before. Examining equation (19) it is straightforward to see why we recover these results. Suppose initially that all firms are non-exporters (so that $d_{jt} = d_{jt-1} = 0$)

[34] Capital grid points are the mean capital level within every two percentiles of the capital distribution. The capital grid size is chosen in this fashion to minimize computational requirements while allowing for depreciation to affect that firm's decisions. For instance, if the capital grid points are chosen too coarsely it is possible that a firm will almost always remain in the capital bin even if they don't invest anything. Naturally, this would broadly bias the results. We find that with 50 capital grid points fixed as above depreciation will lead firms to move to a lower capital grid point if they choose not to invest.

[35] These are well within the estimated range of mark-ups for manufacturing industries. See De Loecker and Warzynski (2012) for an example.

[36] Strictly speaking for this exercise to be valid in this context we also need the additional assumption that the productivity term does not affect all inputs in a strictly Hicks neutral fashion as in Section 1. Only in this case will the relative variation in inputs contain information of productivity separate from the export demand shock. Nonetheless, this particular set of assumptions is not uncommon in the literature. See Aw, Roberts and Xu (2011) or Rodrigue and Soumonni (2014) for examples.

and that recall that our estimate of $\hat{\varphi}_t^*$ is invariant to our assumption about the value of α_l. Assuming that $\alpha_l = 1$ would not change the variables in the estimating equation, only their interpretation. In fact, by overestimating α_l, which is in the denominator of the first two terms, we also cause α_k to be overestimated.

Of course, some firms do export and, as such, the estimates are likely to suffer from omitted variable bias. However, since only 10 percent of firms export in either industry it is plausible that the bias in the point estimates may be small. In fact, when we examine the plastic products industry we observe that estimated coefficient capital in column (2), $\alpha_k = 0.660$ ($\alpha_l = 1$), is very similar to the capital coefficient divided by the variable input coefficient in column (3), $\alpha_k/\alpha_l = 0.347/0.513 = 0.676$ as our model would predict. Similarly, in the fabricated metals industry we observe that in column (4) the capital share coefficient under the constant marginal cost assumption is $\alpha_k = 0.130$, while the ratio of the capital share parameter to the labour share parameter in column (3) is $\alpha_k/\alpha_l = 0.090/0.776 = 0.116$. Simply accounting for increasing marginal costs explains the majority of the estimated differences across models.

Similarly, by incorrectly assuming that $\alpha_l = 1$, the predicted residual in equation (19) will include variation from both the productivity error term, ξ_{jt}, but also the export demand shocks among exporting firms, $\ln \hat{z}_{jt}$. As long as these are not perfectly correlated with each other our model predicts the increase we observe across models.

This difference is not just a matter of empirical interest, but also has important economic consequences. For instance, the omission of the export intensity term, $\hat{z}_{jt}$, in the productivity series (21) implies that any estimate of productivity is likely to be biased downwards among exporting firms.[37] We examine this issue by regressing productivity on the log of capital and an export status dummy variable for productivity estimates from both the increasing and constant marginal cost models:

$$\omega_{jt} = \beta_0 + \beta_1 \ln k_{jt} + \beta_2 d_{jt} + \Gamma_t + \varepsilon_{jt} \tag{25}$$

where Γ_t is a year-specific dummy variable. We find that exporter productivity premium, β_2, is underestimated by 14 and 15 percent in the fabricated metals and plastic products industries, respectively.[38]

4.2 Export Market Size, Export Costs and Investment Costs

The remaining structural parameters, estimated by indirect inference, are presented in first column of Table 6 (labelled "Model 1"). To fully illustrate the impact of omitting the dynamic

[37] A natural analogy exists among less structural estimates of productivity. For instance, numerous models suggest that the distribution of productivity is closely tied to the distribution of domestic revenue across firms (e.g. Eaton, Kortum and Kramarz (2011)). However, if domestic revenue tends to fall in the initial years of export entry because of quasi-fixed factors such as capital, exporting firms will appear smaller and less productive than they would have otherwise.

[38] Full results available upon request. All coefficients are significant at the 5 percent level. See Arkolakis (2010) for an example of a model where most new exporters are both small and unproductive.

capital adjustment process on models of heterogeneous firms and trade we also repeat the second stage estimation exercise in four restricted models. First, we re-estimate the model without convex adjustment costs ($\psi_1 = 0$, "Model 2"). In this case, firms do not pay increasingly high costs for larger investments, but are still subject to non-convex adjustment costs. In the second case, we set both the convex and non-convex adjustment cost parameters to zero ($\psi_1 = \psi_2 = 0$, "Model 3"), but continue to allow firms to choose investment and capital over time. Third, we consider an environment without capital dynamics or investment costs. Importantly, firms are still subject to increasing marginal costs and that capital is fixed over time ("Model 4"). These restrictions create an environment similar to those in Ruhl and Willis (2007), with the exception that we allow firms to receive firm-specific export demand shocks. Last, we repeat this exercise assuming that the firm faces a constant marginal cost function in the short-run as in Das, Roberts and Tybout (1997). To be consistent we use the first-stage estimates and productivity series generated under the same assumption.

The first two parameters of Table 6 capture the estimated fixed and sunk export costs, while parameters 3, 4 and 5 characterize the variable and fixed investment costs. The last three parameters capture the persistence of export demand shocks, the variation in export demand shocks and the relative size of the export market, respectively. Casual observation indicates that there are very large differences in the cost parameters across models. However, the parameters themselves are somewhat difficult to interpret since it is not inherently obvious how export costs are relative to the profits of a typical exporter. To facilitate our interpretation across models, we also report the size of the cost parameters relative to the profits of the median exporter, as defined in equation (8), in Table 7. For variable investment cost parameters (ψ_0, ψ_1) we likewise evaluate them at the median investment rate.[39]

Consider first the sunk and fixed costs of exporting, which have received substantial attention in the firm-level trade literature. The work horse model of firm-level exporting with constant marginal costs (Model 5) predicts very large sunk entry costs to export markets; the parameter γ_S implies that the mean sunk cost draw accounts for at 6 to 7 times the median exporter's annual profits. Clearly, the sunk cost draws implied by this model are significant deterrent to new entry into export markets. As such, new exporters will typically only enter export markets if they are very productive or if they are fortunate to draw very small sunk export costs relative to the average draw. Allowing for tradeoffs across markets, though increasing marginal costs, substantially reduces the estimates of sunk export entry costs. Across industries, sunk entry costs represent only 52-69 percent of the median exporter's annual profits in Model 4. The intuition for this large decline in entry costs can be attributed to the fact capacity constrained exporters benefit much less from exporting since any gains made in the export market are at least partially offset by losses in the domestic market. While Model 4 suggests that allowing for

[39]It is straightforward to alternatively interpret these coefficients in terms of firm-level revenues since operating profits are equal to $-(\lambda\eta)^{-1}$ times firm revenues.

increasing marginal costs may substantially alter the nature of firm entry into export markets, it is important to remember that in this model we have completely restricted firms from investing in new capital and increasing capacity over time. In this sense, the decline in entry cost suggested by Model 4 may be overstated.

In fact, in Model 3 when we introduce capital, but do not allow for convex or fixed investment costs, we find that the estimated model predicts sunk entry costs which are nearly as large as those in the workhorse model (Model 5). If it is not too costly to quickly increase firm capacity, then the increasing marginal cost model behaves much more like the constant marginal cost model and, as such, requires larger sunk costs to fit the data. The model with convex adjustment costs (Model 2) or the model with both convex and fixed investment costs (Model 1) return estimates which are even smaller than those from the model increasing marginal costs, but no capital adjustment (Model 4). Across industries, the sunk export entry cost draw represents only 7-12 percent of the median exporter's annual profits in Models 1 and 2. The convex adjustment costs discourage firms from adjusting capital too quickly. Because of this new exporters are likely to remain capacity constrained for a number of years after initial entry. This, in turn, pushes down the estimates of sunk entry costs. Finally, by increasing the costs associated with future exporting (though higher investment), the estimates of sunk entry costs decline even further.

The fixed export cost parameter is similarly small in Models 1, 2 and 4, but estimated to be relatively large in Models 3 and 5. The fixed export costs largely help pin down the productivity difference between exporting and non-exporting firms. There are two forces at work here. On one hand, the productivity difference between exporters and non-exporters is greater under models with increasing marginal costs. This will tend to inflate fixed export costs in order to keep too many low productivity firms from entering export markets. On the other hand, the return from exporting is smaller since marginal costs increase with production, at least in the short-run. Our results suggest that this second effect dominates the first. Across industries fixed export costs account for at most 12 percent of the median exporter's annual profits in Models 1, 2 and 4, but rises to at least 57 percent in models 3 and 5.

The investment cost parameters (ψ_0, ψ_1, ψ_2) imply that investment is quite costly in the plastics industry, but the nature of these costs also depend heavily on model specification. The parameters (ψ_0, ψ_1) which determine the intensive margin of investment level, conditional on positive investment, suggest that this portion of investment costs are comparable to nearly 36 percent an the median exporter's annual profits. The average fixed investment cost draw is equivalent to nearly 4 percent of the median exporter's annual profits. Restricting some investment parameters to be zero not only inflates the size of the remaining parameters in Models 2 and 3, but also causes the overall expected cost of investment to rise for the median investor in the data. For the median investor, ψ_0 captures approximately 47 and 169 percent of the median exporter's annual revenue in Models 2 and 3, respectively. In contrast, the fixed investment cost parameter only grows to 3.8 (from 3.7) percent of the median investor's annual revenue between Models 1 and 2 when ψ_1 is set to 0.[40]

The estimates from the fabricated metals industry follow an identical qualitative pattern across models but are substantially smaller across all models. In Models 1 and 2 suggest that parameters (ψ_0, ψ_1) account for at most 1 percent of the median investor's annual revenue, while the fixed investment cost ψ_2 is always estimated to account for less than one percent of the median exporter's annual revenue. In contrast, ψ_0 represents 76 percent of the median exporter's revenue in Model 3. The reason the estimates are so much larger in Model 3 is due to the fact that the estimation routine tries to simultaneously match the frequency and magnitude of investment across manufacturing firms in Indonesia. When ψ_1 is set to 0 there is more incentive for firms to make large investments and, to match the data, the parameter ψ_0 increases. Likewise, when the fixed investment cost parameter is set to zero our firms have a greater incentive to invest frequently, which also contradicts key features of the investment data. In order to reduce the frequency of investment, ψ_0 is pushed up even more.

The last three parameters in Table 6, ρ, σ_μ and $\ln \Lambda^X$, capture the persistence of export demand shocks, the variation in export demand shocks and the relative size of the export market, respectively. Intuitively, the first two are identified by variation in export intensity conditional on capital stock and productivity, while the third is pinned down by the average size of export revenues relative to domestic revenues. Across models there is substantial persistence in export demand and relatively large export demand shocks across firms.[41] Export markets are generally much smaller than domestic markets; across models the size of export markets are estimated to represent 30-41 percent of total sales among fabricated metals exporters and 30-38 percent of total sales among plastics exporters.[42]

Although it is clear the capital adjustment process significantly affects the estimates of a number of key parameters, it is not obvious to what extent each model fits the data. Moreover, the estimates themselves do not provide a clear indication of the economic significance of the change in the model's dynamics. We turn to these issues next.

4.3 Model Performance

We simulate all five models to assess their predictive ability relative to the observed empirical patterns exporting, investment and productivity. We take each firm's initial year status

[40] Although the above results suggest that investment is relatively costly in Indonesia, there are at least two reasons that this result is arguably reasonable. First, it is well established that access to credit markets is particularly limited among small producers in developing countries. Second, as suggested by Cooper and Haltiwanger (2006) new investment entails costly disruptions to firm production. Among US producers they estimate that these costs may be as much as 20 percent of total profits. In our context, we observe that among those who invest, they tend invest at a much higher rate. Larger investments, in combination with a weaker institutional environment, are likely to entail much larger disruption costs.

[41] As documented in Demidova, Kee and Krishna (2012) and Rodrigue and Soumonni (2014) export demand shocks vary widely across firms and can be key determinants of export behavior.

[42] The data suggests that the average percentage of total sales from exports among exporting firms is approximately 38 percent in either industry.

$(\omega_{j1}, z_{j1}, k_{j1}, d_{j1})$ in our data as given and simulate the following 5 years' productivity shocks ω_{it}, export demand shocks z_{it}, export costs γ^F, γ^S and fixed investment costs ψ_1. We repeat the simulation exercise 100 times for each firm and report the average of these simulations.

4.3.1 Estimated Investment and Export Moments

The first set of moments we consider are those used to estimate the model. Tables 8 and 9 demonstrate that the model is able to capture the basic export and investment patterns in both industries relatively well. In Table 8 we observe that all three models match the average investment rate among investing firms relatively well, but Models 2 and 3 tend to underpredict the frequency of investment in either industry. We also document that there is more persistence in export status among plastics exporters in the data than in the model. Matching this feature has often proved difficult for heterogeneous firms and trade models and, as such, authors have estimated different sunk costs for differently-sized firms.[43] We abstract from this possibility here in order to focus on the interaction of investment and exporting. In contrast, the variance of export intensity in the fabricated metals industry is consistently estimated to be larger than that in the data (with one exception).

Likewise, in Table 9 we find that the investment rate is increasing in productivity and export status in both the actual and simulated data, although the coefficient on exporting is somewhat smaller than that observed in the data. This plausibly reflects additional heterogeneity not captured by the model. For instance, it is likely that beyond some productivity threshold highly productive firms gain better access to credit markets. Since this is beyond the scope of the current study we leave this for future research. The coefficients on the productivity regression (23) and the export persistence regression (24) are all very close to that found in the data with the possible exception that in the fabricated metals industry export demand is somewhat larger in the simulated model relative to the data.

4.3.2 Investment and Exporting

Table 10 documents investment frequency across exporting and non-exporting manufacturers. We find that the estimated model qualitatively matches the fact that exporting firms export at a substantially higher frequency relative to non-exporting firms. Models 2 and 3, where the investment cost parameters are restricted show a similar qualitative pattern, but are substantially worse at replicating the observed investment frequencies in the data. Both Models 2 and 3 predict investment frequencies which are much higher than those observed in the data and underpredict the difference between exporting and non-exporting firms.

In Table 11 we observe that Model 1 also matches the empirical regularity that exporting firms tend to invest at a higher rate than non-exporting firms, though the predicted difference is

[43] See Das, Roberts and Tybout (1997) or Aw, Roberts and Xu (2011) for examples.

slightly too big in the plastics industry and slightly too small in the fabricated metals industry. As with the investment frequency, Models 2 and 3 are continue to match the qualitative feature of the data that exporting firms invest at a higher rate relative to non-exporting firms, but are less able to match the quantitative differences across exporters and non-exporters.

4.3.3 Survival in Export Markets

It is well known that many new exporters are small and the average duration of exporting is very short. The first column of Table 12 documents the percentage of period t entrants which continue to export in period $t+1$ relative to the survival rate of all period t exporters (the 'unconditional' survival rate). Likewise, columns 2, 3 and 4 document the percentage of period t entrants which continue to export in subsequent years relative to the unconditional 2, 3 and 4 survival rates among all exporters in the data. As noted above, although the probability of survival is low in the first year after entry, the new exporters survival rate is as high, if not higher, than the unconditional survival rate after 4 years. While none of the models can exactly fit the data, allowing firms to invest in new physical capital improves the model's performance. This can be seen differently in both industries. In the plastics industry, each model predicts roughly the same percentage of surviving new exporters four years after initial entry into export markets (5-8%). However, this is only achieved by overpredicting the number of first year survivors in Models 4 and 5. Models 1 through 3 with capital investment, in contrast, match the number of first year survivors closely and predict a similar percentage of survivors in each year.

In the fabricated metals industry, all five models perform similarly after the first year of entry into export markets, though Models 3 and 5 may empirically fit the data after one year best. However, over time the models with capital adjustment, particularly Models 1 and 2, are far more successful in matching the survival probabilities. It is important to emphasize that Models 1 and 2 are able to capture this feature despite the fact that the estimated sunk costs are very small relative to average firm revenues.[44]

Allowing capital to adjust partially addresses these dynamic features of the data. In particular, to the extent that continued exporting will require a larger capital stock, the costs of investment act as costs of exporting and deter unproductive firms from remaining in export markets over time. At the same time, we observe that surviving exporters are much more likely to invest and hold relatively large amounts of capital. For these firms continued exporting is relatively inexpensive since exiting export markets may create excess capacity. In this sense, capital-adjustment inherently builds persistence into the standard heterogeneous firms and trade model.

[44]When we examine the confidence intervals over Models 1, 2 and 3 in the plastics industry and the Models 1 and 2 in the fabricated metals industry we cannot statistically distinguish the performance of the comparable models over time.

4.3.4 Domestic Revenue Dynamics and Exporting

Numerous authors document that domestic revenue growth among new exporters is generally slower than comparable non-exporters.[45] This is true in our data as well. However, we also observe that among new exporters who have growing capital stocks this relationship is significantly weaker. Consider the following regression where we regress the change in log domestic revenues ($\Delta \ln r_{jt}^D$) on the change in productivity (ω_{jt}), the change in export status (Δd_{jt}), the change in capital holdings ($\Delta \ln k_{jt}$) and the change in the interaction of capital and export status in our data:

$$\Delta \ln r_{jt}^D = \beta_0 + \beta_d \Delta d_{jt} + \beta_k \Delta \ln k_{jt} + \beta_{dk} \Delta(d_{jt} \times \ln k_{jt}) + \beta_\omega \Delta\omega_{jt} + \varepsilon_{jt} \tag{26}$$

where ε_{jt} is an error term.[46] When we exclude the terms which captures capital differences across firms, Table 13 reports that the OLS coefficient on β_d is always negative and highly significant. Our estimates suggest that domestic revenue grows 54-63 log points slower among exporters relative to comparable non-exporters. When we include the variables which captures the differences in capital across firms, the coefficient on β_d is even smaller. That is, firms with small capital stocks will suffer disproportionately large losses in domestic sales upon entry into export markets.

We repeat this exercise on the simulated data from all five models. All models with increasing marginal costs (Model 1-4) match the estimated coefficients in the data closely, though Model 1 generally performs best in either industry. In contrast, the coefficient on the change in exporting in the model with constant marginal costs (Model 5) is always insignificant and extremely close to zero.[47]

4.3.5 Export Revenue Dynamics

As documented in Section 1 export revenues grow quickly among surviving exporters. There are arguably a number of mechanisms which might explain this phenomenon. As emphasized in Eaton et al. (2014) surviving exporters demonstrate strong revenue growth in the initial years after first entry and argue that a search and learning mechanism may explain this empirical regularity. Similarly, Ruhl and Willis (2007) suggest that exogenously growing export markets can generate a similar pattern. We argue that capital growth over time can also explain an important part of the observed export revenue growth.

Table 14 document the average export sales growth rate over time among surviving exporters.

[45] See Nguyen and Schaur (2011), Soderbery (2014) and Vannoorenberghe (2012) for example.

[46] As in Nguyen and Schaur (2011), Soderbery (2014) and Vannoorenberghe (2012) we do not include any measure of export intensity in equation (26). However, to the extent that export shocks are relatively persistent, taking first-differences of the dependent and explanatory variables will mitigate the impact of the unobserved firm-level differences.

[47] The first two coefficients in the last column of Table 11 are insignificant in both industries. No coefficient is reported on the change in capital in Models 2 and 3 since k_{jt} is constant over time.

Specifically, we calculate annual export sales growth relative to the year of initial entry:

$$\text{Export revenue growth in year } t = \frac{\text{Export revenues in year } t - \text{Export revenues in year 1}}{\text{Export revenues in year 1}}$$

Overall, all three models with capital investment (Models 1-3) are able to replicates this feature of the data reasonably well.[48] The models without capital investment (Models 4-5) are less able to fit the empirical patterns in the data. In particular, the model increasing marginal costs and no capital investment consistently under predicts the degree of export revenue growth among surviving exporters, while the model with constant marginal costs does exactly the opposite.

The failure of both models without capital investment is intuitive. In the model with increasing marginal costs, any increase in sales on the export market is met by a consequent reduction in sales on the domestic market. As such, only firms with exceptionally large export market demand shocks will be willing to allow export sales to grow quickly. Since the variance of the export shock process is disciplined by the empirical distribution of export sales, extremely large export shocks are, in general, not any more likely in Model 4 than they are in other variants of our model. In the model with constant marginal costs, the estimated model predicts relatively large export (per-period) fixed costs. Because of this strong selection mechanism only firms with very large productivity or demand shocks will be survive in export markets. In this context, surviving exporters are likely to be those which experience very rapid export sales growth and, as such, will overpredict the growth of export sales among survivors.

Table 4 similarly documented that initially firms with relatively large capital stocks tend to grow faster than comparable firms with little existing capital. Overtime, however, smaller firms eventually grew more so than large firms, as is typical. As documented in Table 14 all of the simulated models with capital accumulation (Models 1-3) often generate a similar empirical patterns, but only Model 1 consistently replicates this qualitative feature of the data across years and industries. Likewise, the models without capital accumulation (Models 4-5) do not generally generate a pattern of revenue growth consistent with that in the data. On one hand, these model cannot match the data because firms with small capital stocks are more likely to exit export markets. Those that continue exporting are more likely to have experienced relatively rapid revenue growth, which is inconsistent with the data in the short-run. On the other hand, this is mitigated by the fact that larger capital stocks also represent marginal costs advantages in this context, which are complementary to export demand growth. In any case, we find that if one effect dominates in the first years after entry, it also dominates over time, which is inconsistent with the data.

[48] As expected, Model 1, with all three investment frictions, is best able to match the data. However, the standard errors are the annual growth rates are relatively large and, with a few exceptions, it is difficult to statistically distinguish the performance of Models 1, 2 and 3.

5 Counterfactual Experiments

The objective of this section is to quantify the impact of increased market access or reduced investment costs through tariff reductions on export and investment behavior over time. To evaluate the impact of these policy changes we consider two counterfactual policy experiments: (a) unilateral tariff reductions by foreign governments on Indonesian exports and (b) unilateral reductions of imported capital tariffs in Indonesia. In each experiment we start the model from the ergodic distribution of the model and simulate the model forward 10 years under the counterfactual policy regime. Although we focus on the model with all of the investment and export frictions since it arguably matched the data best in Section 4 (Model 1), we repeat this exercise for each model to investigate the implications of misspecifying the cost structure.

5.1 Tariff Reductions in Export Markets

The first experiment aims to provide insight on the effect of improved foreign market access on Indonesian producers. Over our sample period Indonesian exporters generally faced low tariffs in most foreign markets. Among plastics exporters the trade-weighted external tariff in 1990 was 10 percent, while among fabricated metals producers it was only 3 percent. In both industries the trade-weighted tariff rates are roughly constant over time.[49] This does not necessarily imply that that gains from further reductions in tariffs would necessarily be small in this context. The extent to which Indonesian producers gain in export markets depends both on the tariff rates themselves and the estimated elasticity of substitution. For instance, the term $(1 + \tau^X)^{\eta+1}$ in revenue equation (6) implies the elimination tariffs faced by Indonesian producers in export markets would improve market access by 37 percent in the plastics industry and 35 percent in the fabricated metals industry. After eliminating tariffs in either industry we then re-simulate the model before and after the policy and compare the growth in exports and investment.[50]

Tables 15 and 16 documents the growth in exports and investment for the plastics and fabricated metals industries, respectively. The first row of each panel reports the annual aggregate growth in total exports induced by the policy changes in Model 1 with all export and investment frictions. The first four columns present the gain in exports in the first, third, fifth and tenth years after trade liberalization. The increase in export market size has a large initial impact on export sales. Aggregate exports increase by 16.2 and 35.8 percent in the first year after the change in policy in the fabricated metals and plastics industry. Over the following ten years aggregate exports grow in response to the policy by a further 1 to 3 percent across industries.

Moving down Tables 15 and 16 we find that Model 2 performs very similarly to Model 1, but implies slightly smaller export growth and over time. In either industry, the growth in aggregate

[49] Tariff rates are documented in the Supplemental Appendix.

[50] We are admittedly abstracting from any effect that trade liberalization may have on input prices or technology in the short-run.

exports is 2 percent smaller in Model 2 relative to Model 1 after 10 years. Models 3 and 4 imply even further small reductions in aggregate exports, both initially and over time, while Model 5, with constant marginal costs, implies a much larger initial increase and no growth over time. In fact, we find that across industries Model 5 implies that aggregate exports grow by just over 50 percent in the first year and this gain is maintained over time. Not surprisingly, the growth of aggregate exports in models with investment, but not convex adjustment costs (Model 3) are flat as in the constant marginal cost model, while that is not the case otherwise.

The second row of Tables 15 and 16 indicates the contribution from the extensive margin. That is, the second row calculates the percentage of total exports attributable to firms that were induced to begin exporting because of the change in policy. We observe that model structure has a large impact on the estimated contribution from new exporters. In particular, the constant marginal cost model implies very little growth from the extensive margin reflecting the large entry costs associated with exporting and larger intensive margin increases. In contrast, the model without investment but increasing marginal suggests a relatively large contribution from new exporters. This is intuitive since increasing export sales along the intensive margin is increasingly costly for firms since they cannot expand capacity. The models with investment fall somewhere in between. Across industries, Model 1 suggests an new exporter contribution of 2-4 percent in the fabricated metals industry or 11-14 percent in the plastics industry.

The third row of Table 15 and 16 studies the growth in aggregate investment induced by the change in policy. We observe a very small response of investment to external tariff reductions in any model. Trade liberalization increases new investment by less than 1 percent in any year and industry.[51] Most firms, even those that export heavily, tend to earn most sales from the domestic market. As such, small changes in a relatively small market are not likely to have big effects on the investment behavior of most firms, particularly those that are unlikely to enter export markets. Second, once firms have had sufficient time to adjust to the change in policy, exporting and investment behavior is typically dominated by a relatively small number of large firms.

The fourth row presents the growth in the exporter contribution to aggregate investment. Specifically, we measure the growth in the percentage of total investment which is undertaken by exporting firms. In our context this is a natural lower bound on the total contribution of exporting to investment growth as we ignore all firms which undertake new investment in years prior to entering export markets. In both industries Model 1 implies strong growth in the exporter contribution to aggregate investment; in the plastics industry the fraction of investment due to exporters grows by 12 percent in the first year after trade liberalization, while it grows by 3 percent in the fabricated metals industry. Not surprisingly, this is smaller Models 2 and 3 where we do not observe as many new exporters.

[51] For consistency, we present the growth in annual investment flows. Across industries, cumulative investment, net of depreciation, is 1 percent greater after 10 years.

5.2 Capital Import Tariff Reductions

Our second experiment reduces the tariffs applied to capital imports into Indonesia. We construct this measure as an (industry-level) investment weighted average over the tariffs applied to each type of capital discussed in Section 1. In either industry, τ^K, the tariff applied to capital imports is approximately 13 percent. Reducing the applied capital import tariff to 0 is effectively a reduction in firm-level investment costs. We expect that a reduction in investment costs may potentially lead to a strong rise in investment and exporting. Further, to fully examine the interaction of trade and investment we also consider the impact of contemporaneous reductions in tariffs in export markets and tariffs applied to capital imports.[52]

The second four columns of Tables 15 and 16 report results for capital tariff reductions alone while the last four columns consider the experiment where both policy changes are applied simultaneously. As we would expect there is a jump in aggregate investment in both industries immediately after the cost of investment is reduced. However, since new investment does not become productive until the second year there is no growth in exports along the intensive margin and few non-exporters are induced to start exporting due to the change in policy. In Model 1 the growth in annual investment falls over time, though it remains substantially higher than the benchmark model. Ten years after the change in policy annual aggregate investment is 87.5 percent higher than the benchmark model in the fabricated metals industry and 34.5 percent higher in the plastics industry. The rise in capital holdings in turn has a substantial impact on exports over time. Across industries, exports are predicted to be 14 percent greater than that in the benchmark model after 10 years, while in the plastics industry they are 16 percent larger. In the plastics industry, where marginal costs rise particularly rapidly for capital-constrained firms, reducing investment costs is a relatively effective policy for stimulating exports. In this sense our results mirror those in Manova (2008) and Buera, Kaboski and Shin (2011) which suggest that capital-intensive, financially-dependent industries are likely to grow faster, domestically or internationally, in response to financial development.

Models 2 and 3 behave similarly to Model 1 with small differences. In particular, the investment response, and the related impact on exporting is largest in Model 2 and smallest in Model 3. In general, these findings reflect the overall costs of investment and, as such, the increased attractiveness of the export market. As noted above, the costs of investment Model 3 are particularly high without strictly convex or non-convex adjustment costs, while they are smallest, after the policy change, in Model 2 since the policy change is not modeled to directly affect the the strictly convex costs of adjustment.

The last experiment combines the external tariff reduction exercise with a simultaneous reduction in investment costs. Not surprisingly we find that the combination of the two policies has the largest impact on aggregate exports. Initially, aggregate export behavior closely re-

[52] As documented by Manova (2008), in developing countries trade and financial reform often occur together, and have very different implications across heterogeneous firms and industries.

sembles that under the first experiment, while aggregate investment behavior is very close that under the capital tariff reduction experiment. In either industry we observe that after 10 years the aggregate growth rate of exports is at least double what it was in the preceding experiments. In contrast, there is very little additional impact on aggregate investment, again reflecting the relatively small size of the export market.

6 Conclusion

The goal of this paper was to evaluate the impact of investment on exporting over time. Consistent with our data, we develop a model which shows that new exporters invest heavily in new capital as they enter and grow into export markets. It emphasizes that firm-level investment and export decisions evolve endogenously with firm-specific productivity and export demand shocks.

We show that endogenous responses to differential demand shocks across markets affect productivity estimates due to quasi-fixed factors of production, such as capital stock. Our results suggest the failing to account for these shocks biases the productivity differences between exporting and non-exporting firms by as much as 15 percent. We structurally estimate the model using detailed information on export and investment decisions among Indonesian manufacturing firms. Accounting for capital-adjustment frictions substantially alters the performance of the model. We find that sunk (first-time) export costs are reduced by 90 percent across industries. The estimated model demonstrates that export costs have a much smaller impact on firm-level export decisions after accounting for investment costs.

Allowing firms to endogenously invest in new capital substantially improves the model's ability to match numerous features of firm-level data. In particular, the model with investment dynamics is able to better capture differential investment rates across exporting and non-exporting firms, the exporter survival rates, and domestic and export revenue growth.

Counterfactual experiments assess the impact of trade liberalization and financial reform on the evolution of aggregate exports and investment over time. We find that both policies have an important impact on aggregate exports and investment over time and that there is a strong degree of complementarity between investment and exporting, particularly in capital-intensive industries. After 10 years eliminating tariffs faced by exporters in destination markets increases annual aggregate exports by 18-39 percent and cumulative aggregate investment (net of depreciation) by 1 percent across industries. Similarly, eliminating tariffs on imported capital increases annual aggregate exports by 14-16 percent and annual aggregate investment by 35-88 percent across industries.

References

[1] Ahn, JaeBin and Alexander F. McQuoid. "Capacity Constrained Exporters: Micro Evidence and Macro Implications," Florida International University Working Paper 1301, 2012.

[2] Ackerberg, Daniel A., Kevin Caves, and Garth Frazer. "Structural Identification of Production Functions", Department of Economics UCLA, 2006.

[3] Alessandria, George and Horag Choi. "Do Sunk Costs of Exporting Matter for Net Export Dynamics?" *Quarterly Journal of Economics*, 122(2007), 289-336.

[4] Alessandria, George and Horag Choi. "Establishment Heterogeneity, Exporter Dynamics, and the Effects of Trade Liberalization," *Journal of International Economics,* forthcoming, 2013.

[5] An, Mark Yuying and Ming Liu. "Using Indirect Inference to Solve the Initial-Conditions Problem," *Review of Economic Statistics,* 82(2000), 656-667.

[6] Arkolakis, Costas. "Market Penetration Costs and the New Consumers Margin in International Trade," *Journal of Political Economy*, 118(2010), 1151-1199.

[7] Arkolakis, Costas. "A Unified Theory of Firm Selection and Growth," NBER Working Paper 17553, 2013.

[8] Atkeson, Andrew and Ariel Burstein. "Innovation, Firm Dynamics, and International Trade," *Journal of Political Economy*, 118(2010), 433-484.

[9] Aw, Bee Yan, Sukkyun Chung, and Mark 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.

[10] Aw, Bee Yan, Mark J. Roberts, and Daniel Yi Xu. "R&D Investment, Exporting, and Productivity Dynamics," *American Economic Review*, 1010(2011), 1312-1344.

[11] Bernard, Andrew B., Jonathan Eaton, J. Bradford Jensen, and Samuel Kortum. "Plants and Productivity in International Trade," *American Economic Review*, 93(2003): 1268-1290.

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

[13] Blalock, Garrick and Paul J. Gertler. "Learning from exporting revisited in a less developed setting," *Journal of Development Economics,* 75(2004), 397-416.

[14] Blalock, Garrick, Paul J. Gertler, David I. Levine. "Financial constraints on investment in an emerging market crisis," *Journal of Monetary Economics*, 55(2008), 568-591.

[15] Bond, Eric W., James R. Tybout, Hâle Utar. "Credit Rationing, Risk Aversion, and Industrial Evolution in Developing Countries," *International Economic Review*, forthcoming, 2014.

[16] Buera, Francisco J., Joseph P. Kaboski and Yongsoek Shin. "Finance and Development: A Tale of Two Sectors," *American Economic Review*, 101(2011), 1964-2002.

[17] Bustos, Paula. "Trade Liberalization, Exports and Technology Upgrading: Evidence on the impact MERCOSUR on Argentinian Firms," *American Economic Review,* 101(2011), 304-340.

[18] Caballero, Ricardo J., Eduardo M. R. A. Engel and John C. Haltiwanger. "Plant-level Adjustment and Aggregate Investment Dynamics, *Brookings Papers on Economic Activity*, (1995), 1-39.

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

[20] Constantini, James A., and Marc J. Melitz. "The Dynamics of Firm-Level Adjustment to Trade Liberalization," in E. Helpman, D. Marin, and T. Verdier, eds., *The Organization of Firms in a Global Economy* (Cambridge: Harvard University Press, 2008).

[21] Cooper, Russell W., John C. Haltiwanger and Laura Power. "Machine Replacement and the Business Cycle: Lumps and Bumps," *American Economic Review*, 89(1999), 921-946.

[22] Cooper, Russell W. and John C. Haltiwanger. "On the Nature of Capital Adjustment Costs," *Review of Economic Studies*, 73(2006), 611-633.

[23] Cooper, Russell W., John C. Haltiwanger and Jonathan L. Willis. "Euler-Equation Estimation for Discrete Choice Models: A Capital Accumulation Application," NBER Working Paper 15675, 2010.

[24] Cosar, A. Kerem, Nezih Gunar and James R. Tybout. "Firm Dynamics, Job Turnover, and Wage Distributions in an Open Economy," NBER Working Paper 16326, 2014.

[25] Das, Sanghamitra, Mark J. Roberts, and James R. Tybout. "Market Entry Costs, Producer Heterogeneity, and Export Dynamics," *Econometrica* 75(2007), 837-873.

[26] De Loecker, Jan and Frederic Warzynski. "Markups and Firm-Level Export Status," *American Economic Review*, 102(2012), 2437-2471.

[27] Demidova, Svetlana, Hiau Looi Kee and Kala Krishna. "Do Trade Policy Differences Induce Sorting? Theory and Evidence From Bangladeshi Apparel Exporters," *Journal of International Economics*, 87(2012), 247-261.

[28] Doms, Mark E. and Timothy Dunne. "Capital Adjustment Patterns in Manufacturing Plants," *Review of Economic Dynamics*, 1(1998), 409-429.

[29] Eaton, Jonathan and Samuel Kortum. "Technology, Geography, and Trade," *Econometrica*, 70(2002), 1741-1779.

[30] Eaton, Jonathan, Marcela Eslava, C. J. Krizan, Maurice Kugler and James R. Tybout. "A Search and Learning Model of Export Dynamics," Mimeo, Pennsylvania State University, 2014.

[31] Eaton, Jonathan, Samuel Kortum and Francis Kramarz. "An Anatomy of International Trade: Evidence From French Firms," *Econometrica*, 79(2011), 1453-1498.

[32] Ederington, Josh and Phillip McCalman. "Endogenous Firm Heterogeneity and the Dynamics of Trade Liberalization," *Journal of International Economics*, 74(2008), 422-440.

[33] Evans, David. "The Relationship Between Firm Growth, Size and Age: Estimates for 100 Manufacturing Industries," *Journal of Industrial Economics*, 35(1987), 567-581.

[34] Evenett, Simon, and Anthony Venables. "Export Growth and Developing Countries: Market Entry and Bilateral Trade Flows, University of Bern Working Paper, 2002.

[35] Gouriéroux, Christian S., Alain Monfort and Eric Renault. "Indirect Inference," *Journal of Applied Econometrics*, 8(1993), S85-S118.

[36] Levinsohn, James and Amil Petrin. "Estimating Production Functions Using Inputs to Control for Unobservables," *Review of Economic Studies*, 70(2003), 317-342.

[37] Hall, Bronwyn H. "The Relationship Between Firm Size and Firm Growth in the U.S. Manufacturing Sector," *The Journal of Industrial Economics,* 35(1987), 583-606.

[38] Hayashi, Fumio. "Tobins Marginal and Average q: A Neoclassical Interpretation," *Econometrica*, 50(1982), 213-224.

[39] Hummels, David, and Peter J. Klenow. "The Variety and Quality of a Nations Trade," *American Economic Review*, 95(2005), 704-723.

[40] Kasahara, Hiroyuki and Beverly Lapham, "Productivity and the Decision to Import and Export: Theory and Evidence," *Journal of International Economics*, 89(2013), 297-316.

[41] Kehoe, Timothy, and Kim Ruhl. "How Important is the New Good Margin in Trade? *Journal of Political Economy*, 121(2013), 358-392.

[42] Krusell, Per, Lee E. Ohanian, José-Vctor Ros-Rull and Giovanni L. Violante. "Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis," *Econometrica*, 68(2000), 1029-1053.

[43] Lileeva, Alla and Daniel Trefler. "Improved Access to Foreign Markets Raises Plant-Level Productivity... For Some Plants," *Quarterly Journal of Economics*, 125(2010), 1051-1099.

[44] Lopez, Ricardo A. "Do Firms Increase Productivity in Order to Become Exporters?" *Oxford Bulletin of Economics and Statistics,* 71(2009), 621-642.

[45] Luttmer, Erzo G. J. "Selection, Growth and the Size Distribution of Firms," *Quarterly Journal of Economics*, 122(2007), 1103-1144.

[46] Manova, Kalina. "Credit Constraints, Equity Market Liberalizations and International Trade," *Journal of International Economics,* 76(2008), 33-47.

[47] Manova, Kalina. "Credit Constraints, Heterogeneous Firms, and International Trade," *Review of Economic Studies*, 80(2013), 711-744.

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

[49] Nguyen, Daniel X. and Georg Schaur. "Cost Linkages Transmit Volatility Across Markets," University of Copenhagen, 2011.

[50] Olley, G. Steven and Ariel Pakes. "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica*, 65(1996), 245-276.

[51] Rho, Youngwoo and Joel Rodrigue. "Growing into Export Markets: The Impact of Exporting on Firm-Level Investment in Indonesia," *Review of International Economics*, forthcoming, 2014.

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

[53] Rodrigue, Joel and Omolola Soumonni. 'Deforestation, Foreign Demand and Export Dynamics in Indonesia," *Journal of International Economics*, 93(2014): 316-338.

[54] Ruhl, Kim. "Solving the Elasticity Puzzle, University of Minnesota, 2004.

[55] Ruhl, Kim J. and Jonathan L. Willis. 2007. "New Exporter Dynamics," New York University, 2007.

[56] Schüdeln, Matthias. "Appreciating Depreciation: A Note on Physical Capital Depreciation in a Developing Country," *Empirical Economics*, 44(2012): 1277-1290.

[57] Smith, Jr., Anthony A. "Estimating Nonlinear Time-series Models Using Simulated Vector Autoregressions," *Journal of Applied Econometrics*, 8(1993), S63-S84.

[58] Soderbery, Anson. "Market Size, Structure, and Access: Trade with Capacity Constraints," *European Economic Review*, 70(2014), 276-298.

[59] Vannoorenberghe, Gonzague C.L."Firm-Level Volatility and Exports," *Journal of International Economics*, 86(2012): 57-67.

A Tables

Table 1: Investment and Export Moments

	Plastics			
	Non-Exporters	All Exporters	New Exporters	Inc. Exporters
Investment Rate, i/k	0.065	0.199	0.238	0.179
Inaction Frequency	0.756	0.431	0.462	0.431
Correlation of log export sales and log investment	—	0.380	0.664	0.220
Export Intensity	—	0.413	0.352	0.445
Labour Productivity	0.081	0.104	0.101	0.105
Capital Stock	3.300	21.345	21.280	21.379
Employment	110.119	493.514	396.200	542.877
	Fabricated Metals			
	Non-Exporters	All Exporters	New Exporters	Inc. Exporters
Investment Rate, i/k	0.112	0.323	0.378	0.281
Inaction Frequency	0.619	0.385	0.397	0.375
Correlation of log export sales and log investment	—	0.377	0.476	0.251
Export Intensity	—	0.412	0.385	0.434
Labour Productivity	0.080	0.135	0.154	0.121
Capital Stock	3.837	9.574	10.559	8.813
Employment	130.046	426.173	437.912	417.102

Notes: Table 1 documents investment and export summary statistics for the plastics and fabricated metals industries. Capital stock is measured in millions of 1983 Indonesian rupiahs. Labour productivity is measured as total revenue per worker at the firm-level.

Table 2: Survival Rates Among New Exporters

	Plastics				Fabricated Metals			
Years After Entry	1	2	3	4	1	2	3	4
New Exporters	0.53	0.44	0.36	0.25	0.62	0.24	0.20	0.20

Notes: Table 2 documents survival rates among new exporting firms in year $t + j$ where $j = 1, 2, 3, 4$. The survival rate is computed by determining the fraction of new exporters in year 0 which are still exporting in year j. For instance, the first column indicates that 53 percent of the new plastics exporters continue to export into their second year. The second column measures indicates that 44 percent of initial entry cohort (year 0) continue to export for two consecutive years (into year 2).

Table 3: Domestic Revenues, Exporting and Investment

	Dependent Variable: $\Delta \ln r_{jt}^D$					
	Plastics			Fabricated Metals		
Δd_{jt}^X	-0.407	-0.331	-0.983	-0.363	-0.363	-1.331
	(0.065)	(0.070)	(0.306)	(0.064)	(0.067)	(0.315)
$\Delta \ln k_{jt}$		-0.049	-0.065		-0.030	-0.059
		(0.083)	(0.083)		(0.070)	(0.070)
$\Delta(d_{jt}^X \cdot \ln k_{jt})$			0.080			0.117
			(0.036)			(0.037)
R^2	0.047	0.046	0.049	0.024	0.026	0.027
Observations		1695			1492	

Notes: Table 3 reports the results of an OLS regression of the log change in firm-level domestic revenues, $\Delta \ln r_{jt}^D$, on the change in export status, Δd_{jt}^X, the change in the log of capital stock $\Delta \ln k_{jt}$ and the change in their interaction. Standard errors are in parentheses.

Table 4: Annual Export Revenue Growth (Among Surviving Exporters)

	Plastics				
	Years Since First Entry				Initial Export Sales
	2	3	4	5	Upon First Entry[b]
All	0.842	1.765	2.376	2.596	1.000
High Productivity, Large Capital	0.608	2.986	4.733	3.302	1.758
High Productivity, Small Capital	0.504	2.149	3.051	5.584	0.513
Low Productivity, Large Capital	0.295	0.097	0.494	0.744	0.584
Low Productivity, Small Capital	0.210	0.985	1.081	1.746	0.516
	Fabricated Metals				
	Years Since First Entry				Initial Export Sales
	2	3	4	5	Upon First Entry[a]
All	0.727	1.423	1.809	2.427	1.000
High Productivity, Large Capital	0.126	0.927	0.468	3.411	1.333
High Productivity, Small Capital	-0.344	0.365	0.552	0.507	1.539
Low Productivity, Large Capital	1.297	1.370	2.102	1.875	1.155
Low Productivity, Small Capital	0.326	1.984	3.232	2.528	0.718

Notes: (a) The first four columns calculate the annual export sales growth rate relative to the initial year of entry. For instance, the first column of the first row indicates the export sales grew by 84 percent between the first and second year of consecutive exporting. The second column indicates that annual export sales were 177 percent higher in the third year of exporting relative to the year of initial entry. (b) Initial sales among all firms are normalized to 1 and apply to firms which export for at least two consecutive years. Average initial sales in plastics industry are 12.8 million 1983 Indonesian rupiahs while average initial sales in the fabricated metals industry are 16.1 million 1983 Indonesian rupiahs

Table 5: Mark-Ups, Productivity and Marginal Costs

	Plastics				Fabricated Metals			
	α_l Estimated		α_l Set to 1		α_l Estimated		α_l Set to 1	
Parameter	Estimate	S.E.	Estimate	S.E	Estimate	S.E.	Estimate	S.E.
β	0.425	0.062	0.425	0.065	0.723	0.060	0.723	0.060
α_l	0.513	0.114	1	—	0.776	0.060	1	—
α_k	0.347	0.066	0.660	0.162	0.090	0.036	0.130	0.054
α_0	-0.249	0.383	-0.526	0.849	-0.020	0.100	-0.053	0.171
α_1	0.863	0.018	0.854	0.021	0.917	0.027	0.895	0.030
σ_ξ	0.366	0.072	0.733	0.167	0.147	0.039	0.205	0.070

Notes: Standard errors are calculated using 200 bootstrap replications.

Table 6: Export Market Size, Export Costs and Investment Costs

	Plastics					Fabricated Metals				
Model No.	1	2	3	4	5	1	2	3	4	5
γ^F	1.976	2.071	51.040	2.361	14.657	0.605	0.622	17.327	2.009	5.311
	(0.009)	(0.004)	(0.090)	(0.005)	(0.027)	(0.002)	(0.002)	(0.097)	(0.005)	(0.023)
γ^S	9.042	8.920	224.490	43.502	121.925	6.472	6.008	48.975	7.488	53.357
	(0.040)	(0.017)	(0.635)	(0.286)	(0.522)	(0.048)	(0.028)	(0.252)	(0.034)	(0.091)
ψ_0	54.463	71.029	258.380			10.550	11.102	46.194		
	(0.158)	(0.126)	(0.568)			(0.014)	(0.023)	(0.084)		
ψ_1	3.787					0.533				
	(0.001)					(0.001)				
ψ_2	0.633	0.649				0.062	0.063			
	(0.004)	(0.001)				(0.001)	(0.0002)			
ρ	0.738	0.720	0.707	0.815	0.743	0.934	0.950	0.942	0.929	0.900
	(0.001)	(0.001)	(0.001)	(0.006)	(0.007)	(0.004)	(0.002)	(0.001)	(0.005)	(0.001)
$\ln \sigma_\mu$	0.099	0.109	0.098	0.109	0.105	0.331	0.365	0.358	0.324	0.331
	(0.001)	(0.0001)	(0.0002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.0004)
$\ln \Lambda^X$	-1.268	-1.179	-1.152	-1.157	-1.208	-2.465	-3.034	-2.517	-2.355	-2.778
	(0.007)	(0.003)	(0.004)	(0.013)	(0.006)	(0.009)	(0.003)	(0.008)	(0.008)	(0.008)
Endog. k-Adjust.	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No
MC	Inc.	Inc.	Inc.	Inc.	Const.	Inc.	Inc.	Inc.	Inc.	Const.

Notes: Asymptotic standard errors are in parentheses.

Table 7: Interpreting Export Costs and Investment Costs

Industry	Plastics					Fabricated Metals				
Model No.	1	2	3	4	5	1	2	3	4	5
Fixed Export Costs (γ_F)	0.114	0.120	2.948	0.136	0.846	0.065	0.067	1.855	0.215	0.568
Sunk Export Costs (γ_S)	0.522	0.515	14.911	2.510	7.036	0.693	0.643	5.242	0.801	5.711
Variable Investment Costs (ψ_0, ψ_1)	0.357	0.465	1.692	—	—	0.007	0.007	0.762	—	—
Fixed Investment Costs (ψ_2)	0.037	0.038	—	—	—	0.174	0.183	—	—	—

Notes: This table presents the size of the export and investment costs, documented in Table 6, relative to the annual profits of the median exporter in either industry.

Table 8: Data and Model Based-Moments

		Model No.				
Plastics	Data	1	2	3	4	5
Mean frequency of investment	0.271	0.247	0.176	0.208	—	—
Mean investment rate (i_t/k_t) among firms where $i_t > 0$	0.251	0.226	0.236	0.246	–	–
Mean frequency of exporting	0.104	0.126	0.127	0.116	0.103	0.101
Fraction of year t exporters who exported in year $t-1$	0.763	0.561	0.555	0.543	0.702	0.567
Mean log export sales among exporting firms	8.675	8.498	8.505	8.411	8.595	8.813
Variance of export intensity	0.391	0.368	0.357	0.347	0.536	0.393
		Model No.				
Fabricated Metals	Data	1	2	3	4	5
Mean frequency of investment	0.386	0.369	0.316	0.265	—	—
Mean investment rate (i_t/k_t) among firms where $i_t > 0$	0.309	0.321	0.355	0.338	—	—
Mean frequency of exporting	0.096	0.127	0.102	0.121	0.062	0.070
Fraction of year t exporters who exported in year $t-1$	0.655	0.689	0.671	0.562	0.536	0.586
Mean log export sales among exporting firms	8.841	8.647	8.507	8.587	9.141	8.722
Variance of export intensity	0.665	0.981	1.020	1.103	1.167	0.896

Table 9: Data and Model Based OLS Regression Parameter Estimates

Plastics Parameter	Actual	Simulated Model No. 1	2	3	4	5
ϱ_1	0.044	0.106	0.098	0.101	—	—
ϱ_2	0.098	0.020	0.055	0.074	—	—
ς_0	-2.291	-2.345	-2.343	-2.318	-2.322	-4.446
ς_1	0.661	0.743	0.747	0.697	0.703	1.184
ϑ_1	0.744	0.582	0.577	0.538	0.760	0.631
Fabricated Metals Parameter	**Actual**	**Simulated Model No. 1**	**2**	**3**	**4**	**5**
ϱ_1	0.230	0.276	0.291	0.193	—	—
ϱ_2	0.098	0.004	0.047	0.047	—	—
ς_0	-0.495	-0.521	-0.508	-0.517	-0.488	-0.745
ς_1	0.429	0.512	0.520	0.493	0.538	0.472
ϑ_1	0.580	0.911	0.914	0.826	0.779	0.780

Notes: The squared productivity term in equation (22) is omitted from the regression in the plastic products industry since it is not precisely estimated. Similar tables estimated for the model under constant marginal costs are presented in the Appendix.

Table 10: Investment Inaction Frequency and Export Status

	Plastics				Fabricated Metals			
	Data	Model			Data	Model		
		1	2	3		1	2	3
Non-Exporter	0.756	0.782	0.866	0.816	0.619	0.683	0.734	0.790
All Exporters	0.431	0.558	0.733	0.785	0.385	0.312	0.388	0.548
New Exporters	0.462	0.617	0.762	0.764	0.397	0.285	0.354	0.570
Inc. Exporters[a]	0.431	0.569	0.712	0.802	0.375	0.323	0.402	0.536

Notes: This table documents the investment inaction frequencies in the data and in the simulated models for non-exporting and exporting firms. New exporters are exporting firms which are exporting for the first time, while [a]incumbent exporters include all firms which exported in the preceding year. Models 4 and 5 are omitted since there is no investment decision.

Table 11: Investment Rates and Export Status (Among Investors)

	Plastics				Fabricated Metals			
	Data	Model			Data	Model		
		1	2	3		1	2	3
Non-Exporter	0.190	0.206	0.188	0.144	0.212	0.291	0.332	0.266
All Exporters	0.245	0.328	0.367	0.779	0.370	0.316	0.469	0.387
New Exporters	0.221	0.414	0.467	1.194	0.385	0.383	0.632	0.673
Inc. Exporters	0.251	0.266	0.297	0.374	0.363	0.282	0.383	0.225

Notes: This table documents the investment rates among investing firms in the data and in the simulated models across firms. New exporters are exporting firms which are exporting for the first time, while [a]incumbent exporters include all firms which exported in the preceding year. Models 4 and 5 are omitted since there is no investment decision.

Table 12: Survival in Export Markets

	Plastics				
	Years Since Initial Entry				
	0	1	2	3	4
Data	1.000/1.000	0.533/0.763	0.444/0.492	0.360/0.299	0.250/0.175
Model 1	1.000/1.000	0.561/0.641	0.284/0.326	0.141/0.152	0.060/0.053
Model 2	1.000/1.000	0.550/0.618	0.276/0.309	0.141/0.142	0.057/0.049
Model 3	1.000/1.000	0.483/0.580	0.228/0.288	0.106/0.134	0.041/0.046
Model 4	1.000/1.000	0.723/0.780	0.416/0.453	0.214/0.235	0.088/0.090
Model 5	1.000/1.000	0.622/0.663	0.333/0.309	0.165/0.142	0.0640.045
	Fabricated Metals				
	Years Since Initial Entry				
	0	1	2	3	4
Data	1.000/1.000	0.619/0.655	0.235/0.401	0.200/0.218	0.200/0.099
Model 1	1.000/1.000	0.757/0.818	0.488/0.486	0.294/0.255	0.145/0.099
Model 2	1.000/1.000	0.711/0.773	0.428/0.440	0.244/0.226	0.112/0.085
Model 3	1.000/1.000	0.562/0.661	0.307/0.355	0.163/0.177	0.075/0.066
Model 4	1.000/1.000	0.488/0.603	0.243/0.299	0.114/0.137	0.037/0.047
Model 5	1.000/1.000	0.6480.688	0.337/0.341	0.149/0.150	0.050/0.050

Notes: This table documents the survival rates in both the data and each of the simulated models. The top survival rate is measured as the fraction of new entrants in year 0 which remain active in export markets t years after entry, where $t = 0, 1, 2, 3, 4$. Likewise, the bottom survival rate of any pair is measured as the fraction of all exporters in year 0 which remain active in export markets t years after entry, where $t = 0, 1, 2, 3, 4$.

Table 13: Exporting and Domestic Revenue

	Plastics									
	Data		Model 1		Model 2		Model 3		Model 4	Model 5
Constant	-0.057	-0.044	-0.052	-0.015	-0.060	-0.018	-0.058	-0.013	-0.014	-0.000
	(0.010)	(0.010)	(0.005)	(0.005)	(0.004)	(0.006)	(0.004)	(0.005)	(0.004)	(0.000)
Δd_{jt}^X	-0.626	-1.548	-0.391	-0.914	-0.410	-0.879	-0.370	-0.703	-0.431	0.000
	(0.048)	(0.218)	(0.030)	(0.146)	(0.030)	(0.142)	(0.029)	(0.135)	(0.047)	(0.000)
$\Delta \ln k_{jt}$		0.275		0.464		0.446		0.469		
		(0.056)		(0.036)		(0.041)		(0.036)		
$\Delta(d_{jt}^X \cdot \ln k_{jt})$		0.114		0.068		0.061		0.044		
		(0.026)		(0.017)		(0.010)		(0.009)		
$\Delta\omega_{jt}$	1.264	1.283	1.374	1.390	1.384	1.391	1.379	1.388	1.389	0.745
	(0.027)	(0.027)	(0.011)	(0.036)	(0.011)	(0.010)	(0.011)	(0.036)	(0.009)	(0.000)
	Fabricated Metals									
	Data		Model 1		Model 2		Model 3		Model 4	Model 5
Constant	0.003	0.005	-0.030	-0.020	-0.034	-0.020	-0.040	-0.022	-0.016	-0.000
	(0.011)	(0.011)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.008)	(0.005)	(0.000)
Δd_{jt}^X	-0.544	-1.352	-0.387	-1.149	-0.368	-1.192	-0.409	-1.228	-0.518	-0.000
	(0.045)	(0.212)	(0.061)	(0.326)	(0.064)	(0.345)	(0.050)	(0.262)	(0.074)	(0.000)
$\Delta \ln k_{jt}$		0.193		0.261		0.265		0.270		
		(0.047)		(0.038)		(0.036)		(0.045)		
$\Delta(d_{jt}^X \cdot \ln k_{jt})$		0.096		0.095		0.103		0.105		
		(0.025)		(0.037)		(0.034)		(0.030)		
$\Delta\omega_{jt}$	2.920	2.964	3.345	3.386	3.338	3.376	3.353	3.381	3.373	2.610
	(0.073)	(0.073)	(0.039)	(0.036)	(0.037)	(0.034)	(0.050)	(0.042)	(0.033)	(0.000)
Endog. k-Adjust.	—		Yes		Yes		Yes		No	No
Marginal Costs	—		Increasing		Increasing		Increasing		Increasing	Constant

Notes: Standard errors are in parentheses. The first two coefficients in the last column are insignificant at conventional levels.

Table 14: Annual Export Revenue Growth (Among Surviving Exporters)

	Plastics				Fabricated Metals			
	Years Since First Entry				Years Since First Entry			
	2	3	4	5	2	3	4	5
Data	0.842	1.765	2.376	2.596	0.727	1.423	1.809	2.427
Model 1	0.720	1.584	1.922	2.137	0.854	1.788	2.824	3.010
Model 2	0.709	1.456	1.588	2.511	1.031	2.335	4.049	4.424
Model 3	0.862	2.048	2.877	3.404	1.073	2.179	3.140	3.643
Model 4	0.512	1.186	1.621	1.634	0.712	1.598	1.803	1.567
Model 5	1.071	2.391	3.765	4.129	1.799	4.659	7.881	8.805

Notes: The first four columns calculate the annual export sales growth rate relative to the initial year of entry. For instance, the first column of the first row indicates the export sales grew by 84 percent between the first and second year of consecutive exporting. The second column indicates that annual export sales were 177 percent higher in the third year of exporting relative to the year of initial entry.

Table 15: Plastics: Counterfactual Export and Investment Growth

Experiment	Unilateral Export Tariff Reduction				Unilateral Capital Tariff Reduction				Both			
Year	1	3	5	10	1	3	5	10	1	3	5	10
Model 1												
Aggregate Exports (%)	35.8	38.1	38.2	38.6	0.3	14.0	15.3	15.8	36.1	57.3	59.2	60.5
Extensive Margin (%)	10.8	14.9	14.8	14.3	100.0	12.9	14.8	14.3	11.5	15.2	15.8	15.5
Aggregate Investment (%)	0	0	0.1	0.1	137.8	35.5	34.6	34.5	137.8	35.5	34.6	34.5
Exporter Contribution (%)	11.6	12.4	12.0	11.7	0	5.5	4.8	5.0	11.6	17.9	17.4	16.9
Model 2												
Aggregate Exports (%)	35.6	36.1	36.1	36.4	0.3	28.9	31.4	36.7	38.7	74.7	78.5	86.0
Extensive Margin (%)	6.6	5.5	4.9	5.1	100.0	5.2	7.4	9.9	12.5	13.3	16.3	19.7
Aggregate Investment (%)	0.1	0.1	0.3	0.3	174.1	97.6	109.0	98.9	174.2	97.7	109.2	99.5
Exporter Contribution (%)	5.3	7.9	6.7	10.8	5.3	5.2	1.4	0.4	11.1	12.7	10.1	9.5
Model 3												
Aggregate Exports (%)	32.8	32.8	32.8	32.8	0.6	8.8	9.9	11.6	35.6	44.4	46.2	48.5
Extensive Margin (%)	0.7	0.8	0.9	1.4	100.0	12.7	17.1	16.9	3.0	4.1	4.9	6.6
Aggregate Investment (%)	0.1	0.1	0.1	0.2	33.2	32.8	30.8	31.9	33.4	32.9	30.8	31.9
Exporter Contribution (%)	0.1	0.2	0.2	0.2	0.2	1.4	2.2	2.5	0.4	1.6	2.4	2.6
Model 4												
Aggregate Exports (%)	30.8	32.5	32.7	34.7	—	—	—	—	—	—	—	—
Extensive Margin (%)	6.6	10.5	11.2	14.2	—	—	—	—	—	—	—	—
Aggregate Investment (%)	—	—	—	—	—	—	—	—	—	—	—	—
Exporter Contribution (%)	—	—	—	—	—	—	—	—	—	—	—	—
Model 5												
Aggregate Exports (%)	53.7	51.6	51.0	50.7	—	—	—	—	—	—	—	—
Extensive Margin (%)	0	0.02	0.02	0.02	—	—	—	—	—	—	—	—
Aggregate Investment (%)	—	—	—	—	—	—	—	—	—	—	—	—
Exporter Contribution (%)	—	—	—	—	—	—	—	—	—	—	—	—

Notes: Aggregate export and investment growth are measured relative to annual benchmark flows (these are not cumulative measures).

Table 16: Fabricated Metals: Counterfactual Export and Investment Growth

Experiment	Unilateral Export Tariff Reduction				Unilateral Capital Tariff Reduction				Both			
Year	1	3	5	10	1	3	5	10	1	3	5	10
Model 1												
Aggregate Exports (%)	16.2	17.5	17.5	17.5	0.04	6.2	9.5	14.1	16.2	25.0	28.7	34.2
Extensive Margin (%)	2.3	3.0	3.7	3.6	100.0	2.4	3.5	3.3	2.6	3.2	3.9	3.9
Aggregate Investment (%)	0	0.1	0.1	0.1	135.2	93.4	96.9	87.5	135.2	93.4	97.1	87.5
Exporter Contribution (%)	1.6	2.3	2.3	2.8	5.7	2.0	1.6	2.1	7.5	4.5	3.6	4.3
Model 2												
Aggregate Exports (%)	14.9	15.2	15.2	15.0	0.04	8.7	14.4	18.3	14.9	25.2	31.8	36.2
Extensive Margin (%)	2.0	2.8	3.0	3.1	100.0	1.9	2.5	2.8	2.2	2.8	3.3	3.1
Aggregate Investment (%)	0.01	0.02	0.02	0.1	187.7	145.7	125.1	123.8	187.8	145.9	125.2	123.6
Exporter Contribution (%)	0	2.2	2.0	2.6	0	3.3	5.4	7.2	0.4	5.6	7.5	8.9
Model 3												
Aggregate Exports (%)	14.1	14.1	14.1	14.2	0.4	3.7	4.7	6.0	14.2	18.5	19.5	21.4
Extensive Margin (%)	0.2	0.2	0.2	0.3	100.0	2.5	2.3	2.4	0.6	0.8	0.8	0.9
Aggregate Investment (%)	0	0.1	0.1	0.03	36.0	29.4	20.1	20.3	36.0	29.4	20.1	20.3
Exporter Contribution (%)	0.03	0.03	0.1	0.1	0.02	0.09	0.06	1.8	0.03	0.08	0.07	1.9
Model 4												
Aggregate Exports (%)	17.3	18.6	18.6	18.6	—	—	—	—	—	—	—	—
Extensive Margin (%)	13.9	17.8	17.0	17.8	—	—	—	—	—	—	—	—
Aggregate Investment (%)	—	—	—	—	—	—	—	—	—	—	—	—
Exporter Contribution (%)	—	—	—	—	—	—	—	—	—	—	—	—
Model 5												
Aggregate Exports (%)	53.1	52.8	52.8	52.6	—	—	—	—	—	—	—	—
Extensive Margin (%)	0	0.01	0.01	0.01	—	—	—	—	—	—	—	—
Aggregate Investment (%)	—	—	—	—	—	—	—	—	—	—	—	—
Exporter Contribution (%)	—	—	—	—	—	—	—	—	—	—	—	—

Notes: Aggregate export and investment growth are measured relative to annual benchmark flows (these are not cumulative measures).

B Figures

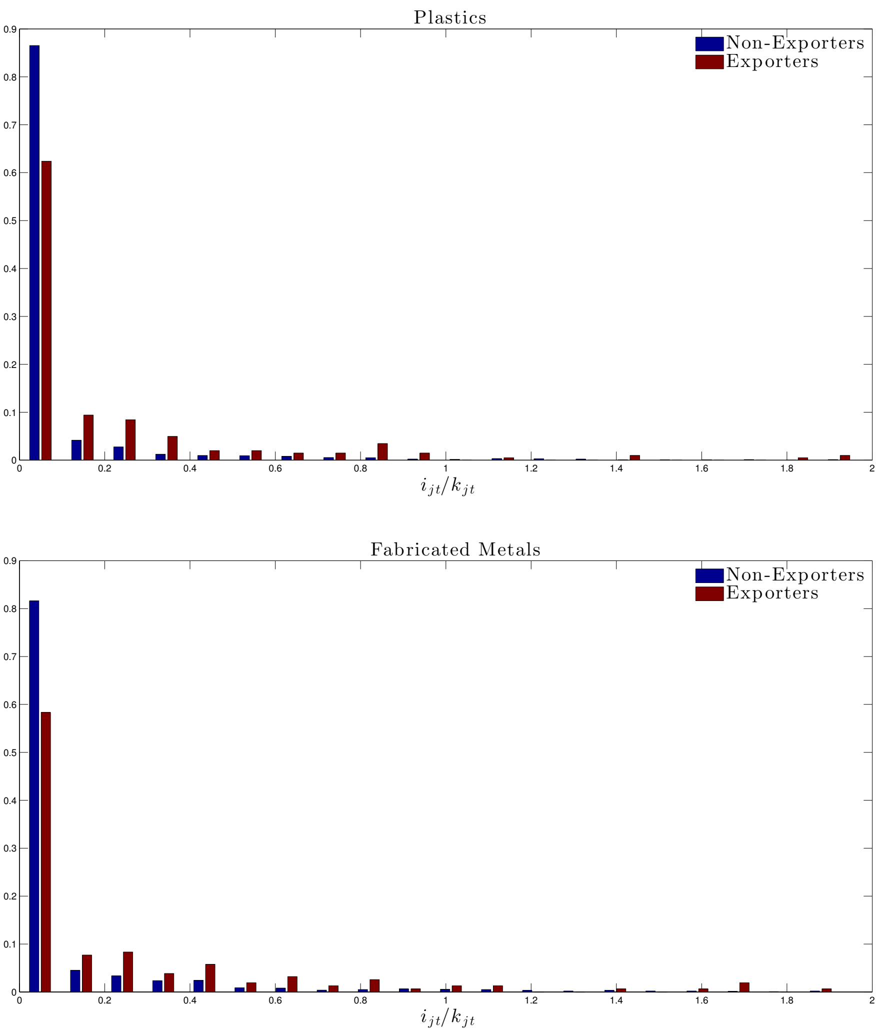

Figure 1: Investment Rate Histograms

Supplemental Appendix for "Firm-Level Investment and Export Dynamics"

by Youngwoo Rho and Joel Rodrigue

Department of Economics, Vanderbilt University, Nashville, TN, United States

E-mail: youngwoo.rho@vanderbilt.edu; joel.b.rodrigue@vanderbilt.edu

NOT FOR PUBLICATION

This document is the Supplemental Appendix for the paper "Firm-Level Investment and Export Dynamics." The following sections provide a detailed data description and all summary statistics which were omitted from the main text.

A Data Construction

The primary source of data is the Indonesian manufacturing census between 1990 and 1995. We focus on these years because the data contain a complete investment series for each firm and the estimates will not be influenced by the 1997-1998 Asian crisis. 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 firm-level information on over 100 variables covering industrial classification (5-digit ISIC), revenues, intermediate inputs, labour, capital, investment, energy, wages and trade behavior. Nominal values of total sales, capital and inputs are converted to the real values using the manufacturing output, input, and export price deflators at the industry level.[53] In order to focus on the domestic industry, we drop all plants where more than 10 percent of equity is held by foreign investors. Table A1 contains a list of the variables under study and a very brief set of sample moments for the entire manufacturing sector and both industries we study in particular.

[53] Price deflators are constructed as closely as possible to Blalock and Gertler (2004). A concordance table between the industry price deflators and the 5-digit industrial classification was provided by BPS Indonesia.

Table A1: Variable Description

Variable	Plastics Obs.	Mean	Std. dev.	Fabricated Machinery Obs.	Mean	Std. dev.
Domestic Sales	2058	14.994	91.282	1782	16.970	44.518
Export Sales	208	20.934	39.787	160	29.769	59.943
Export Share	208	0.401	0.247	160	0.420	0.288
Capital Stock	2058	5.123	29.247	1782	26.255	375.067
Investment	2058	1.015	9.436	1782	0.972	4.513
Fuel	2058	0.284	1.042	1782	0.476	1.216
Electricity	2058	0.809	2.679	1782	0.378	0.938
Intermediate Materials	2058	7.870	38.132	1782	12.478	36.806
Total Number of Employees	2058	0.149	0.253	1782	0.166	0.279
Total Wage Bill	2058	1.172	2.686	1782	1.922	9.316

Notes: Figures are reported in millions of 1983 Indonesian Rupiahs. Export sales and export share are only reported for firms with positive export sales.

B Industry Trends

Table B1 documents macroeconomic trends Indonesian economic environment. The GDP growth rate is calculated from the *International Financial Statistics* from the IMF. The manufacturing share is the share of manufacturing in the Indonesian GDP. The export share is the share of manufacturing exports in total manufacturing revenues. The plastics share and the fabricated metals share are the plastics and fabricated metals revenues in total manufacturing revenues. The exchange rate is the US-Indonesian exchange rate from the Penn World Tables.

Table B1: Macro Trends

	1990	1991	1992	1993	1994	1995
Annual Real GDP Growth Rate	0.07	0.07	0.06	0.06	0.07	0.08
Manufacturing Share	0.32	0.34	0.37	0.39	0.42	0.41
Export Share	0.16	0.20	0.25	0.23	0.27	0.28
Plastics Share	0.02	0.02	0.03	0.03	0.02	0.02
Fabricated Metals Share	0.03	0.03	0.03	0.03	0.03	0.03
Exchange Rate	1843	1950	2030	2087	2161	2249

We observe that there is a strong degree of stability in the Indonesian macroeconomy between 1990 and 1996. The real GDP growth rate grows between 0.06 and 0.08 annually, while the manufacturing share rises by 9 percent between 1990 and 1996. The export share, plastics share, fabricated metals share and the exchange rate move very little over the period.

C Tariff Construction

Figure C1 plots the variation in Indonesian tariff rates over the 1991-1995 period. The export tariff rates are trade-weighted tariff rates faced by Indonesian exporters in export markets. Specifically, let x_{dt} represent the bilateral export flows from Indonesia to a given destination country d in year t. The trade-weighted export tariff in any year is then computed as

$$\tau_t^X = \frac{\sum_{d \in \mathscr{D}} x_{dt}\tau_{dt}}{\sum_{d \in \mathscr{D}} x_{dt}}$$

where τ_{dt} captures the tariff charged to Indonesian exports in destination markets. Since there is very little variation over time and we do not observe firm-level export destinations, we abstract from tariff variation and fix the tariff faced by Indonesian exporters in either market at the sample average

$$\tau^X = \frac{1}{T}\sum_{t=1}^{T} \tau_t^X.$$

The capital import tariffs are similarly constructed. In each industry we first construct determine the average percentage of capital of each type (land, buildings, machinery and equipment, vehicles). We then use this percentage weight the tariff associated with each type of capital. Let $w^{\mathcal{K}}$ denote the weight associated with each type of capital, $\mathcal{K} \in \mathscr{K} = \{$land, buildings, machinery and equipment, vehicles$\}$. The import tariff on capital is then calculated as

$$\tau_t^K = \sum_{\mathcal{K} \in \mathscr{K}} w^{\mathcal{K}} \tau_t^{\mathcal{K}}$$

Again, since there is very little variation over time, we abstract from tariff variation and fix the import tariff on capital imports faced by Indonesian producers at the sample average

$$\tau^K = \frac{1}{T}\sum_{t=1}^{T} \tau_t^K.$$

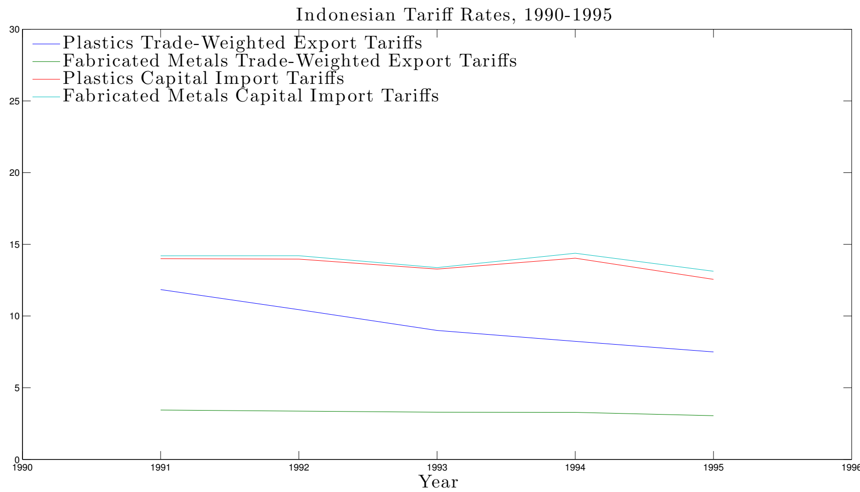

Figure C1: Indonesian Tariffs, 1991-1995