ESSAYS ON TRADE AGREEMENTS AND EXPORT DYNAMICS

By

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To my Wife and Son

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TARIFF OVERHANG AND TEMPORARY TRADE BARRIERS: SUBSTITUTES OR COMPLEMENTS?

Introduction

The WTO trade agreements provide two kinds of trade policy flexibilities for countries when there is shock to the demand for protection. One is most favored nation (MFN) tariff policy flexibility that results from the fact that countries set bound tariffs. If the MFN tariff is less than the bound tariff, which is referred to as a case of tariff overhang, then the government has the flexibility to increase the MFN tariff to protect the import market. The other policy flexibility is temporary trade barriers (TTBs) which include anti dumping, countervailing duties (CVD)and safeguards (SG). To impose TTBs, there is a process of investigation, initiated by the local industry, by which the government determines whether the sector has been injured by the other countries' unfair trade.[1]

The existing literature has emphasized the idea that TTBs are substitutes for MFN tariff adjustment. For example, Busch and Pelc (2010) have shown that TTBs are more likely to be used when there is less overhang level. This means that if the country has less room for the MFN tariff adjustment, then the country use TTBs more to protect

[1]To complete this process, the government should make a law and institutions handling these issues. The objective of AD is to protect import markets from unfair pricing by exporting countries. Article VI of the The General Agreement of Tariff and Trade (GATT) provides for the right of contracting parties to apply anti-dumping measures, i.e. measures against imports of a product at an export price below its normal value(usually the price of the product in the domestic market of the exporting country) if such dumped imports cause injury to a domestic industry in the territory of the importing contracting party. CVD has similar motivation but can only be used in the presence of exporting countries' subsidies. Finally, SG is to protect the import market from serious injury. Article XIX of the General Agreement allows a GATT member to take a safeguard action to protect a specific domestic industry from an unforeseen increase of imports of any product which is causing, or which is likely to cause, serious injury to the industry.

the import market. They focus on the common factor in both policy flexibilities that is contingency for unexpected shock.

However, TTBs differ from MFN tariff adjustment because they allow discrimination between exporting countries. This shoes that discrimination is one of important reasons for TTBs. Since 1995, TTBs have been used extensively by developing countries where tariff overhang is substantial. These facts suggest that there may be complementary characteristics in two kinds of policy flexibilities, meaning that two policy flexibilities response to different forms of shocks. A country specific import shock from different exporting countries is more likely to generate a discriminative response.

My paper focuses on the relationship between the MFN and TTB flexibilities. Emphasizing the discrimination, I make simple model that shows that the incentive for each policy flexibility is different, and test this theoretical findings using nine developing countries panel data. My findings provides the counter examples to the substitutability argument and shows that there is a complementarity characteristics between two policy flexibilities.

In my paper, the complementarity is ex-post characteristic in the sense that the bound tariff is fixed when the country choose tariff flexibilities. This is different from several researches focusing on the endogeneity of bound tariff. Beshkar and Bond (2012) show that contingent protection[2] and tariff overhang are substitute and they may not coexist under a certain condition. This argument is related to the ex-ante substitutability because the availability of contingent protection make the bound tariff lower, which gives the country less MFN flexibility. Kucik and Reinhardt (2008) initiated the "flexibility hypothesis" which is closely related to the ex-ante substitutability. Their empirical study indicates that the

[2] They focus on the safeguard. Safeguard is different from other TTBs because the discrimination is not allowed.

countries that the availability of TTBs more have lower bound and MFN tariffs. This means that the contingency motivates these two kinds of policy flexibilities to protect the import market.[3] However, my paper assumes that the bound tariff was given when the country choose any flexibility, so it is treated as exogenous condition.

My paper was motivated from the observations of developing countries' tariff policies after 1995. Since the WTO started in 1995, many developing countries rigorously imposed anti dumping tariffs (AD) on other trading partners. These developing countries also have significant level of tariff overhangs, which allow them to use MFN flexibilities during the same periods. Bown (2006) shows that 40% of anti dumping tariffs are used by nine developing countries during the period 1995-2004. This is a big change in the trade policy of developing countries. Before 1995, the anti dumping tariff was mainly used by developed countries, and developing countries rarely imposed AD but mainly used the MFN tariff policy.[4] If we only focus on the ex anti substitutability, then it is hard to explain the phenomenon that happened in developing countries after 1995. These facts show that the MFN adjustment and TTBs may have complementarity characteristics rather than substitutability.

Table 1. Characteristics of tariff policy flexibility

		Temporary Trade Barriers	
	Tariff Overhang	Anti-Dumping, Counter-veiling Duty	Safeguard
How to implement?	Increase MFN tariff	Impose new tariff	New tariff, Quota
How much?	Less than Bound tariff	No limit	No limit
Discrimination	No	Yes	No
Cost	No	Prove injury and unfairness	Prove injury

MFN means most favored nation tariff. The country that impose tariff should equally treat all WTO countries.

My study is based on the country specific tariff theory that is related to the dis-

[3] Bhagwati's (1988) "the law of constant protection theory", emphasized that the total protection of the country is the same but the policy tool of protection changes. This theory is closely related to the flexibility hypothesis

[4] During the period 1985-1994, 73% of the total anti-dumping tariff was imposed by developed countries, but this portion decreased to 33% during 1995-2004.

crimination issue. Gardner and Kimbrough (1990) show that the country specific tariff is necessary to maximize the welfare of the country if there is a pretty big difference between exporting countries. This framework was applied to analyze anti-dumping duties. Saggi (2004) provides more specific theoretical tool to analyze the discriminatory tariff. He suggests that under the Cournot-Nash competition, the optimal tariff policy is to impose higher tariffs on the goods that have lower costs. The implication of these papers is that if there is a big difference between exporting countries, then discriminatory tariff policy is better than non-discriminatory (MFN) policy.

I developed these theories and made a simple three-country Cournot-Nash competition model in which home country imports from two different foreign countries. In my model, I clarify that TTBs are different from the MFN flexibilities in two points. First, I include the cost factor in implementing TTBs. To impose TTBs, the country should make the legal process and institutions that handle TTBs. initiation to imposition. Especially, if the import country fails to prove injury of industry and unfairness of exporting countries, the initiated TTBs cannot be imposed.[5] These are treated as a cost when the country imposes TTBs. However, there is no cost in adjusting MFN tariff if there is a tariff overhang.

Second, the model assumes that discrimination is allowed when the country imposes TTBs.[6] The objective of AD and CVD is to protect the importing market from unfair trade of any specific exporting country,[7] but these are used to protect domestic producers by many countries. Nelson (2006) emphasize the political economic aspect of anti dumping which shows that the anti dumping policy is the result of direct or indirect lobbying of

[5]The common process of anti-dumping tariff is: the applicant submit petitions⇒ government gives notice to foreign exporters and investigates it ⇒ if the petition is accepted then the government imposes anti-dumping tariff. The process of safeguard is similar.

[6]Discrimination is allowed when the country imposes ADs or CVDs, so they are called 'country specific tariffs'

[7]The requirement of anti-dumping duty is to prove that the price from exporting country is below the fair price.

industries. This is one of the reasons why TTBs are considered as a tariff policy.[8] Table 1 shows the differences between policy flexibilities.[9].

The main implication of my model is that the economic shocks which trigger specific tariff policy flexibility are different from each other. If there is a big difference in market share between exporting countries, then the optimal tariff policy of home importing country is discriminatory policy. However, if the shock is more general, not country specific and the difference of market share between exporting countries is small, then the MFN tariff adjustment is best response to the shock. Theoretical analysis shows that these two kinds of flexibilities are closely related to the different economic environments.

To test the hypothesis made by the model, I used nine developing countries' panel data (1997-2011).[10] The empirical part is distinguished from previous studies in several points.

First, I made a theoretical foundation that shows the optimal policy choices are functions of economic variables and make econometric model that matches with the theoretical motivation. Previous papers mainly focus on the direct relationship between the MFN and TTBs. Busch and Pelc (2012) document the relationship between ADs, bound tariffs, and tariff overhangs.[11] Moore and Zanardi (2007) analyze the effects of ADs on the

[8]In the real world, it is relatively easy to show the price difference between exporting price and fair price, which is called the dumping margin. In addition to this, there are many cases in which ADs are initiated but not imposed because the government could not prove injuries. The average success rate of ADs is 60% (Bown,2006). However, empirical data shows the import market started to respond when AD (CVD) was initiated. This is the reason why these ADs and CVDs are treated as trade policies instead of legal issue in international trade. The WTO agreements do not allow discriminatory tariffs when the country adjusts MFN tariffs or uses SGs.

[9]The duration of protection by the TTBs is fixed before execution. The range of the tariff is also different between the MFN and the TTBs. The TTBs are not restricted by the bound tariffs, allowing an importing country's government to impose higher tariff rates than the bound tariff rates. More than 90% of TTBs have greater tariff rate than the bound tariff

[10]The countries are Argentina, Brazil, Columbia, Ecuador, India, Indonesia, Mexico, Peru, and Turkey

[11]They show that the sectors having bound tariffs have a greater probability of using TTBs because the bound tariffs restrict the room for MFN flexibility. Their empirical analysis supports the law of constant protection theory. They used only AD data because AD is the most popular TTB, so most of empirical studies focus on analyzing AD.

trade liberalization in developing countries.[12] Prusa and Li (2012) analyze reverse causality. They analyze the effect of TTBs on the level of tariff overhang.[13] These previous papers focus direct relationship between the MFN and TTBs, in which one of them is independent and the other is dependent variable. However, my theoretical motivation shows that both policies are closely related to the specific economic environment change. In my study, I made a multivariate probit model that includes both policy flexibility as choice variables, and then test the relationship between these choice variables and economic variables.

Second, I used highly disaggregated sectoral level data that is HS-6 digit level.[14] Kucik and Reinhardt (2008) used country level data to provide the evidence for "flexibility hypothesis". I tested this hypothesis using sectoral level data and show the results are different from this hypothesis.

Third, I also tested the classical optimal tariff theories, which shows that the MFN tariff is closely related to the market power measure. The previous papers use cross section data to support this argument, but I use panel data and show that the time variation of market power is positively and significantly correlated with the probability of MFN tariff increasing.[15] My empirical study shows the dynamic aspects of the previous optimal tariff theory.

[12] They showed that ADs are negatively correlated with trade liberalization, which is measured by the amount of decreasing MFN tariff. This means that the sectors using ADs do not decrease tariffs as much as the other sectors that do not use AD. This is a counter example to the argument that TTBs contribute to trade liberalization.

[13] Their main argument is that there is no consistent, and significant relationship between TTBs and tariff overhang level. This evidence is also counter example to the substitutability argument. Bown (2012) analyzes Turkey's case where this country used these flexibilities heavily after the 2008 financial crisis. He finds that these flexibilities are closely related to economic variables, which indicates that the motivation of tariff policy is to protect the import market from the unexpected change of economic environments.

[14] The WTO and UN provide HS-6 digit level tariff and trade data.

[15] Broda, Limao, and Weinstein (2006) use export supply elasticity as a market power measure and they show that there is a positive relationship between the market power and the optimal tariff level. Beshkar, Bond, and Rho(2012) uses the import ratio as a market power measure and shows that the tariff bindings and overhangs are negatively related with the market power. Bown(2007) analyzes the time variant characteristics of anti-dumping tariffs. He focuses on analyzing the determinants of anti-dumping tariffs in developing countries using political-economic variables and the WTO agreement's evidentiary and macroeconomic variables. In this paper, these variables are closely related to the probability of imposing ADs.

The theoretical and empirical studies show that the motivation of the MFN and TTBs are different and these policies are used in different economic environments. If there is an import surge in specific sectors, which is measured by the change of import share to the world import, the probabilities of MFN increasing and TTBs increases.[16] The import surge is common factor that induce the government to protect the import market by using any policy tools. If the import ratio increase by 1 standard deviation then the probabilities of MFN increasing and TTBs increase by 3-6% if the other control variables are constant. The import ratio change is used as a proxy for general shock to the sector of import country.

However, the changes of import market structure affect only the probability of TTBs, which means that TTBs are used to protect the import market if the import market is monopolized by specific countries. The import market Herfindahl index (HI) is made for measuring the market structure change. If HI increases, which means that the exporting share of a specific countries increase, then the probability of the TTBs also increases. The prediction of MVP model indicates that if the HI increases by one standard deviation, then the probability of TTBs initiated also increases by more than 10%. However, HI is not significantly correlated with the probability of the MFN increasing. In this study, I found that the HI is a critical variable that affects the decision of government about tariff policies.

I also found that the level of tariff overhang in previous year has an important role in deciding optimal tariff policy. If the overhang is small, which means that the government has a small room for increasing the MFN tariffs, then the probability of MFN increasing decrease by more than 30%. This shows that the role of bound tariff on the MFN tariff policy. The other variables, for example, inverse export elasticity and time average output ratio, have different effect on the probabilities of MFN and TTB choices.

[16] In the model, the difference of marginal costs between exporting countries has one to one relationship with the market share of exporting countries. The sum of marginal cost is also measured by the total import of that sector.

My empirical findings show that the two flexibilities have complementary characteristics to each other in the sense that the economic shocks that induce the MFN and TTB policies are different, so the country needs both polity flexibilities to response to the diverse economic shocks.

The rest of this paper proceeds as follows: the next section presents the motivation for the policy flexibility. Section 3 is the data description and the empirical results. Section 4 is the conclusion and the discussion.

The Theoretical Motivation for Policy Flexibility

The policy flexibilities are necessary to protect the import market from unexpected shocks. This chapter examines the motivation of the discriminatory and contingent tariffs using simple a Cournot duopoly model[17]. I examine the optimal tariff theory under a bound tariff constraint.[18] This is because the bound tariff is fixed when the government changes the tariff policy.[19]

The first part is related to the MFN tariff policy, which includes the MFN tariff variation and safeguard. These MFN policy flexibilities are related to the overall exporting countries' productivity. The second part shows the motivation of discriminatory tariffs (AD and CVD). If there is a big difference in productivity between exporting countries, then discriminatory tariff policy is optimal under bound tariff constraint. The theoretical example shows policy flexibilities are the result of optimizing policy responses to unexpected shocks.

[17] The theoretical model is given by Saggi(2004)

[18] We can also think about the endogenous bound tariff decision model. This is out of the coverage of this paper

[19] The data is from 1998 that is after the WTO starts. The bound tariff is given when the countries make the MFN tariffs.

(1) MFN tariff

This is a 3 country partial equilibrium model. Consumer preferences are represented by the quasi linear utility function, $U(x_0, x_1...x_N) = \sum_{j=1}^{N} g(x_j) + x_0$ and $g(x_j) = x_i - \frac{1}{2}x_i^2$. Good x_0 is the quantity of *numeraire* good and x_i indicates other goods. From this utility function, the demand function of good j is derived as $p_j = 1 - d_j$. I focus only one sector problem from now on.[20] Each country has one firm in one sector and marginal cost of the firm in country i is constant. $MC_i = c_i$

We also assume Cournot competition in the home country market. The politically weighted social welfare function of sector i is [21]

$$W = CS + \theta PS + TR \tag{I.1}$$

where CS is consumer surplus, PS is producer surplus, TR is tariff revenue and θ is political weight put on the producer's surplus. I assume that domestic interest groups lobby to protect their import market and government policy is affected by these lobbies. In this case θ is greater than 1. There is a constraint of the bound tariff (t^B) because bound tariff is fixed when the country decide optimal tariff policy. So the maximization problem is

$$\begin{aligned} Max_t W(t:\Theta) &= CS(t:\Theta) + \theta PS(t:\Theta) + TR(t:\Theta) \\ s.t. \quad & t \leq t^B \\ \Theta &= (c_1, c_2, c_3, \theta) \end{aligned}$$

This welfare function is quadratic and concave in tariff(t) so the optimal tariff that maxi-

[20] After this I do not use subscript j to represent sector.

[21] The subscript i is left out.

mizes social welfare is

$$t^* = \frac{1 + 5c_1 + (2\theta - 3)C + 2\theta - 6c_1\theta}{14 - 4\theta}, \text{ if } t^* \leq t^B \quad (I.2)$$

$$t^* = t^B, \text{ if } t^* > t^B \quad (I.3)$$

$$C = c_2 + c_3$$

If the home country imposes the MFN tariff on both exporting countries, then the optimal MFN tariff is: $t^m = t^*$ if $t^* \leq t^B$ and $t^m = t^B$ if $t^* > t^B$.

From this formula, it is clear that if this problem has an interior solution then[22]

$$\frac{\partial t^m}{\partial \theta} = \frac{4(2 - 4c_1 + C)}{(7 - 2\theta)^2} > 0 \quad (I.4)$$

The MFN tariff is an increasing function of political weight ($\theta(\geq 1)$). This formula also shows that the MFN tariff only depends on the sum of foreign countries' marginal cost parameters ($C = c_2 + c_3$). The first derivative to the sum of foreign countries' marginal cost parameters is:

$$\frac{\partial t^m}{\partial C} = \frac{2\theta - 3}{14 - 4\theta} \quad (I.5)$$

Under the assumption that $\theta < \frac{3}{2}$, t^m is a decreasing function of C. Under these settings, the level of total imports of the home country is also a function of C.

$$IM^m = \frac{3 + c_1 - 2\theta + 2c_1\theta - 2C}{7 - 2\theta}$$

$$\frac{\partial IM^m}{\partial C} = \frac{-2}{7 - 2\theta} < 0$$

As the sum of the foreign countries' marginal cost parameters decreases, then the imports of the home country increase. This means the market power of the home country increases,

[22]This inequality is from the assumption that the home firm produces positive amounts of good after the tariff.

and the optimal tariff also increases.[23] This theoretical example shows that the MFN tariff is sensitive to the political weight of the sector and the sum of foreign countries' marginal cost parameters.

One of the TTBs is safeguard policy which allows the country to impose a tariff that is greater than the bound tariff, but there is a cost in imposing it. If the optimal tariff which is induced by import surge (export countries' marginal cost decrease) or political shock is greater than the bound tariff, then the government can impose a safeguard tariff after paying a cost. If the cost of imposing safeguard is fixed as F^S, then a necessary condition for imposing the safeguard policy is

$$W^S(t^S;\Theta) - W^B(t^B;\Theta) \geq F^S \tag{I.6}$$

This simple model can explain when the country use safeguard tariff policy. The safeguard tariff has to follow the MFN principal.[24] In this model, social welfare function is increasing in t if t is less than the optimal tariff (t^*). There is an area that satisfies $W(t^*) > W(t^B)$ but $W(t^*) - W(t^B) < F^S$. In this case, the safeguard tariff is not optimal because its welfare benefits are exceeded by its costs. However, if $W(t^*) - W(t^B) > F^S$, then the country tried to impose safeguard tariff.[25] This is shown in figure 1.

(2) Discriminatory tariff

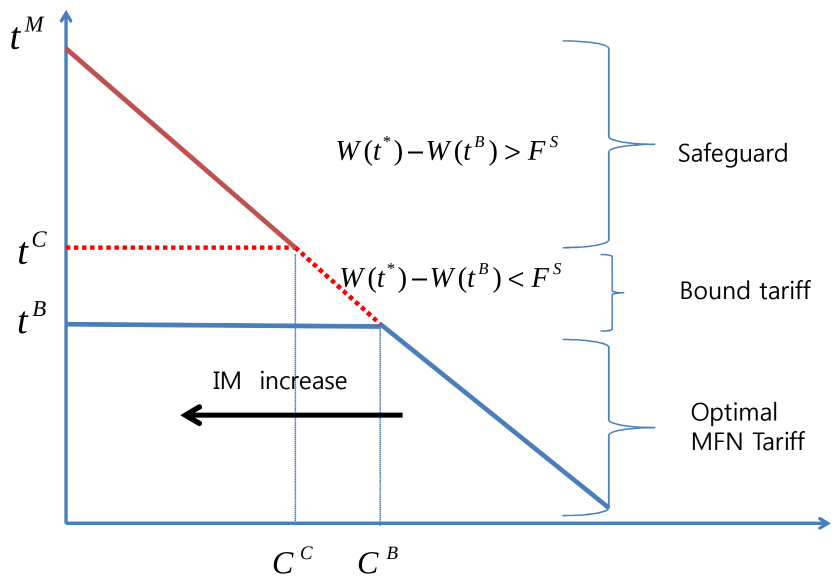
With the same setting as the MFN tariff case, the optimal discriminatory tariff is also derived from the social welfare maximization problem. The WTO agreements allow

[23] The import country's market power is measured by inverse export elasticity or import ratio to the world import. See Beshkar, Bond and Rho (2012)

[24] Beshkar and Bond (2012) provide the theoretical model explaining the escape clause of the WTO agreements.

[25] Safeguard includes not only tariff but also other trade barriers

Figure 1. Safeguard and MFN tariff



the discriminatory tariff to lie above the bound tariff, so there is no bound tariff constraint. We also assume that there is a fixed cost (F^D) to imposing discriminatory tariffs.

$$Max_{t_2,t_3} W(t_2, t_3 : \Theta) = CS(t_2, t_3 : \Theta) + \theta PS(t_2, t_3 : \Theta) + TR(t_2, t_3 : \Theta) - F^D$$

The optimal discriminatory tariffs on country 2 and 3 are: [26]

$$t^2 = \frac{2 + 10c_1 - 13c_2 + c_3 + 4\theta - 12c_1\theta + 6c_2\theta + 2c_3\theta}{28 - 8\theta} \tag{I.7}$$
$$t^3 = \frac{2 + 10c_1 + c_2 - 13c_3 + 4\theta - 12c_1\theta + 2c_2\theta + 6c_3\theta}{28 - 8\theta}$$

It is clear to show that $\frac{\partial t^i}{\partial \theta} > 0$, $\frac{\partial t^i}{\partial c_i} < 0$, and $\frac{\partial t^i}{\partial c_j} > 0$. The marginal cost of country i (c_i) is also related to the imports from country i, so this formula shows that if the imports from exporting country i increase (which has the same effect as a decrease in c_i), then the optimal

[26] I assume the cost of imposing discriminatory tariff. But it is a fixed cost, then the maximization problem is the same as the MFN tariff case.

tariff imposed on country i increases. The political effect that occurs from the change of θ on the discriminatory tariff is the same as the MFN tariff case.

If the country can impose the optimal MFN tariff, which means the optimal MFN tariff is less than bound tariff ($t^* < t^B$), then the relationship between discrimination and the MFN tariff is

$$\begin{aligned} t^2 - t^m &= \frac{1}{4}(-c_2 + c_3) \\ t^3 - t^m &= \frac{1}{4}(-c_3 + c_2) \\ t^m &= \frac{t_2 + t_3}{2} \end{aligned} \tag{I.8}$$

If $c_2 < c_3$, then $t^2 > t^m$ and if $c_3 < c_2$, then $t^2 < t^m$. So if the exporting country has a low marginal cost, it pays a higher tariff. It is also clear that $W^d(t^2, t^3) > W^m(t^m)$. The difference of welfare between two policies is

$$W^d(t^2, t^3) - W^m(t^m) = \frac{1}{8}(c_2 - c_3)^2 \tag{I.9}$$

As previously assumed, the home country must pay a cost when it imposes a discriminatory tariff. Considering this cost, the necessary condition for imposing a discriminatory tariff is

$$W^d(t^2, t^3) - W^m(t^m) = \frac{1}{8}(c_2 - c_3)^2 > F^D \tag{I.10}$$

where F^D is the fixed cost of imposing a discriminatory tariff. As the difference in marginal costs between exporting countries rises, there is more incentive to impose a discriminatory tariff. The sufficient condition for discrimination is that the difference in marginal costs between exporting countries is sufficiently high to cover the fixed cost of implementing the discriminatory tariff.

The other case is that the optimal MFN tariff is greater than the bound tariff

$(t^* > t^B)$. If this is the case, the only alternative to imposing a discriminatory tariff is imposing the bound tariff. If the country imposes the bound tariff, then welfare is less than it would have been under the optimal tariff (e.q.,$W(t^*) > W(t^B)$). The sufficient condition for imposing a discriminatory tariff is

$$W^d(t^2, t^3) - W^B(t^B) > W^d(t^2, t^3) - W^*(t^*) \tag{I.11}$$

This means that if there is a relatively small shock to the foreign exporting countries, the home country prefers to impose a discriminatory tariff when the alternative policy is to impose the bound tariff. The level of the bound tariff has an important role in deciding whether a discriminatory tariff is imposed.

The above formula shows that only the difference of the marginal cost parameters is important when an importing country government chooses discriminatory tariff policy. The level of tariff is decided by the value of parameters and political weight (θ) of the sector, but only the difference of MC between exporting countries matters when choosing tariff policy.

The Cournot model suggests simple and clear implications about tariff policy. Although it relies on the assumption that firms only compete on quantity, the theoretical prediction and motivation for the use of discriminatory tariffs are similar to those obtained from the Cournot model when firms are allowed to competition in other dimensions. The appendix provides theoretical results when the quantity competition assumption is relaxed.

(3) Policy Implication

Tariff policy is closely related to changes in the economic environment of domestic or foreign countries. In the previous section, we showed that the sum of foreign export countries' productivity shock and the importing country's market structure are important determinants of tariff policy. Figure 2 illustrates the optimal tariff policies as responses to economic shocks.[27] In this graph, x and y axes are the marginal cost parameters of exporting countries. Any point in this plane shows the marginal costs of exporting countries that are directly related to the import levels from two countries. The total import of home country depends only on the sum of marginal cost parameters of exporting countries, m shows the total import level and if m is closer to to origin then the import of home country increases.

I assume that S_t is state in period t. S_t shows not only the total import level but also the import share of each exporting country. At S_t, c_2 is same as c_3, so the market share of each export country is same, which is 50%.

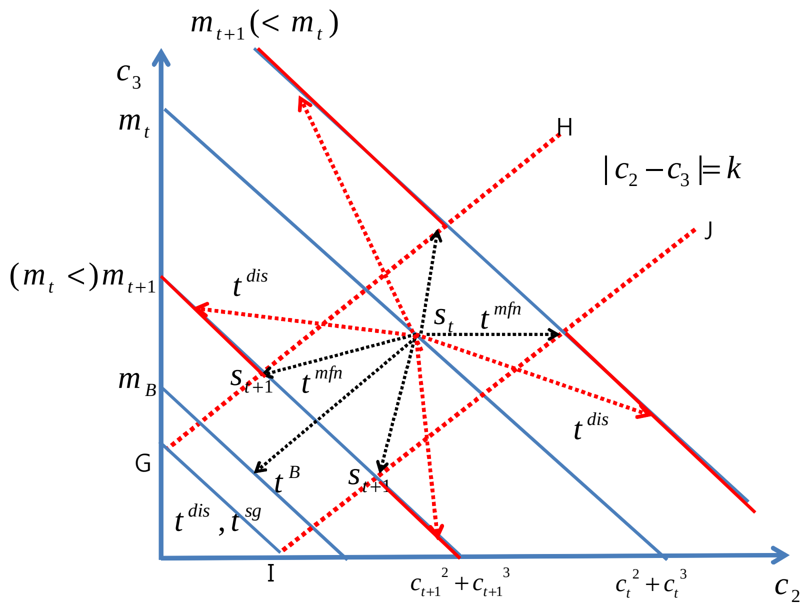
In period $t+1$, the total import and market structure could change. As I show in theory part, the optimal MFN tariff change depends on only the sum of the exporting countries' marginal cost (productivity) shock. If there is a change in the total sum of exporting countries' marginal costs, then there is an incentive to change the MFN tariff. If there is a downward shock on exporting countries' sum of marginal costs, then there is an incentive to increase MFN tariff.[28] However there is a downward marginal cost shock only in one of the exporting countries, then the market share of that country increases. The difference of marginal cost shock between exporting countries is greater than a critical point, then the incentive of discriminatory tariff increases.

These optimal tariff policies is shown in this graph. If the new point (S_{t+1}) is outside of the lines $\overline{GH}$ and $\overline{IJ}$, then the incentive to impose discriminatory tariff increases. If the new point lies inside of the area of $\overline{GH}$ and $\overline{IJ}$, then the MFN tariff is more attractive.

[27]In this part, we assume the political shock is not time variant.

[28]If c_2 and c_3 are independent random variable that has same distribution, then $(c_2 + c_3)$ and $(c_2 - c_3)$ are also independent. It is possible that $c_2 + c_3$ and $c_2 - c_3$ be on any point on the graph.

Figure 2. Optimal Tariff Policy



If the point is close to the origin then the incentive to raise MFN tariff increases. If the total productivity shocks of exporting countries are large enough to move the $c_2 + c_3$ line close to the origin, then the optimal policy is SG. This is because m_B shows the level of MFN tariff that is equal to the bound tariff. If the optimal MFN tariff is greater than the bound tariff, then the country can use SG to protect the importing sector. Figure 2 also shows the policy mix case. If the marginal cost parameter decreases so fast and the difference in the marginal costs also grows, then the policy mix of the MFN and TTB would be optimal. The data shows this kind of tariff policy mix. This graph can also illustrates that the cost of implementing a TTB is important in deciding tariff policy. If the cost is big, then the area for optimally imposing a TTB decreases and the policy mix area of the MFN and TTB also decreases.[29]

Data and Empirical Strategy

The model in the previous section has prediction based on welfare changes. Using this prediction, I made an empirical model and test it using nine countries' panel data. The main hypothesis is that the policy choice depends on the economic environment change. To test the hypothesis, I make econometric model and a proxies which are closely related to the theoretical model and estimate the effect of economic variables on the policy choices.

Data Description

I analyze data from nine counties between 1997 and 2011: Argentina, Brazil, Columbia, Ecuador, India, Indonesia, Mexico, Peru and Turkey. There are several reasons why these countries were chosen. First, these countries have large tariff overhang levels, which means that they have room to use MFN policy flexibility.[30] Table 2 shows the average bound and MFN applied tariffs of these countries. The overhang, the gap between bound and MFN tariff, is more than 10%, which means that these countries can increase MFN tariff by 10 percent points without paying any cost. Second, these nine countries used TTB flexibilities more often than other developing countries. Bown (2006) shows that the portion of anti-dumping tariffs which are used by these developing countries are about 40% of total number of anti-dumping tariffs during the period 1995-2004. This portion is greater than the number of ADs that are used by developed countries. By analyzing these countries, I study the motivation of each policy flexibility and the relationship between

[29] The cost of TTBs is related to the level of k in this graph. If k is big enough, then the area of TTB policy become much smaller.

[30] Many developed countries, such as the US, Canada, have overhang levels which are close to 0. In this case the country has no room for MFN flexibility

these two policies. Third, these countries provide consistently tariff data during the period 1999-2011.

Table 2. Countries Characteristics

Country	number of sectors	bound tariff ratio(%)	average of bound tariff	average of MFN tariff	frequency of MFN increase	frequency of MFN decrease	frequency of TTB use
Argentina	3518	100(%)	32.06	13.11	174	564	20
Brazil	3543	100	30.9	14.35	72	719	2
Columbia	3518	100	35.38	11.47	29	203	10
India	3302	85.3	34.28	19.38	361	1804	42
Indonesia	3500	96.1	35.92	6.89	80	193	6
Peru	3496	100	29.2	8.91	18	610	17
Turkey	3471	33.1	15.66	3.39	115	608	22
Mexico	3543	100	34.82	13.48	281	803	6
Ecuador	3476	100	21.19	11.11	93	431	17

GDP, per capita GDP, import, export is time average, average MFN is time and sector average

The sample captures disaggregated manufacturing sectors from all nine countries.[31] The sectors are highly disaggregated into Harmonized System (HS) 6 digit categories. The WTO provides MFN and bound tariff data at the HS6 digit level.[32]

The World Bank provides the TTB data. This data is more disaggregated than the MFN or bound tariff data. TTB data is available at the HS-8 or HS-10 digit level because AD and CVD are imposed on specific exporting countries at the HS-8 or HS-10 digit level. While TTB tariff rates are generally much greater than those of MFN tariffs, this does not mean that TTBs protect import-competing industries more than MFN tariffs. MFN tariffs often affect a broad set of traded goods, while TTBs are highly disaggregated and target specific countries.[33]

The trade data is from the UN Comtrade data set. The UN provides annual import and export data at the HS-6 digit industry level. It also identifies import and

[31] The sectoral production data from the agriculture industry is not available. Further, agricultural tariffs are more affected by political factors and TTBs are more popular in manufacturing sectors.

[32] The tariff is more disaggregated into HS-8 or HS-10 digit, then HS-6 digit tariff is the average of the sectors that are categorized by HS-8 or 10 digit.

[33] The data set shows that the average number of countries in one sector of one import country is around 20. If the importing country imposes 100% AD on one specific country, then the average tariff rate of that sector is simple average of the TTB divided by the number of exporting countries. (20). So it has the same effect as a 5% increase in the MFN tariff rate.

export partners and trade volumes between those partners. Sectoral output data is from the United Nations Industrial Development Organization (UNIDO).[34]

Table 2 provides summary statistics for each country. All of these countries have AD laws over this period. They can choose TTB policies when the domestic legal conditions of each policy are satisfied. All countries set up bound tariffs in 1995, but the WTO provides these countries a phase-in period. Usually this period is 10 years after making WTO trade agreements. This means that they can use any policy flexibility even if the applied tariff is greater than or equal to the bound tariff. Most countries in my sample have a significant overhang level, so they can choose any of the policy flexibilities whether they are in phase in period or not.

Table 3. The probability of policy flexibilities (probit)

	Panel	Cross section
	$Prob(\Delta t_t^{ttb} > 0\|X)$	$Prob(t^{ttb} > 0\|X)$
$Over_{t-1}$	$-.00064^{***}$	
	(.00018)	
$\overline{Over}$		$-.00084^{***}$
		(0.0003)
Pseido R-square	0.055	0.0532
Num. of observation	389348	31364
Con.,year fixed effect	Yes,Yes	Yes, No

Table 3 is the result of simple test that shows the relationship between tariff overhang and TTB policy flexibilities. I estimate the probability of TTB flexibilities using previous overhang level as a main independent variables. First two column is the result of panel data. The dependent variable is binary variable that shows the sector use the TTB flexibility in year *t*. The independent variable is the overhang level in pervious year (*t-1*).[35] The previous year's overhang is negatively correlated with the probability of TTB flexibility.

[34]The unit of output data is ISIC 4 digit categories. This is more aggregated than HS 6 digit level. We matches the code and put the same output to the HS 6 digit industries which are in the same ISIC 4 digit categories.

[35]If the sector has no bound tariff, which is unbound sector, then I put the maximum bound tariff level for that sector. The maximum bound tariff in my data set is 150.

This result is consistent with Busch and Pelc (2010) in the sense that the probability of TTB decreases if the overhang increases in previous year.

The second column in table 3 shows the result of similar estimation, but in this case I used cross section data. The binary variable takes value 1 if the sector used TTB flexibility at least one time during the sample period (99-2010). The main independent variable is the time average level of tariff overhang. The results of cross section estimation have the same result as panel data case. The probabilities of TTB policy flexibility is negatively correlated with the average overhang level, which has the similar implication to the previous panel data case.

Figures 3 shows the frequency of policy flexibilities that are used during the sample periods. The red solid line shows the number of TTBs that are initiated in each year. The green dotted line is the number of TTBs imposed. The blue dotted line is the number of sectors in which MFN increases. The variation of imposed TTBs is stable as this figure shows. The number of TTBs initiated increased very quickly in 2004-2005. This period is the time when the phase in periods end so it was hard to use MFN flexibility to protect import markets. Instead of using MFN flexibility, many developing countries used TTB flexibilities for protection. Figure 3 shows that the number of MFN adjustments decreased in this period. This figure supports the argument that TTBs are used as an escape from the bound tariff commitments, as indicated by the "flexibility hypothesis".[36]

Another interesting fact is that the number of MFN adjustment increased rapidly in 2007-2008, which is the global financial crisis period. However TTBs were not used much in this period. The financial crisis was a global shock. Figure 3 indicates that the MFN flexibility was used to protect the domestic market from a global shock.

[36]Kucik and Reinhardt (2008) test this hypothesis using country level tariff and AD data. They found the negative causality between AD law and the level of bound tariff.

The most popular tool among TTBs is anti-dumping tariffs. More than 85% of TTBs are anti-dumping tariffs. The second popular tool in TTB is China-specific countervailing duties which accounts for 8.9% of TTBs. This indicates many developing countries used TTBs to protect their market from China's rapidly increasing exports after 2000. Many developed countries used countervailing duties but this tool is very rarely used in developing countries, which is only 0.8% of this sample. The portion of safe guide is less than 5%.[37] This means more than 95% of TTBs are focused on a specific country, so most TTBs were discriminatory when they were used. In the previous section, I focused on the discriminatory issue to maximize social welfare. This approach can be justified by the TTB data.

Table 10 shows the number of policy flexibilities that are used from 1999 to 2011. All countries used tariff policy flexibilities during this period. This table also shows that the frequency of increasing MFN tariff is concentrated in specific years, which means that the country and year specific factors are important in explaining MFN tariff adjustment.

Table 7 shows the frequency of each policy combination. The total number of observations between 1999-2011 is 306,242.[38] In this sample, 17577 (4.47%) observations used MFN policy flexibilities. 0.5% of total observations used TTB policy flexibilities. A very small number of observations (0.03%) used both policy flexibilities in the same year. The number of observations that decrease tariffs is 68562, which is 17.42% of total observations. Table 8 shows similar facts but in this table, I use the the frequency of TTB

[37] If the country wants to increase the MFN tariff above the bound tariff, they can also use a safeguard. The safeguard is a tool of contingency protection in special cases. The country cannot discriminate against any country and should apply MFN principle when it uses safeguards. When the countries use safeguards, they use quotas or other restriction of imports instead of increasing tariff rate, so it is hard to get the equivalent tariff rate for safeguard. The bound tariff rate is closely related to the MFN tariff policy because the bound tariff is the upper bound of MFN tariff. However, if the country is in the phase-in period, then there is no restriction on imposing MFN tariff. The phase-in period ends in 2004 or 2005 in our sample.

[38] The data for 1998 is missing because we cannot calculate a first difference.

imposed. In this case, the number of sectors that use both flexibilities are smaller (0.01%) than that in previous table (0.05%).

Econometric Model

I assume several things to implement the empirical model. First, the country can choose a policy flexibility when they recognize an import shock from foreign exporting countries. There is a one period time lag between recognition and implementation.[39] Second, the import shock is time variant. Third, the shock is country and sector specific. Each sector of each country experiences specific shocks, and the tariff policy flexibilities are related to the characteristics of these shocks.

Basically I define three kinds of policy choices to response the economic shocks: MFN increases, MFN decreases, and TTB use. When the country initiates TTBs, they have to fix the duration of protection. This means that the TTB decrease[40] case is not decided by the economic environment change, so I do not consider about the TTB decreasing case. The policy choice variables are made by first difference of the tariff rates. In our experiment, the choice variable is the change of tariff policy in year t. If there is no change in tariff policy, then I assume the government does not choose any policy flexibility.

Under these assumptions, I made a probit model to estimate the probability of each policy which is chosen to protect the domestic market from economic shocks. The

[39] In theoretical model, I did not consider explicitly the time difference between the time when the shock happen and the time when the policy is implemented. In empirical model, I introduce the time lag.

[40] This means that the country decrease TTB, or the end of imposing TTB.

basic equations of the probit model are

$$y_{ijt}^{m*} = \beta^{m'} X_{ijt}^{m} + \varepsilon_{ijt}^{m}, \; m = 1,2,3 \tag{I.12}$$

$$y_{ijt}^{m} = \begin{cases} 1 & \text{if } y_{ijt}^{m*} > 0 \\ 0 & \text{otherwise} \end{cases}$$

The definition of the MFN flexibility in this paper is that $y_{ijt}^{1} = 1$, if $t_{ijt}^{m} - t_{ijt-1}^{m} > 0$, where i is the HS-6 digit sector, j indicates country and t indexes years. The government is choosing to use its upward MFN flexibility if $\Delta t_{ijt} > 0$. In relation to another policy choice, I define $y_{ijt}^{1} = 1$ if the country initiate a TTB. I observe many cases in my data which shows that after initiating a TTB the import of that sector responds to the policy change even if TTB is not imposed. This is because once the TTB is initiated, the government starts to investigate, which affects the trade pattern in that sector. This is the reason why I define TTB flexibility when it is initiated. In the main estimation, I used the binary variable which is related to initiating TTBs. In the appendix, I add the results using the binary variable that indicates imposing TTBs and compare the results. In addition to this, if the government initiates TTBs on several countries or more highly disaggregated level of sectors (HS8 or HS 10 digit) in year t, then I put the number $t_{ijt}^{d} = 1$ and otherwise $t_{ijt}^{d} = 0$. This means I do not consider the degree of protection when I define the binary variable of TTB.[41]

When a government uses a TTB, it has to fix the duration of protection. Because we focus on policy variation, the first year of the TTB takes the value 1. The other periods in which the TTB is imposed take the value 0 because no policy change has occurred in those periods. This means the choice variable of TTBs is $y_{ijt}^{2} = 1$ if $t_{ijt}^{d} - t_{ijt-1}^{d} > 0$.

[41] The maximum number of anti-dumping initiated in one HS-6 digit sector is 55 in my sample. This can happen when the country initiated AD in highly disaggregated level, i.e. HS 8 or HS 10, and on many countries. In this empirical section I do not consider this case differently from the other cases. The degree of protection when TTB is initiated will be considered in future research.

The other choice variable, an MFN tariff decrease, is similarly defined to the tariff increase. In this case, $y^3_{ijt} = 1$ if $\Delta t_{ijt} < 0$. This flexibility only includes the case in which MFN downward flexibility is used. Table 10 shows the frequency of policy choices.

These choices are closely related to the social welfare maximization problem defined in the previous section. If we observe that sector i in country j chooses policy 1 at time t, then it must be that $W^1_{ijt} > W^2_{ijt}$ and $W^1_{ijt} > W^3_{ijt}$. We assume that the latent variable can be written $W^m_{ijt} = \beta^m X^m_{ijt} + \varepsilon^m_{ijt}$, where X_{ijt} are economic variables which determine the choice variable.

With these specifications, I estimate 3 kinds of estimations. First, I estimate the probability of each policy using single probit model. In this case, I assume that the error terms (ε^m_{ijt}) are independent in each policy case. Second, I focus on the MFN increases and the TTB cases. In this case, I assume that there are common unobserved factors that affect both policies. The error terms have a bivariate normal distribution which have correlation parameter $\rho(\neq 0)$. Third, I use a multivariate probit model (MVP) to estimate the relationship between the chosen policies and key economic variables. This case includes MFN decrease policy choice. In this case, I assume that ε^m_{ijt}, error term, has a multivariate normal distribution with 0 mean, and a symmetric variance-covariance matrix V ($\rho_{jk} = \rho_{kj}, k \neq j$), and takes the value 1 on the leading diagonal elements ($\rho_{ii} = 1$). y^m_{ijt} is a binary variable that indicates which kind of policy flexibility is chosen. One of the advantages of this model is that it allows the error terms to be correlated across choices. It also estimates the correlation between error terms and tests the significance.[42]

[42]The multi-nominal logit (MNL) model is simpler to calculate, but MNL assumes the independence if irrelative alternatives (IIA). This is strict assumption in policy choice case. I also use the GHK (Geweke, Hajivassiliou,Keane) estimation procedure when I use MVP. This procedure has two steps. First, the decomposed error term is drawn from the truncated distribution function, which is related to the choice variables. The probability of each choice is calculated in each draw. After iterating this process R times, the average of probability of that choice is calculated. Second, we calculate the parameters that maximize the log of the likelihood function as standard maximum likelihood estimate (MLE) using the average probability of each

Two explanatory variables are introduced to measure the economic shocks in the import market. We measure each determinant in first difference under the hypothesis that these variables determine policy change.

The first explanatory variable is the difference of the world import ratio in each year. As we show in the previous section, this is the proxy of the total productivity shock from all exporting countries.[43] The world import ratio is defined as

$$RI_{ijt} = \frac{IM_{ijt}}{\Sigma_{j=1}^{J} IM_{ijt}} \tag{I.13}$$

where IM_{ijt} is the import value of sector i, country j and year t. RI_{ijt} indicates the home country's relative import market size. I introduce the time variation of RI as a proxy of shock that affect total import variation.[44] First, RI can control of the variation of currency. Each country's import values are measured in dollars. The change of dollars in each country is canceled out by dividing by the world import value. Second, RI also captures the variation from global shocks. If the global import volume increases or decreases, this variation cannot affect the relative market size of one country. In section 2, the import shock arises from productivity shocks in foreign exporting countries. The relative import size which is measured by RI can capture the variation of foreign exporting countries' productivity.

The second shock captures a change of import market structure, more precisely, the degree of monopolization in a specific sector. In the previous section, the sufficient condition for the discriminatory tariffs is that the difference in marginal costs between

choice. This process is simulated MLE (SMLE). In this estimation procedure, it is important to use a sufficient number of iteration to get the consistent estimate. The necessary condition for consistent estimation is that R is greater than the square root of the sample size. In this paper, the sample size of estimation is 269,167, so minimum R is around 500. I use the Stata package by Cappellari and Jenkins (2003). In this paper,we report R=500 case.

[43] Or the marginal cost shock

[44] Empirical evidence shows that sectors with greater market size have a smaller bound tariffs.

exporting countries must be greater than the fixed cost of imposing TTBs. The bigger the difference in marginal cost between exporting countries, the greater the incentive to impose TTBs. An import market 'Herfindahl Index'(HI) is introduced to measure the degree of import concentration.

$$H_{ijt} = \sum_{k=1}^{N} s_{ikjt}^2 \tag{I.14}$$

The time difference of H_{ijt} is used to capture changes in import market structure.[45] In this formula *'s'* is the market share of exporting country *'k'*, in importing country *'j'*, in sector *'i'*, at time *'t'*. If this index rises, then exporting country's market share increases.

The current period imports are affected by the tariff policy in the same period. This means RI_{ijt} and H_{ijt} are a function of tariff policy in year t, which introduces an endogeneity problem. In this paper, I assume there is a time lag between the time in which the shock occurs and the time in which the policy is implemented. Under this assumption, I use the measure of these variables in the previous year as explanatory variables, ΔRI_{ijt-1} and ΔH_{ijt-1}. Figure 4 plots the relationship between these two variables: ΔRI_{ijt} and ΔH_{ijt}. This figure shows that both variables are very weakly correlated with each other. The correlation is 0.06. My sample shows that these two explanatory variables are independent of one another. In this case we can check the effect of each variable on the dependent variable separately because there does not appear to be multi-collinearity problem.

There are two time invariant variables to control sector specific political weight and market power. The time average sectoral output ratio in each country is used as a proxy for political weight, $O_{ij} = \frac{O_{ij}}{\sum_{i=1}^{I} O_{ij}}$.[46] The sector with large output ratios has more lobbying power than the other sectors.[47] Sectoral output data is available only at the ISIC

[45] H_{ijt} is between 0 and 1.

[46] Bown(2007) uses output ratio and the employment ratio as a proxy of political power.

[47] If firm ownership is concentrated in one industry then lobbying power also increases, but we do not have

4-digit industry level. The variation of the output ratio is much smaller than that for tariff and import data, so there is a clustering issue in using this variable.

The other variable is the inverse export elasticity which is measured in HS 3-digit sectors. The classical optimal tariff theory shows that the optimal tariff and inverse export elasticity have a positive relationship. This is because if the sectors have a less inelastic export elasticity have more market power, which in turn affects the world price, so the optimal tariff is greater in these sectors. I use the Broda, Limao and Weinstein (2006) elasticity data to measure the time invariant market power.

I also use country level variables to control for country-level shocks in each year. These variables include growths of gross domestic production (GDP) and the trade balance.[48] Table 10 shows that the tariff policy is closely related to the country's time variant variables.

I use two dummy variables. One of them is overhang dummy variable. The overhang level indicates the room for the MFN flexibility. In my sample, most of the countries have a lot of overhang. The average overhang is about 20%. Instead of using the overhang level, I made an overhang dummy variable, which is 1 when the overhang in previous year is less than 10% and 0 otherwise. One hypothesis is that the probability of MFN increases is greater if the overhang level is large. The another reason we can use overhang dummy as an explanatory variable is because of the phase-in period of the WTO trade agreements. Even in the phase-in period, I expect that the overhang coefficient shows the effect of trade agreements on a sector. Bacchatta and Piermatini (2011) provide empirical evidence that the existence of bound tariffs has an effect on tariff reductions.

data that shows the concentration of ownership. If the number of owner is smaller than other sectors that have similar amounts of output then the sector with the smaller owner has more political power. This is because the smaller number of owner can lobby more effectively.

[48] The trade balance is the difference between aggregate exports and imports.

Similar arguments can be tested using the overhang dummy in this paper.

Another dummy variable captures the financial crisis. After financial crisis occurred in 2007, the world trade volume fell rapidly, which is considered global economic shock. This dummy variable takes the value 1 if the year is 2007 or later, and is 0 otherwise.

To capture the effect of previous tariff policy, I include the time lag of every dependent variables, which are binary variables. I try to show the relationship between previous and current policy choices.

Table 9 presents the correlation between explanatory variables. The maximum correlation is 0.1, so these variables are relatively linearly independent. We use country and time dummies to control for country and time specific factors. One country specific factor is the fixed cost of the TTBs. Each country has a different economic and political regime to impose TTBs so we can expect that the fixed cost of TTB policy is different by country. A time dummy captures the phase-in period effect. If the time is close to the end of the phase-in period then the sectoral tariff should be less than or equal to the bound tariff.[49] To focus on comparing policy flexibilities with each other, we only use the sectors that use at least one of the flexibilities during the period(1999-2011).

Results

In this section I present the results of the estimation using the probit model. The multivariate probit model (MVP) with 3 choices (MFN increasing, decreasing, and TTB) is the most generalized version of the probit model if there are multiple choices. I begin by discussing the results from this model in Table 4. The first three columns of Table 4

[49]When I use financial crisis dummy, I do not use year dummies because there is a multi colinearity problem.

presents the results with the change of import ratio (RI) and and the Herfindahl index (H) in previous year as explanatory variables. The previous year's RI change is significantly and positively correlated to the probability of increasing MFN tariffs. This means that the MFN flexibility is sensitive to increases in RI. As it is shown in the first three column, the probability of decreasing MFN tariffs is negatively correlated with positive import shocks.

The Herfindahl index variation has no significant effect on the probability of increasing MFN tariffs but has highly significant negative effect on the probability of decreasing MFN tariffs. However, the increases in the import ratio and Herfindahl index have significant and positive effects on the probability of using TTBs. This shows that both policies are used to protect the domestic market if the import ratio surges, which is consistent with the theoretical model in section 2. In particular, Herfindahl index is an important factor in determining TTB policies. The Herfindahl index increases when the degree of monopolization in the import market increases. TTBs are used not only for responses to import surges but also for changes in import market structure.

To test the effects of import market structural change on the probability of TTB more directly, the cross term ($\Delta H \times \Delta RI$) is introduced in the second estimation. The result is presented in column 2. The signs of other coefficients are similar to the first estimation.

In 4-6th columns, we introduce a dummy variable that captures the direction of import shocks: $d_{im} = 1$ if $\Delta RI > 0$ and $d_{im} = 0$ otherwise. Under this specification, the coefficients have a similar sign and significance to the previous case. Examining the probability of using TTBs we find that the variable $(1 - d_{im}) \times \Delta H$ has a positive and significant coefficient. This means that TTBs are more sensitive to variation in the Herfindahl index when the import shock does not increase. This means that if the import market is monopolized, the government prefers TTBs even if the total import decreases.

Table 4. Probability of Policy Flexibility

Variables	mvprobit(1)			mvprobit(2)			mvprobit(finance crisis)		
	MFN up	TTB	MFN down	MFN up	TTB	MFN down	MFN up	TTB	MFN down
ΔR_{t-1}	1.38^{***} (0.38)	1.83^{**} (0.72)	-0.79^{***} (0.24)	1.39^{***} (0.37)	1.83^{**} (0.72)	-0.79^{***} (0.24)	2.3^{***} (0.32)	1.85^{***} (0.72)	-1.17^{***} (0.23)
ΔH_{t-1}	0.01 (0.01)	0.19^{***} (0.04)	-0.05^{***} (0.01)						
$(\Delta H) \times d^{RI}$				0.05^{*} (0.03)	0.22^{***} (0.06)	-0.05^{**} (0.02)	0.04 (0.03)	0.23^{***} (0.06)	-0.05^{**} (0.02)
$(\Delta H) \times (1 - d^{RI})$				-0.04 (0.03)	0.16^{**} (0.06)	-0.04 (0.02)	-0.04 (0.03)	0.15^{**} (0.06)	-0.05^{**} (0.02)
Output Ratio	-1.2^{***} (0.19)	4.37^{**} (0.24)	1.48^{***} (0.12)	-1.19^{***} (0.19)	4.37^{***} (0.24)	1.48^{***} (0.12)	-1.26^{***} (0.18)	4.35^{***} (0.24)	1.42^{***} (0.12)
Inv.export elasticity	0.0001^{***} (0.00001)	-0.0001^{***} (0.00005)	-0.00002^{*} (0.00001)	0.0001^{***} (0.00001)	-0.0001^{***} (0.00005)	-0.00002^{*} (0.00001)	0.0001^{***} (0.00001)	-0.0001^{***} (0.00005)	-0.00001 (0.00001)
ΔGDP_{t-1}	-0.05^{***} (0.003)	0.008^{*} (0.005)	-0.16^{***} (0.001)	-0.05^{***} (0.003)	0.008^{*} (0.005)	-0.16^{***} (0.001)	0.06^{***} (0.002)	0.01^{***} (0.005)	-0.08^{***} (0.001)
$\Delta cGDP_{t-1}$	-0.35^{***} (0.09)	0.41^{***} (0.11)	2.32^{***} (0.04)	-0.35^{***} (0.09)	0.41^{***} (0.11)	2.32^{***} (0.04)	-1.57^{***} (0.05)	0.06 (0.11)	1.75^{***} (0.03)
$\Delta Balance_{t-1}$	0.007^{***} (0.0004)	0.001 (0.001)	-0.01^{***} (0.0006)	0.007^{***} (0.0004)	0.001 (0.001)	-0.01^{***} (0.0006)	0.001^{***} (0.0004)	0.003 (0.0009)	-0.01^{***} (0.0005)
$Over_{t-1}$	-0.2^{***} (0.01)	0.28^{***} (0.02)	-0.09^{***} (0.009)	-0.2^{***} (0.01)	0.28^{***} (0.02)	-0.09^{***} (0.009)	-0.19^{***} (0.01)	0.26^{***} (0.02)	-0.03^{***} (0.008)
Lag of MFNup	-0.65^{***} (0.03)	-0.03 (0.04)	1.05^{***} (0.01)	-0.65^{***} (0.03)	-0.03 (0.04)	1.05^{***} (0.01)	-0.33^{***} (0.02)	0.006 (0.04)	0.98^{***} (0.01)
Lag of TTB	-0.14^{**} (0.07)	0.92^{***} (0.05)	-0.15^{***} (0.03)	-0.15^{**} (0.07)	0.92^{***} (0.05)	-0.15^{***} (0.03)	-0.16^{**} (0.06)	0.85^{***} (0.05)	-0.17^{***} (0.03)
Lag of MFNdown	0.03^{**} (0.01)	-0.07^{**} (0.02)	0.71^{***} (0.008)	0.03^{**} (0.01)	-0.07^{**} (0.02)	0.71^{***} (0.008)	-0.11^{***} (0.01)	-0.08^{***} (0.02)	0.71^{***} (0.007)
Financial crisis							0.04^{***} (0.009)	-0.14^{***} (0.01)	-0.17^{***} (0.009)
$\rho 12, \rho 23, \rho 31$	0.02 (0.01)	-0.99^{***} (0.002)	-0.02^{*} (0.01)	0.02 (0.01)	-0.99^{***} (0.002)	-0.02^{*} (0.01)	0.03^{**} (0.01)	-0.83^{***} (0.007)	-0.06^{***} (0.01)
N. of Obsrevartion		269167			269167			269167	
Year, country fixed effect		Yes.			Yes.			No.	

Table 5. Probability of Policy Flexibility-continued

Variables	mvprobit(TTB imposed)			mvprobit(w/o SG)			mvprobit(w/o SG)		
	MFN up	TTB	MFN down	MFN up	TTB	MFN down	MFN up	TTB	MFN down
ΔR_{t-1}	1.39^{***}	-1.84	-0.79^{***}	1.37^{***}	1.8^{**}	-0.8^{***}	1.38^{***}	1.8^{**}	-0.8^{***}
	(0.37)	(1.37)	(0.24)	(0.37)	(0.74)	(0.24)	(0.37)	(0.74)	(0.24)
ΔH_{t-1}				0.009	0.18^{***}	-0.04^{***}			
				(0.02)	(0.05)	(0.01)			
$(\Delta H) \times d^{RI}$	0.05^{*}	0.19	-0.05^{**}				0.05^{*}	0.18^{**}	-0.05^{**}
	(0.03)	(0.14)	(0.02)				(0.03)	(0.07)	(0.02)
$(\Delta H) \times (1 - d^{RI})$	-0.04	0.21^{*}	-0.04^{*}				-0.05	0.18^{***}	-0.04
	(0.03)	(0.12)	(0.02)				(0.03)	(0.07)	(0.02)
Output Ratio	-1.19^{***}	3.1^{**}	1.49^{***}	-1.19^{***}	4.63^{***}	1.46^{***}	-1.19^{***}	4.63^{***}	1.46^{***}
	(0.19)	(0.55)	(0.12)	(0.19)	(0.25)	(0.12)	(0.19)	(0.25)	(0.12)
Inv.export elasticity	0.0001^{***}	-0.0003^{***}	-0.00002^{*}	0.0001^{***}	-0.0001^{***}	-0.00002^{*}	0.0001^{***}	-0.0001^{***}	-0.00002^{*}
	(0.00001)	(0.0001)	(0.00001)	(0.00001)	(0.00005)	(0.00001)	(0.00001)	(0.00005)	(0.00001)
ΔGDP_{t-1}	-0.05^{***}	-0.02^{***}	-0.16^{***}	-0.05^{***}	0.002	-0.16^{***}	-0.05^{***}	0.002	-0.16^{***}
	(0.003)	(0.009)	(0.001)	(0.003)	(0.005)	(0.001)	(0.003)	(0.005)	(0.001)
$\Delta cGDP_{t-1}$	-0.35^{***}	0.14	2.32^{***}	-0.35^{***}	0.67^{***}	2.3^{***}	-0.35^{***}	0.67^{***}	2.3^{***}
	(0.09)	(0.22)	(0.04)	(0.09)	(0.12)	(0.04)	(0.09)	(0.12)	(0.04)
$\Delta Balance_{t-1}$	0.007^{***}	-0.003^{*}	-0.01^{***}	0.007^{***}	-0.0003	-0.01^{***}	0.007^{***}	-0.0003	-0.01^{***}
	(0.0004)	(0.002)	(0.0006)	(0.0004)	(0.001)	(0.0008)	(0.0004)	(0.001)	(0.0008)
$Over_{t-1}$	-0.2^{***}	-0.12^{***}	-0.09^{***}	-0.2^{***}	0.32^{***}	-0.09^{***}	-0.2^{***}	0.32^{***}	-0.09^{***}
	(0.01)	(0.04)	(0.009)	(0.01)	(0.02)	(0.009)	(0.01)	(0.02)	(0.009)
Lag of MFNup	-0.65^{***}	0.12	1.05^{***}	-0.65^{***}	-0.13^{***}	1.05^{***}	-0.65^{***}	-0.13^{***}	1.05^{***}
	(0.03)	(0.07)	(0.01)	(0.03)	(0.04)	(0.01)	(0.03)	(0.04)	(0.01)
Lag of TTB	-0.14^{**}	2.96^{***}	-0.15^{***}	-0.21^{**}	0.93^{***}	-0.15^{***}	-0.21^{***}	0.93^{***}	-0.15^{***}
	(0.07)	(0.04)	(0.03)	(0.07)	(0.05)	(0.03)	(0.07)	(0.05)	(0.03)
Lag of MFNdown	0.03^{**}	0.05	0.71^{***}	0.03^{**}	-0.02	0.71^{***}	0.03^{**}	-0.02	0.71^{***}
	(0.01)	(0.04)	(0.008)	(0.01)	(0.02)	(0.008)	(0.01)	(0.02)	(0.008)
Financial crisis									
$\rho 12, \rho 23, \rho 31$	0.02	-0.99^{***}	-0.02^{*}	0.02	-0.98^{***}	-0.03^{**}	0.02	-0.98^{***}	-0.03^{**}
	(0.01)	(0.002)	(0.01)	(0.01)	(0.002)	(0.01)	(0.01)	(0.002)	(0.01)
N. of Obsrevartion		269167			268855			268855	
Year, country fixed effect		Yes.			Yes.			Yes.	

This empirical result shows that the TTBs are closely related to changes in market structure while the MFN policy is more sensitive to the total import surges. The objective of both policies is to protect the import market, but each policy is used to protect the market from different kinds of shocks. This empirical evidence indicates the MFN and TTB flexibilities having complementary characteristics because RI and H can be identified as different kinds of economic shocks.

The inverse export elasticity and output ratio have opposite signs under this specification. The market power measure, the inverse export elasticity, has a positive effect on the probability of MFN increases but has a negative effect on the probability of TTBs. This result is consistent with optimal tariff theory. The effect of tariff on the world price is greater if the sector has greater market power, which means that the MFN tariff adjustment is more efficient to increase domestic countries welfare. However, TTBs are imposed only specific countries, this policy would not effect much on world prices. In addition to the optimal tariff theory, Beshkar, Bond and Rho (2012) show that the market power measures are closely correlated to the level of bound tariff, using cross-sectional data. This paper shows the market power effects on the MFN tariff adjustment with panel data analysis.

The output ratio is negatively correlated with the probability of MFN tariff increases but positively correlated with the probability of TTBs. The output ratio is used a proxy of political power because the industry that produce more output have more lobbying power, and can affect government policy.[50] This means that sectors that have greater political power have higher probability of TTBs rather than MFN tariff policy. This evidence indicates that interest groups focus on the TTB policies to protect their domestic market.

Macro indicators also have different effects on the probability of tariff policy. An

[50] The Output data is available in an ISIC 3 digit level. Every country has only 50-60 3 digit ISIC sectors. The number of 3 digit ISIC sectors is much less than that of the HS6 digit sector in each country. There could be a clustering issue affecting the standard error.

increasing growth rate of GDP has negative and highly significant coefficients in the case of MFN increases. However, the GDP growth rate is not significantly correlated with the probability of TTBs. This shows that as a country develops, it uses less the MFN flexibility.[51] The trade balance growth rate is positively correlated with the probability of MFN increases and TTBs.

In the 7-9th columns of Table 4, the financial crisis dummy variable takes opposite signs across estimations. This dummy variable is highly significant and takes a positive sign in the MFN increase case but has a negative sign in the TTB case. This result is consistent with the graph in Figure 3. After the financial crisis, the countries in the sample increased MFN tariffs in many more sectors than before. However, they did not use TTBs to protect their domestic markets. This evidence shows that the MFN tariff adjustment is a more effective response to global economic shocks.

The previous period's overhang level is positively related to the probability of increasing MFN tariffs. However, this dummy variable is negatively correlated with the probability of TTBs. As mentioned above, the previous period's overhang measures the room for increasing MFN tariffs, so it is natural there is a positive relationship with MFN tariff increases and a negative relationship with MFN tariff decreases. Overhang is also negatively related to the probability of using TTBs. If tariff overhang is a strict standard observed by WTO countries, then the probability of using TTBs should be negatively correlated with the previous overhang level. The empirical results are consistent with this argument. This is the evidence of the argument that TTBs and MFN flexibilities have substitutable characteristics. In 1980s and early 1990s, countries with lower bound tariffs used TTBs more than the countries which had larger bound tariffs. These facts are used

[51] I mainly focus on the sector level variation of economic variables, but this table shows that the macro variables have strong effects on overall tariff policies.

as an evidence of the "Constant protection hypothesis" which focuses on the substitutable characteristics of tariff policies. My sample shows a similar pattern if I focus on the relationship between overhang level and the probability of policy flexibilities. However, there is also evidence for the argument that emphasizes the complementary characteristics across policies.[52]

The probability of MFN increases is negatively correlated with previous choice of MFN increasing and TTB flexibilities. This means the government increased MFN tariff or imposed TTBs in last year, then the probability of increasing MFN decreases in current period. However, the probability of TTB is not correlated with MFN increasing in previous period. This shows the previous year's MFN increasing does not affect the TTB policy in current period. Overall, the MFN tariff policy is more sensitive to the trade policy in previous year than TTB.

The last row in the table show the correlation of the error terms. The error terms of the MFN tariff increases and TTB use have a positive and significant correlation, and the parameter of the covariance matrix is 0.04. This means there could be common factors that affect both flexibilities. The correlations for the error terms between TTB use and MFN decreases is negative and marginaly significant. The correlation between the errors of MFN tariff increases and MFN tariff decreases is highly significant and positive.

The first three columns in table 5 shows the result with a different measure of TTB choices. In this case, we use the imposition of TTBs as the choice variable, which means the binary TTB variable has the value 1 if TTB application is imposed, and has the value 0 otherwise. In the previous regression, we used the initiation of TTBs as the choice variable. To impose a TTB it needs to be initiated first. After that, the government

[52]The overhang effect on the probability of the MFN tariff increases is similar to the result of Bacchatta and Piermatini (2011). This means that the effect of trade agreements on trade liberalization is positive and significant.

investigates the injury of the industry. If the injuries are justified then TTBs are imposed. There is a time lag between initiation and the imposition of TTBs.[53] The result of this estimation is somewhat different from that in table 4. The coefficients of RI and H are not statistically significant. However, the sign of coefficient of RI is negative. This is related to the process of TTBs. When the government initiates TTBs, then the import and market structure has already started to change. TTBs are imposed One of two years after initiation. There is a significant time lag between initiation and imposition of TTBs. During this time, economic conditions change, which affects the regression result. Further, there is a potential endogeneity problem between economic variables and TTB policies. This affects the result from my estimation. The political power measure (output ratio) is still very highly correlated with the probability of TTB imposition. This is because output ratio is not a time variant variable. This means that the sectors that have relatively greater political power were much more likely to impose TTBs, which is similar to the result with the TTB initiation variable. The coefficient on overhang dummy is positive and significant. This is consistent with the role of tariff overhang. This also reflects the substitutable characteristics between MFN and TTB policies.

The 4-9th columns in table 5 show the result from a different sample. In this estimation, we drop sectors in which the country used safe guard (SG) policy to focus on comparing MFN policies with discriminatory policies.[54] The results under this specification are similar to the previous cases.

Table 6 shows the marginal effect of independent variables which change by one standard deviation on the probability of each policy choice.[55] If the import ratio changes by 1 standard deviation, then the probability of MFN increasing goes up by 0.08% points.

[53] The rate of success of TTBs is 62.5%, (Bown,2000)

[54] When the government impose SG, discrimination is not allowed by the WTO agreement.

[55] In this simulation, the number of iteration is 100 because of the computer and program capacity.

Table 6. The Marginal Effect of Key Variables

Variables	$P(\Delta t^{mfn} > 0 \vert \Delta t^{ttb} = 0)$	$P(\Delta t^{ttb} > 0 \vert \Delta t^{mfn} = 0)$	$P(\Delta t^{mfn} < 0 \vert \Delta t^{ttb} = 0)$
ΔRI_{t-1}	0.00078	0.00020	-0.00228
ΔH_{t-1}	0.00011	0.00033	-0.0029
$(\Delta H) \times d^{RI}$	0.00042	0.00027	-0.00175
$(\Delta H) \times (1 - d^{RI})$	-0.00031	0.00017	-0.00236
$Over_{t-1}$	-0.00818	0.00343	-0.01957
Financial crisis	0.00155	-0.0015	-0.0401
Predicted probability	0.02098	0.00306	0.14559

Considering the predicted probability of MFN increasing is 2.1% at the mean values of independent variables, the import ratio changes increase the probability of MFN increasing by 4%. As the same way, the probability of TTB increase by 10%, if the Herfindahl index increases by 1 standard deviation. This table also shows the effect of overhang and financial crisis dummies.[56] These marginal effects are consistent with the prediction in theoretical motivation.

Table 12 and 13 in the appendix present the results of single probit and bivariate probit regressions. These tables also show that the factors which induce the government to use MFN flexibility are different from the factors that induce the use of TTBs. Compared with the previous 3 choice model, the size of coefficients are smaller but the sign and significance are similar. Table 13 presents the results from the bivariate probit estimation. In this model, we can control and estimate the correlation of the error term from separate single probit models. The magnitude and significance from this model is similar to the single probit model and the correlation of the error term is close to 0. This means the results from the single and bivariate probit model are almost same because there are no omitted variables issues that could affect the probability of each flexibility at the same time. In these results, we also find that both policy flexibilities are used in different economic situations.

[56]The marginal effect of dummy variable is calculated by comparing the probability of choice variable in two cases: dummy variable is 0 or 1.

Conclusion

The objective of this paper is to analyze the economic factors that induce particular tariff policy behaviors under the WTO trade agreements. This paper focuses on the discrimination and contingency attributes of tariff policy. We examine the theoretical motivation under which discriminatory tariff policy can be justified when there are large differences in productivity between the exporting countries. The incentive to impose discriminatory tariffs is to increase tariff revenue and terms of trade effects.[57]

Using a simple Cournot model with three countries, we suggest three motivations for the tariff policy flexibilities: the sum of the exporting countries' marginal cost change, the difference in the marginal costs between exporting countries, and the tariff overhang level. More precisely, when there is a productivity shock in foreign exporting countries, measured by the total amount of imports in the domestic market, the optimal policy is to adjust MFN tariffs. However, if there is a productivity shock in a specific country that induces the market structure to change, the optimal tariff policy is to use discriminatory tariff policies. Theoretical motivations also show that the higher bound tariff levels induce the country to use MFN tariff adjustment.

In this paper, I provide evidence that is consistent with the model's predictions. First, I made proxies that capture two kinds of economic shocks. One is the time difference of the import ratio. The import ratio is defined as the ratio of the home country's import value divided by world import value in the same sector. This variable is used as a proxy for the sum of foreign exporting countries productivity shocks. Another key variable is the time difference of import market Herfindahl index. This variable captures sector-level changes in market structure.

[57] The country that exports more has to pay more tariff, so the price of that country after tariff decrease when discriminatory tariff is imposed. We call this as the terms of trade effect.

Second, by analyzing nine countries' data over thirteen years, I provide empirical evidence that supports the theoretical motivation. The probability of the MFN tariff increases is positively correlated with the import ratio surges. Also, the probability of MFN tariff decreases is negatively correlated with the import ratio surges. Sectors with higher overhang use MFN tariff policy more frequently to protect their market from unexpected foreign countries productivity shocks. Import ratio surges are also positively correlated with the probability of TTBs. However, discriminatory tariff policies are more strongly correlated the import market structure changes rather than MFN tariff policies. Other economic variables have different effect on the probability of tariff policy behavior. The inverse export elasticity and the output ratio have opposite effects on the choice of MFN and TTB policies. The probability of TTB is higher if the overhang level is lower, which is opposite to the MFN tariff case.

The empirical evidence gives us new insight into tariff policy. The TTBs are more sensitive to the risk of monopolization which characterize import market structure change. The MFN tariff policies are used to protect the import market from the import surges. The empirical analysis also provided some evidence that is consistent with the classical optimal tariff theory. The probability of the MFN tariff adjustment is positively correlated with the market power measure (inverse export elasticity). Overall, my data analysis suggests that the MFN and TTB are used in different economic situations. This is a counter example to the law of constant protection theory (or the flexibility hypothesis) which emphasizes the substitutability between the MFN and TTB flexibilities.

Previous research focused on the country level data to find the evidence of this hypothesis. Those data confirm the flexibility hypothesis.[58] In this paper, I use the highly

[58] This is also related to the development of each country. Developed countries use TTBs more but developing countries mainly use MFN.

disaggregated HS-6 digit sector level data.

The empirical evidence presented in this paper indicates that both flexibilities have complementary characteristics. My data analysis supports the argument that the important factors that induce TTB use is different from the factors that induce the MFN flexibility because many economic variables have opposite effect on the probability of each policy. This is the counter example to the "flexibility hypothesis" or the "law of constant protection theory", which argues that the country can choose any policy flexibilities to protect their import market and there is no difference between TTBs and MFN flexibilities. My observation shows that the developing countries use two kinds of policy flexibilities in different economic situations, which is the evidence for the "complementarity argument".

I would like to discuss several avenues for future research. This paper assumes that the bound tariff is chosen when the country chooses specific tariff policies: MFN and TTBs. However, if we think about the dynamic optimization problem, the bound tariff includes the expectation of future economic shocks. Therefore, we need to analyze the bound tariff decision mechanism using a dynamic optimization setup. Another topic is to do similar empirical research with different samples. This paper includes nine developing countries' panel data because of data limitations. In particular, there is a relative deficit in the availability of sectoral output data. If more data or a better proxy is available then the sample size could increase. While this paper analyzes only the probability of tariff policy choice, the size of tariff policy changes is also an important variable to analyze.

Appendix: tables and figures

Table 7. Frequency of Policy Adjustment

Tariff variation		MFN Flexibility		
		Increase	Decrease	Stable
TTB Flecibility	Initiate	105 (0.03%)	407 (0.1%)	1201 (0.31%)
	Not Use	17472 (4.44%)	68155 (17.32%)	306242(77.81%)

Table 8. Frequency of Policy Adjustment

Tariff variation		MFN Flexibility		
		Increase	Decrease	Stable
TTB Flecibility	Impose	45 (0.01%)	291 (0.07%)	656 (0.17%)
	Not Use	17532 (4.45%)	68271 (17.35%)	306787(77.95%)

Table 9. The correlations between explanatory variables

Variables	ΔRI_{t-1}	ΔH_{t-1}	Output Ratio	Inv. Export Els.	ΔGDP_{t-1}	$\Delta cGDP_{t-1}$	$\Delta Balance_{t-1}$
ΔRI_{t-1}	1.0						
ΔH_{t-1}	0.064	1.0					
Output Ratio	0.018	0.002	1.0				
Inv. Export Els.	-0.004	-0.007	0.014	1.0			
ΔGDP_{t-1}	0.064	-0.03	0.014	-0.046	1.0		
$\Delta cGDP_{t-1}$	0.045	-0.037	0.011	-0.007	0.775	1.0	
$\Delta balance_{t-1}$	-0.021	0.013	-0.014	0.0008	-0.007	-0.032	1.0

Table 10. Tariff policy flexibilities

con	Sector	99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Argentina	$\Delta MFN > 0$	223	56	699	17	1	7	7	61	68	548	5	497	69
	$\Delta MFN < 0$	361	419	2769	3456	8	31	8	92	72	7	13	50	48
	TTB(initiate)	24	49	31	10	1	13	8	9	7	25	49	21	11
	TTB(impose)	25	17	25	31	30	2	12	2	9	4	24	33	15
Brazil	$\Delta MFN > 0$	21	29	14	82	-	-	8	33	37	497	6	63	7
	$\Delta MFN < 0$	713	646	3443	2860	-	-	85	60	51	18	8	15	9
	TTB(initiate)	1	1	4	1	-	1	1	1	4	1	1	1	8
	TTB(impose)	1	1	1	1	-	5	1	0	1	4	1	1	1
Columbia	$\Delta MFN > 0$	43	0	0	40	0	5	227	3	38	4	4	2	10
	$\Delta MFN < 0$	26	0	0	40	0	230	15	7	36	6	18	27	2238
	TTB(initiate)	8	3	2	0	0	4	59	31	2	8	3	2	7
	TTB(impose)	0	0	0	0	0	0	0	3	21	0	3	0	0
Ecuador	$\Delta MFN > 0$	16	3	0	17	2	0	0	147	455	417	5	26	127
	$\Delta MFN < 0$	3171	9	0	43	142	0	0	8	1134	899	7	87	103
	TTB(initiate)	19	1	0	0	8	0	191	0	4	0	0	2	0
	TTB(impose)	0	1	1	0	0	2	0	0	0	0	0	1	0
India	$\Delta MFN > 0$	-	1725	36	236	-	-	0	0	71	7	1153	24	-
	$\Delta MFN < 0$	-	1246	2728	2029	-	-	3036	3077	2755	188	25	1154	-
	TTB(initiate)	24	21	41	53	-	20	24	13	73	45	61	85	-
	TTB(impose)	14	22	21	33	-	12	17	27	14	70	17	27	-
Indonesia	$\Delta MFN > 0$	0	1	16	22	9	223	34	48	121	3	7	6	549
	$\Delta MFN < 0$	245	1311	16	15	4	92	51	50	275	3	152	10	290
	TTB(initiate)	20	0	4	2	2	3	5	4	1	7	13	8	4
	TTB(impose)	6	0	0	0	0	2	1	3	0	1	2	4	17
Mexico	$\Delta MFN > 0$	3162	15	20	48	75	24	15	1	3	39	251	0	6
	$\Delta MFN < 0$	31	20	16	28	86	530	2739	2094	10	61	1902	2250	666
	TTB(initiate)	12	4	7	9	10	3	15	5	4	1	2	3	2
	TTB(impose)	4	9	1	5	7	4	5	2	0	0	1	2	1
Peru	$\Delta MFN > 0$	0	0	0	9	0	2	1	190	5	0	17	14	0
	$\Delta MFN < 0$	0	0	731	1054	667	40	6	153	1662	1936	97	23	1557
	TTB(initiate)	30	1	20	25	121	4	1	4	1	4	11	0	1
	TTB(impose)	20	9	1	20	19	31	2	1	1	0	4	7	1
Turkey	$\Delta MFN > 0$	173	7	5	12	5	60	134	271	224	263	46	36	257
	$\Delta MFN < 0$	2565	958	787	733	719	945	304	183	255	190	6	28	236
	TTB(initiate)	3	75	4	9	14	35	9	31	22	43	33	7	3
	TTB(impose)	0	4	53	29	12	14	11	43	6	25	38	37	4

Table 11. Summary Statistics for Variables used in econometric estimation

Variables	Mean	Standard Deviation	Minimum	Maximum
Dependent variables				
Binary variable =1 if sector (i) of country(j) increased MFN tariff in year (t)	0.04	0.2	0	1
Binary variable =1 if sector (i) of country(j) decreased MFN tariff in year (t)	0.19	0.39	0	1
Binary variable =1 if sector (i) of country(j) initiated TTB in year (t)	0.0057	0.075	0	1
Binary variable =1 if sector (i) of country(j) imposed TTB in year (t)	0.0032	0.05	0	1
Explanatory variables				
Country, sector, and time variant				
Import ratio change in t-1 (RI_{ijt-1})	0.0003	0.011	-0.3	0.32
Herfindahl index change in t-1 (H_{ijt-1})	-0.002	0.175	-0.766	0.763
Country and sector variant				
Time average output ratio (ISIC 3digit)	0.023	0.024	0	0.225
Inverse export elasticity (HS 3 digit)	83.43	267.78	0.0005	1254.49
Country and time variant				
GDP increasing rate in t-1 (ΔGDP_{jt-1})	4.0	3.99	-10.89	9.8
Per capita GDP increasing rate in t-1 (ΔGDP_{jt-1})	0.086	0.152	-0.62	0.44
Trade balance increasing rate in t-1 ($\Delta Balance_{jt-1}$)	0.8	0.15	-0.62	0.44
Dummy variables				
Overhang dummy=1 if previous years overhang is less than 10%	0.2	0.4	0	1
Financial crisis dummy=1 if year is greater than 2006	0.44	0.49	0	1
Year			1999	2011
Country			1	9

Table 12. Probability of Policy Flexibility (Marginal effects)

Variables	probit(1)			probit(2)			probit (3,finance crisis)		
	MFN up	TTB	MFN down	MFN up	TTB	MFN down	MFN up	TTB	MFN down
ΔR_{t-1}	0.047^{**} (0.02)	0.016^{**} (0.006)	-0.2^{***} (0.05)	0.047^{**} (0.02)	0.016^{**} (0.006)	-0.2^{***} (0.05)	0.16^{***} (0.02)	0.019^{**} (0.007)	-0.28^{***} (0.05)
ΔH_{t-1}	0.00013 (0.0014)	0.001^{***} (0.0004)	-0.01^{***} (0.004)						
$(\Delta H) \times d^{RI}$				0.003 (0.001)	0.002^{***} (0.0006)	-0.01^{**} (0.005)	0.003 (0.002)	0.025^{***} (0.0007)	-0.01^{**} (0.005)
$(\Delta H) \times (1 - d^{RI})$				-0.003 (0.002)	0.001^{**} (0.0006)	-0.019^{***} (0.005)	-0.001 (0.002)	0.0015^{**} (0.0007)	-0.01^{***} (0.006)
Output Ratio	-0.07^{***} (0.01)	0.04^{**} (0.002)	0.33^{***} (0.02)	-0.07^{***} (0.01)	0.04^{***} (0.002)	0.33^{***} (0.02)	-0.09^{***} (0.01)	0.04^{***} (0.002)	0.31^{***} (0.02)
Inv.export elasticity	$8.34e-6^{***}$ (8.84e-07)	$-1.45e-6^{***}$ (4.97e-7)	$-3.93e-6$ (2.87e-6)	$8.33e-6^{***}$ (8.84e-07)	$-1.45e-6^{***}$ (4.97e-7)	$-3.94e-6$ (2.87e-6)	$8.1e-6^{***}$ (1.14e-07)	$-1.59e-6^{***}$ (5.55e-07)	$4.2e-6$ (2.98e-6)
ΔGDP_{t-1}	-0.002^{***} (0.0001)	0.00019^{***} (0.00002)	-0.02^{***} (0.0002)	-0.002^{***} (0.0001)	0.00019^{***} (0.00002)	-0.02^{***} (0.0003)	0.001^{***} (0.00008)	0.0001^{***} (0.00004)	-0.007^{***} (0.0001)
$\Delta Balance_{t-1}$	0.0004^{***} (0.00002)	0.00001 (0.00001)	-0.003^{***} (0.0001)	0.0004^{***} (0.00002)	0.00001 (0.00001)	-0.003^{***} (0.0001)	0.0002^{***} (0.00003)	$5.34e-6$ (9.8e-6)	-0.003^{***} (0.0001)
$Over_{t-1}$	-0.006^{***} (0.0006)	0.003^{***} (0.0003)	-0.01^{***} (0.001)	-0.006^{***} (0.0006)	0.003^{***} (0.0003)	-0.01^{***} (0.001)	-0.01^{***} (0.0007)	0.003^{***} (0.0003)	-0.01^{***} (0.002)
Lag of MFNup	-0.02^{***} (0.0004)	-0.0002 (0.0003)	0.37^{***} (0.004)	-0.02^{***} (0.0004)	-0.0002 (0.0003)	0.37^{***} (0.004)	-0.01^{***} (0.0009)	-0.0001 (0.0004)	0.33^{***} (0.004)
Lag of TTB	-0.007^{**} (0.002)	0.031^{***} (0.004)	-0.03^{***} (0.007)	-0.007^{**} (0.002)	0.03^{***} (0.004)	-0.03^{***} (0.007)	-0.01^{***} (0.003)	0.02^{***} (0.003)	-0.03^{***} (0.008)
Lag of MFNdown	-0.0003 (0.0007)	-0.0006^{***} (0.0002)	0.18^{***} (0.002)	-0.0003 (0.0007)	-0.0006^{***} (0.0002)	0.18^{***} (0.002)	-0.01^{***} (0.0008)	-0.0009^{***} (0.0002)	0.2^{***} (0.002)
Financial crisis							0.004^{***} (0.0006)	-0.001^{***} (0.0001)	-0.039^{***} (0.001)
Observed prob.	0.043	0.0057	0.194	0.043	0.0057	0.194	0.043	0.0057	0.194
Predicted prob.	0.021	0.003	0.142	0.02	0.003	0.142	0.032	0.0035	0.165
N. of Obsrevartion		269167			269167			269167	
Year, country fixed effect		Yes.			Yes.			No.	

Table 13. Probability of Policy Flexibility (Bivariate Probit)

Variables	biprobit(1)		biprobit(2)		biprobit(financial crisis)	
	coefficient	marginal effect	coefficient	marginal effect	coefficient	marginal effect
MFN up flexibility						
ΔRI_{t-1}	0.93^{**}	0.046^{**}	0.95^{***}	0.047^{**}	2.2^{***}	0.156^{***}
	(0.4)	(0.02)	(0.39)	(0.02)	(0.33)	(0.02)
ΔH_{t-1}	0.001	0.00004				
	(0.02)	(0.001)				
$(\Delta H_{t-1})d^{IM}$			0.06	0.002	0.04	0.003
			(0.03)	(0.001)	(0.03)	(0.002)
$(\Delta H_{t-1})(1-d^{IM})$			-0.06^{*}	-0.003^{*}	-0.03	-0.002
			(0.04)	(0.002)	(0.03)	(0.002)
Output Ratio	-1.4^{***}	-0.07^{***}	-1.4^{***}	-0.07^{***}	-1.3^{***}	-0.09^{***}
	(0.21)	(0.01)	(0.21)	(0.01)	(0.19)	(0.01)
Inv. Export Elasticity	0.0001^{***}	$8.3e-6^{***}$	0.0001^{***}	$8.3e-6^{***}$	0.0001^{***}	$8.2e-6^{***}$
	(0.00001)	(0.00)	(0.00001)	(0.00)	(0.00001)	(0.00)
ΔGDP_{t-1}	-0.03^{***}	-0.001^{***}	-0.03^{***}	-0.001^{***}	0.06^{***}	0.004^{***}
	(0.002)	(0.0001)	(0.002)	(0.0001)	(0.02)	(0.0001)
$\Delta cGDP_{t-1}$	-0.26^{***}	-0.01^{***}	-0.26^{***}	-0.01^{***}	-1.3^{***}	-0.09^{***}
	(0.08)	(0.003)	(0.08)	(0.003)	(0.05)	(0.003)
$\Delta balance_{t-1}$	0.008^{***}	0.0004^{***}	0.008^{***}	0.0004^{***}	0.002^{***}	0.0001^{***}
	(0.0004)	(0.00002)	(0.0004)	(0.00002)	(0.0004)	(0.00003)
$Over_{t-1}$	-0.13^{***}	-0.006^{***}	-0.13^{***}	-0.006^{***}	-0.2^{***}	-0.01^{***}
	(0.01)	(0.0006)	(0.01)	(0.0006)	(0.01)	(0.0007)
Lag of MFNup	-1.09^{***}	-0.02^{***}	-1.09^{***}	-0.02^{***}	-0.32^{***}	-0.01^{***}
	(0.05)	(0.0004)	(0.05)	(0.0004)	(0.02)	(0.0009)
Lag of TTB	-0.18^{**}	-0.008^{**}	-0.18^{**}	-0.008^{**}	-0.17^{***}	-0.01^{***}
	(0.07)	(0.002)	(0.07)	(0.002)	(0.06)	(0.003)
Lag of MFNsown	-0.006	-0.0003	-0.006	-0.0003	-0.15^{***}	-0.01^{***}
	(0.01)	(0.0007)	(0.01)	(0.0007)	(0.01)	(0.0008)
$Financialcrisis$					0.08^{***}	0.006^{***}
					(0.009)	(0.0006)
predicted prob.	0.02		0.02		0.0319	
TTB flexibility						
ΔRI_{t-1}	1.82^{**}	0.016^{**}	1.81^{**}	0.016^{**}	1.82^{**}	0.017^{**}
	(0.72)	(0.006)	(0.72)	(0.006)	(0.72)	(0.007)
ΔH_{t-1}	0.19^{***}	0.0017^{***}				
	(0.04)	(0.0004)				
$(\Delta H_{t-1})d^{IM}$			0.22^{***}	0.002^{***}	0.23^{***}	0.002^{***}
			(0.06)	(0.0006)	(0.06)	(0.0006)
$(\Delta H_{t-1})(1-d^{IM})$			0.15^{**}	0.0014^{**}	0.15^{**}	0.0015^{**}
			(0.06)	(0.0006)	(0.06)	(0.0006)
Output Ratio	4.3^{***}	0.04^{***}	4.3^{***}	0.04^{***}	4.3^{***}	0.04^{***}
	(0.24)	(0.002)	(0.24)	(0.002)	(0.24)	(0.002)
Inv. Export Elasticity	-0.0001^{***}	$-1.6e-6^{***}$	-0.0001^{***}	$-1.4e-6^{***}$	-0.0001^{***}	$-1.5e-6^{***}$
	(0.00005)	(0.00)	(0.00005)	(0.00)	(0.00005)	(0.00)
ΔGDP_{t-1}	0.008^{*}	0.00008^{*}	0.008^{*}	0.00008^{*}	0.01^{***}	0.0001^{***}
	(0.005)	(0.00005)	(0.005)	(0.00005)	(0.004)	(0.00005)
$\Delta cGDP_{t-1}$	0.41^{***}	0.003^{***}	0.41^{***}	0.003^{***}	0.09	0.001
	(0.11)	(0.001)	(0.11)	(0.001)	(0.11)	(0.001)
$\Delta balance_{t-1}$	0.001^{*}	0.00001	0.001^{*}	0.00001	0.0005	$4.3e-6$
	(0.001)	(0.00001)	(0.001)	(0.00001)	(0.0009)	(0.00001)
$Over_{dummy}$	0.28^{***}	0.003^{***}	0.28^{***}	0.003^{***}	0.26^{***}	0.003^{***}
	(0.02)	(0.0003)	(0.02)	(0.0003)	(0.02)	(0.0003)
Lag of MFNup	-0.037	-0.0002	-0.03	-0.0002	-0.01	-0.00005
	(0.04)	(0.0003)	(0.04)	(0.0003)	(0.04)	(0.0004)
Lag of TTB	0.92^{***}	0.03^{***}	0.92^{***}	0.03^{***}	0.85^{***}	0.02^{***}
	(0.05)	(0.004)	(0.05)	(0.004)	(0.05)	(0.003)
Lag of MFNsown	-0.07^{***}	-0.0006^{***}	-0.07^{***}	-0.0006^{***}	-0.09^{***}	-0.0008^{***}
	(0.02)	(0.0002)	(0.02)	(0.0002)	(0.02)	(0.0002)
$Financialcrisis$					-0.14^{***}	-0.001^{***}
					(0.01)	(0.0001)
predicted prob.	0.0029		0.0029		0.00338	
rho	0.02		0.02		0.03	
	0.02		0.02		0.03	
N. of Obsrevartion	269167		269167		269167	
Year fixed effect	Yes.		Yes.		No.	
Country Fixed effect	Yes.		Yes.		Yes.	

Marginal effect is calculated in the case in which only MFN increases or only TTB is used, excluding the case using both.

Figure 3. The trend of protection

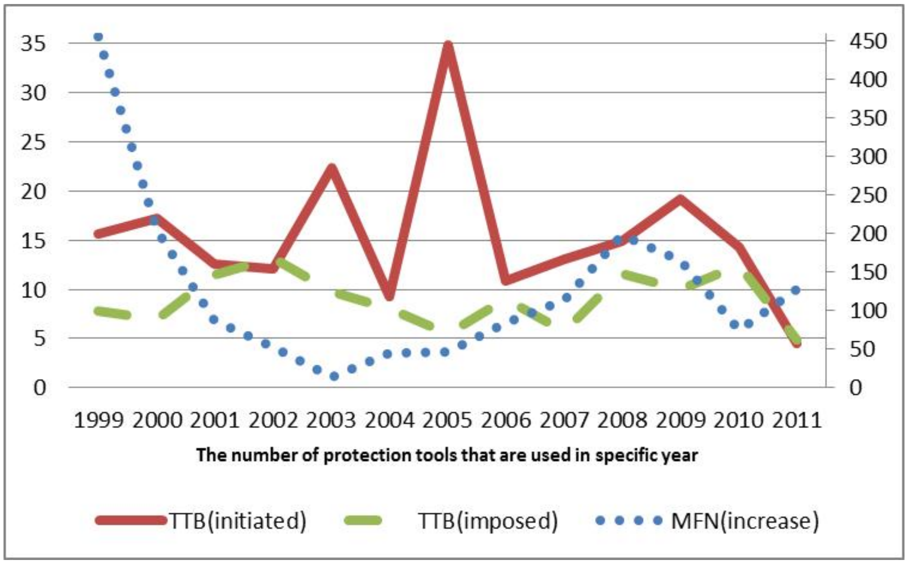
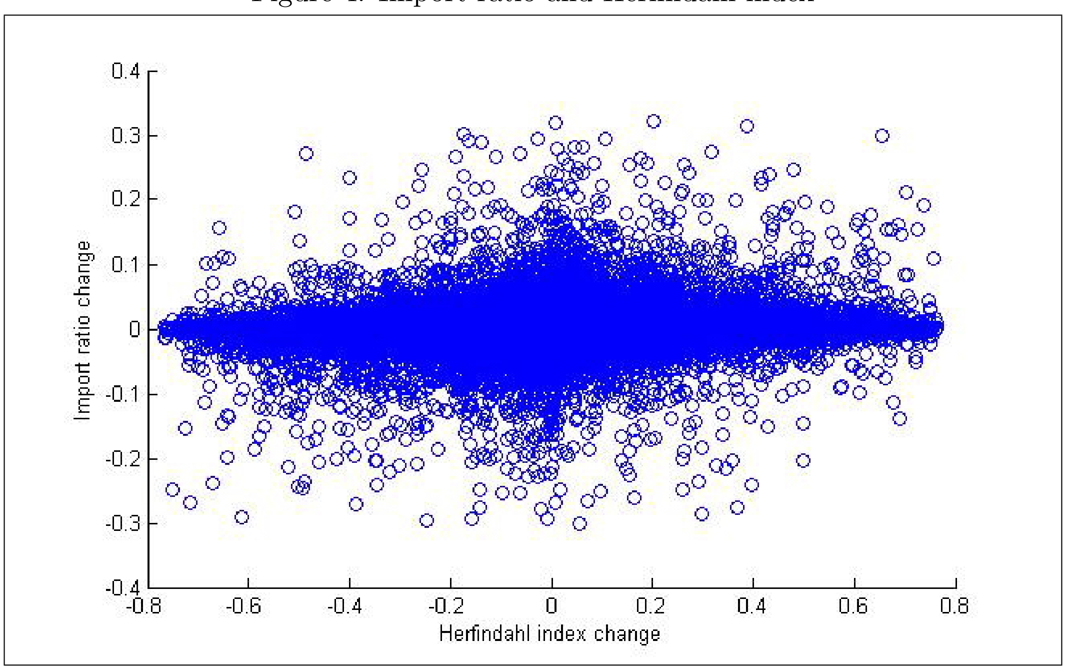


Figure 4. Import ratio and Herfindahl index



CHAPTER II

TARIFF BINDING AND OVERHANG: THEORY AND EVIDENCE

with Eric W. Bond and Mostafa Beshkar

Introduction

Following the original proposition by Bickerdike (1906) that for a nation, "advantage is always possible in normal circumstances from either import or export taxation," the question of optimum tariff has become the subject of an intensive literature. Bickerdike's insight was based on the premise that the incentive to tax imports is heightened if the cost of such policies can be shifted to foreigners. This idea was later formalized in the optimal tariff theory, which suggested that a country's tariffs should be positively related to their market power, as reflected by the inverse of the elasticity of export supply it faces. Thus, one would expect larger countries to have higher tariffs than small countries under the optimal tariff theory.

A nation's gains from shifting the cost of taxation to other countries are most likely reversed if other nations pursue similar policies to their own advantage.[1] Trade agreements can be viewed as a means of escape from this terms-of-trade-driven prisoner's dilemma among governments, with all countries able to benefit from reciprocal tariff reductions. Bagwell and Staiger (1999) show that under a fairly general set of government objective functions, "it is the terms of trade–and this externality alone–that creates an inefficiency when governments set their trade policies unilaterally." Thus, an optimal trade agreement

[1]The seminal treatment is Johnson (1953). Syropoulos (2002) provides a recent treatment focusing on the role of country size.

should preclude governments from using their international market power to manipulate their terms of trade. Similarly, the 'Trade Talk' result of Grossman and Helpman (1995) indicates that efficient tariffs are independent of the countries' international market power. In these political-economy models of trade agreements, departures from free trade reflect the political preferences of the governments rather than their international market power.

In contrast, the theory we develop in this paper suggests that market power is an important determinant of optimal tariff bindings under the WTO. This result follows from a trade-off between flexibility and discipline in the setting of tariff bindings. We argue that the key to explain this pattern of tariff binding commitments is the fact that governments value flexibility in setting their trade policy, so that they can respond to shocks to their preferences regarding openness to international trade. The WTO, which aggregates the preferences of the member countries, will thus want to incorporate mechanisms which allow governments to respond to preference shocks, while incorporating the externalities on other countries.[2]

An optimal agreement, however, will not provide full flexibility to countries to respond to shocks when governments have private information about the magnitude of these shocks. That is because there is an incentive for the importing country to misrepresent the magnitude of the shock in order to take advantage of its market power. Providing flexibility to more powerful trading partners through higher tariff bindings will thus cause a relatively greater efficiency loss, so they will be given lower tariff bindings under an optimal agreement. This is the essence of the trade-off between "flexibility" to respond to shocks and "discipline"

[2]Using a model in which a free-riding problem discourages governments from negotiating efficient tariffs, Ludema and Mayda (2010) show that the level of the negotiated tariff is lower when the free-riding problem is less severe. Their framework differs from ours in that they do not distinguish between bound and applied tariffs. We use the prevalence of tariff overhang and the negative relationship with importer's market power as evidence that trade negotiations have been influenced by the trade-off between flexibility and discipline, as explained in our model.

on opportunistic use of trade policy.[3]

Table 14. Tariffs and Trade Summary Statistics

Binding Status	Num. of sector	Share(%)	Import(bil.$)	Share (%)
Applied Tariff below Binding	196,062	65.32	1,760	24.14
Strong Binding (Applied Tariff at Binding)	51,680	17.22	4,410	60.48
Applied Tariff over Binding	8,301	2.76	413	5.66
Unbound	44,136	14.70	709	9.72
Total	300,129	100	7,292	100

Note: Applied tariff data is from 66 WTO members in 2007.

The data on tariff binding commitments in Table 14 illustrate the magnitude of flexibility that is present in the WTO agreements. These data show that for 66 WTO member countries, 65% of the tariff lines at the HS 6-digit level had applied MFN tariff rates that were below their tariff binding. The average tariff overhang in these sectors, which is the difference between the binding and the applied rate, was more than 20 percentage points. The prevalence of sectors with tariff binding overhang suggests that many governments have retained substantial flexibility in adopting their import tariffs.[4]

A second observation from this data is that the fraction of tariff lines which are below their bindings varies substantially across sectors and across countries. The members in the sample with the largest economies (US, EU, Japan, and China) all have more than 90% of tariff lines at the binding, while 25 members with smaller economies had 5% or less of their tariffs at the binding. The share of imports which are in tariff lines where there is a positive binding overhang is 24% of all imports. These observations are consistent with the prediction that flexibility will be lower where there is a greater degree of market power.[5]

[3] In general, relative bargaining power of the parties in negotiations may also cause variation in tariff commitments across countries. However, if parties have access to side payments at the time of negotiating the agreement, bargaining power will not impact the choice of tariff commitments.

[4] Rho (2012) and Estevadeordal, Freund and Ornelas (2008) show that in sectors with tariff overhang, applied tariffs adjust both up and down over time, which is a further evidence that governments do use tariff overhang as a flexibility mechanism.

[5] Bagwell and Staiger (2011) find empirical evidence for the hypothesis that countries with greater import market power have agreed to greater *tariff cuts* under the WTO. This hypothesis, however, is weaker than the central prediction of conventional terms-of-trade theories, which maintain that an optimal agreement should prevent governments from using their market power to manipulate their terms of trade.

Our theory also provides predictions about the relationship between market power and the pattern of applied tariffs and binding overhang under an optimal tariff binding agreement. The fact that bindings are lower for countries with greater market power, given the distribution of political power, means that there is a higher probability that a country with greater market power will be at its binding. For countries with sufficiently large market power, the tariff will always be at its binding. As a result, the expected binding overhang will be a decreasing function of a country's market power.

We also find that the relationship between average applied tariffs and import market power is non-monotonic. For low levels of import market power we find that this relationship coincides with the optimum tariff result, i.e., applied tariffs (on average) are increasing in import market power. This occurs because countries will impose their optimal tariff when the tariff is below the binding. However, as market power increases, the fraction of the time at which the tariff is constrained by the binding increases. This must result in a negative relationship between market power and the average applied tariff for countries in the neighborhood of the threshold level of market power at which the tariff is always at its binding. [6]

Our theory provides a useful framework for an empirical analysis of tariff commitments. Previous attempts at testing the terms-of-trade theory of trade agreements assume that governments negotiate tariff cuts.[7] In reality, however, governments negotiate

[6]This result may be better understood in light of our first result regarding optimal tariff bindings and the conventional optimum tariff result. On one hand the unilaterally optimal tariff is increasing in market power and, on the other hand, the maximum tariff that may be chosen by a government under an optimal agreement is decreasing in the level of market power. Our analysis shows that the former (latter) effect dominates for low (high) levels of import market power.

[7]As shown by Bagwell and Staiger (2011) an implication of the conventional terms-of-trade theories is that countries with greater import market power should agree to greater *tariff cuts* under an optimal agreement. This hypothesis, however, is weaker than the central prediction of conventional terms-of-trade theories, which maintain that under an optimal agreement there must be no relationship between a countries tariff comitments and its market power. This central prediction is obviously rejected by empirical observations from WTO, as we show in this paper.

their bound tariffs and as a result, due to existence of overhang in many sectors/countries, GATT/WTO commitments do not necessarily constitute a tariff cut. By generating a mismatch between the theory and the empirical observations, this assumption has imposed unnecessary limitations on previous empirical studies in this area.[8]

Previous empirical tests of terms of trade theories assume that once governments enter into a trade agreement they are unable to exercise their market power in setting trade policy. As a result, the two important inquiries of the terms-of-trade literature (namely, optimum tariff and optimal agreements) are pursued independently. Our theoretical framework, however, enables us to analyze how countries utilize their market power in setting trade policy while they are restricted by tariff binding agreements. Therefore, in addition to analyzing the relationship between market power and optimal tariff commitments (as in Bagwell and Staiger (2011)), we are also able to study the relationship between applied tariffs and market power (as in Broda, Limao and Weinstein (2008)). Moreover, our approach allows us to increases the number of countries that can be included in the study from 16 countries (all of which are developing countries) in Broda, Limao and Weinstein (2008) and Bagwell and Staiger (2011) to 66 countries (which includes both developed and developing countries) in this paper.

We find strong empirical support for our theoretical predictions. First, we observe that the levels of tariff binding rates under the WTO are inversely related to measures of import market power.[9,10] This relationship is both statistically and economically important.

[8] Pre-agreement applied tariffs are needed to calculate the size of tariff cuts in the accession process. As a result, Bagwell and Staiger (2011) focus on new WTO members who presumably agreed to reduce their tariffs from non-cooperative to cooperative levels in one round of negotiations, as opposed to old GATT members who reduced their tariffs through several negotiation rounds that took place over 4 decades. This reduces the total number of countries in their study to 16, all of which are developing countries.

[9] As measures of market power, we use inverse export elasticities and the country's share of the world import in the concerned sector.

[10] Bagwell and Staiger (2011) also find that new WTO members with greater import market power have generally agreed to greater *tariff cuts*, which is defined as the difference between pre-WTO applied tariffs and the WTO tariff bindings.

In particular, we find that a one-standard-deviation increase in a country's share of the world import in a given industry, reduces the tariff binding rate of the country in that industry by 3.5 to 4.46 percentage points.

We also find a statistically-significant negative relationship between the size of tariff binding overhang and the importing country's international market power in the concerned sector. This relationship is also substantial since a one-standard-deviation increase in the share of world import in a given sector reduces the size of tariff binding overhang by around 8-17 percentage points in different empirical specifications. As a related result, we find that it is substantially more likely to observe a zero overhang in sectors with greater international market power.

Political environment also plays a role in determining the size of optimal tariff binding in our theory, such that a greater volatility in political pressure parameter increases the level of optimal binding. Using a country-level variable for political instability, we find strong cross-country evidence for this relationship.

Our empirical study also sheds light on Subramanian and Wei's (2007) finding that membership in the WTO increases a country's import volume substantially only if the member under consideration is a developed country. Their finding may be better understood in light of our observation that under an optimal agreement, less important import markets are given more discretion and flexibility in setting their trade policies. Similarly, our theory provides a theoretical explanation for Freund's (2003) finding that the North-South Free Trade Agreements (FTAs) are a far-cry from being reciprocal, while the North-North and South-South FTAs feature reciprocal exchange of market access.

Different aspects of flexibility in trade agreements have been studied in the literature. Most of this literature, however, formulate the problem of optimal tariff agreements in a way that no binding overhang is theoretically generated. Instead, these works focus on contingent flexibility measures such as escape clauses or safeguards (GATT Article XIX), antidumping measures and countervailing duties.[11]

The theoretical part of our paper builds on the nascent literature on the use of tariff bindings as a flexibility measure.[12] Bagwell and Staiger (2005) analyze the role of tariff bindings when countries have private information. Bagwell (2009) extends the analysis to the case of a repeated game where tariffs must be self-enforcing. Among other results, Bagwell (2009) finds that optimally-chosen tariff bindings improve the welfare of governments compared to a no-agreement case. Amador and Bagwell (2010) advance this result by finding conditions under which a tariff binding is the best mechanism among those that restrict the set of tariffs from which governments can choose. While sharing some basic elements of these two papers, our theory introduces country-specific parameters that enables us to study the asymmetry of obligations under an optimal agreement.[13]

In the next section we introduce the basic settings for our model. In Section

[11]Such papers include Bagwell and Staiger (1990), Feenstra and Lewis (1991), Sykes (1991), Ludema (2001), Beshkar (2010a), Beshkar (2010b), and Maggi and Staiger (2011b), Maggi and Staiger (2011a)

[12]The literature provides several explanations for the use of tariff bindings. Horn, Maggi and Staiger (2010) show that at the presence of contracting costs, instead of writing a fully contingent agreement it may be optimal to specify tariff bindings to save on contracting costs. Maggi and Rodriguez-Clare (2007) show that giving discretion to governments to choose a tariff below the binding reduces the inefficiency due to a domestic commitment problem. In Maggi and Rodriguez-Clare (2007), however, the governments always apply a tariff equal to binding and, thus, overhang is not predicted by the theory.

There is also an emerging literature that explores the role of tariff bindings at the presence of trade policy uncertainty. Under various modeling assumptions, Froncois and Martin (2004), Sala, Schroder, and Yalcin (2010), Handley (2010), and Handley and Limao (2010) show that one benefit of tariff bindings is to reduce uncertainty by censoring the possible range of applied tariffs and limiting losses in the worst case scenario. Finally, Limao and Tovar (2011) argue that governments choose tariff bindings to improve their bargaining position vis a vis domestic interest groups. These papers, however, could not explain the existence of tariff overhang.

[13]These papers as well as the current paper focus on tariff bindings, while in practice tariff bindings and contingent protection measures are both included in the agreement. In an ongoing research, Beshkar and Bond (2012) study optimal trade agreements when tariff bindings and contingent protection measures are both available. Bagwell and Staiger (2005) also introduce a model of tariff bindings with contingent protection in which incentive compatibility is ensured by a dynamic constraint on the use of contingent protection. Finally, Prusa and Li (2009) argue that due to the flexibility provided by tariff binding overhangs, the use of antidumping measures as a contingent protection measure is less critical for the governments. Based on this argument, Prusa and Li (2009) call for a reform in antidumping's "vague and economically illogical rules."

II.3, we characterize optimal tariff binding as a function of import market power and other variables of interest. Section II.3.1 studies the implications of our model regarding the applied tariffs and overhang under the optimal agreement. In sections II.4 and II.5 we discuss our empirical model and results, respectively. We provide concluding remarks and more discussion of the existing literature in Section II.6.

The Basic Setting

We consider a two-country $(n+1)$-good world economy. Letting good 0 to be the numeraire, we assume that preferences in country i are given by

$$U_i = q_{0i} + \sum_{j=1}^{n} u_{ji}\left(q_{ji}\right),$$

for $i = 1, ..., n$ and $j = 1, 2$. These preferences induce a demand function for good i in country j that can be expressed as $d_{ij}(p_{ij})$. On the supply side, we assume that the numeraire good is produced one-for-one from labor so that the wage is equal to one. Each of the other goods is produced with a sector-specific factor and labor, which is mobile between sectors. We let $y_{ij}(p_{ij})$ denote the supply function of industry i in country j as a function of the local price.

We assume that the only trade policy at governments' disposal is ad valorem import tariffs, denoted by t_{ij}. The world price is denoted by p_j^*. We assume that a government's preferences over tariffs can be described by a weighted social welfare function in which the producers' surplus in the import-competing sector receives a weight of $\theta_{ij} \geq 1$. This weight may vary across sectors and importing countries. In the subsequent discussion we focus on one good that is imported to country 1 and, hence, drop the country and industry subscripts.[14] Formally, letting V denote the importing country's political welfare attributed to the importable sector, we assume that

$$V(p, p^{*}, \theta) = S(p) + (1+\theta)\,\pi(p) + tp^{*}m(p), \tag{II.1}$$

where, $S(p) \equiv \int_{p}^{\infty} d(\widetilde{p})\, d\widetilde{p}$ is consumer surplus, $\pi(p) \equiv \int_{0}^{p} y(\widetilde{p})\, d\widetilde{p}$ is producer surplus, $m = d - y$ is the import volume, and θ is the extra weight given by the government to the profits of the import-competing sector. Moreover, the welfare of the foreign government from its respective exportable sector is given by

$$V^{*}(p^{*}) = S^{*}(p^{*}) + \pi^{*}(p^{*}).$$

The non-cooperative tariff of the importing country, t^{N}, may be obtained by setting $\frac{dV}{d\tau} \equiv 0$. Solving for this optimality condition yields

$$t^{N} = \omega + \theta\left(\frac{1+t^{N}}{\varepsilon\frac{m}{y}}\right), \tag{II.2}$$

where, ω, ε, and $\frac{m}{y}$ are inverse export elasticity, import elasticity, and import penetration ratio, respectively.[15] The first term is the inverse of the foreign export supply function which reflects the part of optimal tariff that is due to the terms-of-trade motive. The second term in (II.2) captures the political benefit of raising the tariff. This term is increasing in the weight placed on political interests, but decreasing in $\eta \equiv \varepsilon\frac{m}{y}$. The term η reflects the domestic resource distortion per dollar of profits transferred to domestic producers, since a more elastic import demand raises the deadweight loss of raising the tariff and a larger import penetration ratio reduces the gain in profit obtained from an increase in the tariff.[16]

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[14] Focusing on one good is without loss of generality within our framework in which a numeraire good is available.

[15] Equation II.2 is essentially equivalent to Grossman and Helpman's (1995) formula for non-cooperative tariff, although in their model the political weight, θ, is common across sectors.

[16] Solving for t in II.2 yields the non-cooperative tariff $t^{N}(\theta) = \frac{\eta\omega+\theta}{\eta-\theta}$,where $\eta \equiv \varepsilon\frac{m}{y}$. We assume throughout the paper that $\theta < \eta$ such that the Nash ad valorem tariff does not prohibit trade.

In the analysis that follows, we assume that the inverse elasticity of export supply can be expressed as a function of the foreign country's export price, $p^*(t)$, and exogenous factors z_ω reflecting the technology, factor endowments and preferences of the foreign country in that sector. A similar assumption will be made regarding the domestic elasticity and import penetration ratio. With a slight abuse of notation, we will perform comparative statics exercises using $d\omega$ and $d\eta$ to denote the effect of changes in these exogenous factors. Assuming that the second order conditions are satisfied, it is shown in the Appendix that we can use (II.2) to express the optimal tariff as a function of three key parameters,

$$t^N = \tilde{t}^N(\theta, \omega, \eta), \tag{II.3}$$

such that $\tilde{t}^N_\theta > 0$, $\tilde{t}^N_\omega > 0$, $\tilde{t}^N_\eta < 0$. Greater market power and a larger political shock will make the home country more protectionist, while a large domestic cost of tariff distortions will reduce the optimal tariff.[17]

Defining the joint political welfare of the two governments as $W(t, \theta) \equiv V(t, \theta) + V^*(t)$, the necessary condition of world welfare maximization is given by $\frac{\partial W}{\partial t} \equiv 0$. Solving for t in this equation yields the politically efficient tariff

$$t^E(\theta) = \frac{\theta}{\eta - \theta}. \tag{II.4}$$

where $\eta > \theta$ must hold at an interior maximum. The politically efficient tariff is increasing in the value of protection and decreasing in the cost of protection, η. The difference between

[17] As an example, consider the asymmetric country model of Bond and Park (2002) with linear supply and demand functions in each country: $d(p) = \lambda(1-p), d^*(p^*) = (1-\lambda)(1-p^*)$, $s(p) = \beta p$ and $s(p^*) = p^*$. Here $\lambda \in (0,1)$ may be interpreted as the relative size of the home country and $\beta > 1$ as the measure of the degree of foreign comparative advantage. In this case, $\omega = \frac{\lambda(1+\beta-2t)}{1+\beta}$ and $\eta = 2$, which implies that the inverse export supply elasticity is increasing in the home country's relative size and the degree of foreign comparative advantage. These parameters would represent the exogenous factors determining the home country's optimal tariff in (II.3).

the importer's optimal tariff and the efficient tariff will be $t^N(\theta) - t^E(\theta) = \frac{\omega\eta}{\eta-\theta}$, which is positive as long as the importer has positive market power. The difference between the importer's unilaterally optimal tariff and the efficient tariff reflects the terms of trade externality.

Information Structure

We will assume that the political weight, θ, is a random variable that has a pdf $f(\theta)$ with compact support $\Theta = [\underline{\theta}, \overline{\theta}]$. The home government is thus uncertain about its future preferences regarding tariffs, and expected world welfare is $\int_{\underline{\theta}}^{\overline{\theta}} W(t(\theta), \theta) f(\theta) d\theta$. If the realization of θ is publicly observable, then a complete trade agreement that specified tariffs $t^E(\theta)$ would maximize expected world welfare. Such an agreement would involve reciprocal trade liberalization, since it would reduce tariffs by an amount $t^N(\theta) - t^E(\theta)$ in state θ for each imported good in each country, while allowing governments the flexibility to respond to domestic political shocks.

Our analysis of trade agreements will focus on the case in which θ is not observable to other countries. We will also assume that state-contingent transfers between countries are not possible. With these assumptions, a trade agreement $t(\theta)$ will be incentive compatible if the importing country not prefer the tariff assigned in state θ to that in any other state,

$$V(t(\theta), \theta) - V(t(r), \theta) \geq 0 \text{ for all } r, \theta \in \Theta \tag{II.5}$$

The full information agreement, $t^E(\theta)$, will not be incentive compatible for the importing country for $\theta < \overline{\theta}$, since the importing country would report the state to be the value $r > \theta$ for which $t^E(r) = t^N(\theta)$.

Optimal Tariff Bindings

An optimal trade agreement in the presence of private information is one that maximizes expected world welfare subject to the incentive compatibility constraint (II.5). In our analysis, we will limit attention to agreements that take the form of a tariff binding, which allows a country to impose any tariff that is less than or equal to its tariff binding. We make this restriction because tariff bindings are the mechanism used in the GATT/WTO agreements, and because they are incentive compatible. Furthermore, it has it has been shown by Alonso and Matouschek (2008) and Amodor and Bagwell (2010) in models similar to ours that this restriction is without loss of generality under certain conditions on preferences and the distribution of the political shocks.

Letting t^B denote the tariff binding assigned to the importing country under a trade agreement, the importer will choose its optimal tariff in any state where its optimal tariff is below the tariff binding, and will choose the binding otherwise. Since the importer's optimal tariff is increasing in θ, we can invert (II.3) to obtain the threshold value of the political shock at which the tariff is at the binding as

$$\theta^B(t^B, \omega, \eta) = \max[\underline{\theta}, \tilde{t}^{N^{-1}}(t)], \tag{II.6}$$

$$\tilde{t}_t^{N^{-1}} > 0, \quad \tilde{t}_\omega^{N^{-1}} < 0, \quad \tilde{t}_\eta^{N^{-1}} > 0 \ \cdot$$

Increasing the tariff binding will raise the threshold at which the given tariff binding will bind more frequently for a country with a larger optimal tariff, so the threshold (at an interior solution) will be decreasing in market power The incentive compatible tariff schedule under the tariff binding can be expressed as

$$t(\theta) = \begin{cases} t^B & \text{if } \theta \geq \theta^B(t^B, \omega, \eta), \\ \\ \tilde{t}^N(\theta, \omega, \eta) & \text{if } \theta < \theta^B(t^B, \omega, \eta). \end{cases} \tag{II.7}$$

We refer to the outcome $t^B > t^N(\underline{\theta})$ as one with tariff overhang, since there will exist states of the world for which the tariff is strictly less than the binding.

Given the schedule of applied tariff in (I.13) and the distribution of political parameters, the expected joint welfare of the importing and exporting countries under the tariff binding, t^B, is given by

$$E[W] = \int_{\underline{\theta}}^{\theta^B} W(t^N(\theta); \theta) f(\theta) d\theta + \int_{\theta^B}^{\bar{\theta}} W(t^B; \theta) f(\theta) d\theta. \tag{II.8}$$

Assuming that the objective of the negotiators is to maximize their expected joint welfare, the optimal tariff binding is obtained by choosing t^B to maximize the expression given by (II.8).[18]

Noting that $W(t; \theta) = W(t; 0) + \theta\pi(t)$, the first-order condition for optimality at an interior solution is given by

$$\int_{\theta^B}^{\bar{\theta}} \left[W_t\left(t^B; 0\right) + \theta\pi_t\left(t^B\right)\right] f(\theta)\, d\theta = 0.$$

Rearranging this condition, we can express the necessary condition as

$$-W_t(t^B, 0)/\pi_t(t^B) = E\left[\theta | \theta > \theta^B(t^B, \omega, \eta)\right]. \tag{II.9}$$

The left hand side of this expression is the deadweight loss per dollar of profit generated for import-competing producers. The right hand side is equal to the expected political

[18] This objective function is appropriate if lump sum transfers can be made between countries at the time that the agreement is signed.

premium from raising an additional dollar for producers, $E\left[\theta|\theta > \theta^B\right]$.

The solution for the optimal binding is illustrated in Figure 5, which plots the left and right hand sides of (II.9) against t^B. As shown in Lemma 2 in the appendix, the left-hand side of II.9 may be written as $-W_t(t^B, 0)/\pi_t(t^B) \equiv \frac{t^B}{1+t^B}\eta$, which is increasing in t^B as long as η does not decline too rapidly in t^B. The $E\left[\theta|\theta > \theta^B(t^B, \omega, \eta)\right]$ locus ranges over $[E(\theta), \overline{\theta}]$ and is non-decreasing in t^B. For $t^B < t^N(\underline{\theta})$, the importing country will keep its tariff at the binding for all θ and the expected benefit locus is horizontal at $E(\theta)$ over this interval. For $t \in (t^N(\underline{\theta}), t^N(\overline{\theta}))$, increases in the binding raise the threshold, $\frac{\partial E\left[\theta|\theta > \theta^B\right]}{\partial t^B} = \left(\frac{f(\theta^B)}{1-F(\theta^B)}\right)\frac{\partial \theta^B}{\partial t^B} > 0$, and thus raise the expected value of the shock above the threshold. An intersection in this region yields an agreement with tariff overhang. For $t^B > t^N(\overline{\theta})$, the tariff binding will never constrain the tariff policy of the home country because it exceeds the maximum the home country would impose. In order for a solution to the necessary conditions to represent a local maximum, the slope of the $\left(\frac{t^B}{1+t^B}\right)\eta$ locus must exceed that of the expected benefit locus at an intersection.

A solution for a maximum with a bound tariff in the interval $[0, t^N(\overline{\theta}))$ exists under fairly weak conditions.[19] Assuming these conditions are satisfied, we can derive the relationship between the model's parameters and the optimal binding. A corner solution with no tariff overhang arises if (II.9) is satisfied at $t^B < t^N(\underline{\theta})$. Substituting from (II.2) and (II.9) into this condition yields a corner solution if

$$\omega \geq \frac{E[\theta] - \underline{\theta}}{\eta - E[\theta]}. \tag{II.10}$$

[19] If $E(\theta) \geq 0$ and $\eta < \infty$, the expected benefit of raising the binding will be no less than the cost at $t^B = 0$. A solution to (II.9) with $t^B < t^N(\overline{\theta})$ will then exist if $\left(\frac{t^B}{1+t^B}\right)\eta - E\left[\theta|\theta > \tilde{\theta}^B(t^B)\right]$ is continuous in t^B and is positive when evaluated at $t^N(\overline{\theta})$. Noting that $t^N(\theta) = \frac{\eta\omega+\theta}{\eta-\theta}$, this latter condition requires $\left(\frac{\eta-\overline{\theta}}{1+\omega}\right)\omega > 0$. The existence of an interior solution for the efficient tariff with $t^E(\overline{\theta}) > 0$ requires $\eta > \overline{\theta}$, so this condition will be satisfied if $\omega > 0$.

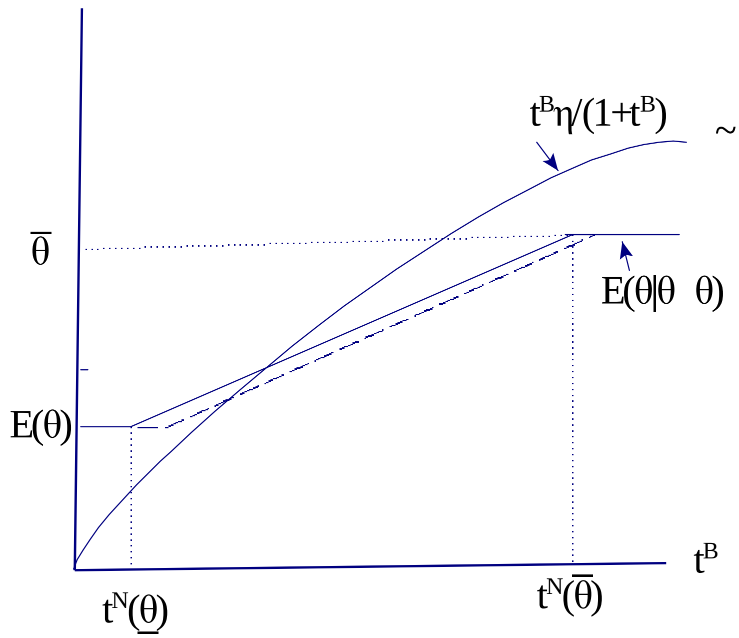


Figure 5. Expected Benefit and Cost of Raising a Tariff Binding

This condition will be satisfied if a country's market power, as measured by ω, is sufficiently high relative to the expected value of the political shock when evaluated at $\underline{\theta}$. In order to provide flexibility, the bound tariff must be sufficiently high that it exceeds $t^N(\underline{\theta})$ .For countries with significant market power, this cost is too high to justify allowing flexibility through the use of tariff overhang.

If the condition in (II.10) fails when evaluated at $\underline{\theta}$, then the necessary conditions will have an interior solution on $(t^N(\underline{\theta}), t^N(\bar{\theta}))$. Figure 5 can be used to illustrate the model's predictions about the relationship between country characteristics and the level of the tariff binding in a world-welfare-maximizing agreement. First consider the effect of an increase in a country's market power, i.e., an increase in ω. This has the effect of raising the Nash tariff and lowering $\theta^B(t^B)$ for $t^B \in (t^N(\underline{\theta}), t^N(\bar{\theta}))$, which shifts the expected benefit locus as illustrated by the dotted line in Figure 5. An increase in the market power of the importing country reduces the expected benefit of raising the binding, and thus reduces the optimal binding.

A reduction in η will have a similar effect on the expected benefit locus as an increase in market power, because it also raises the Nash tariff and reduces the threshold at which the binding holds. However, it also has the effect of reducing the cost of raising the binding, which shifts the cost locus downward proportionally. If the solution is a strict binding with no overhang (i.e. $t^B < t^N(\underline{\theta})$), only the latter shift applies and the tariff binding will rise. If the solution is an interior solution with tariff overhang, the effect on the binding will be ambiguous. Finally, note that a shift in the distribution of political shocks that raises $E(\theta|\theta \geq \theta^B)$ will raise the tariff binding at all solutions for t^B.

The following proposition summarizes our results thus far:

Proposition 1 (Optimal Binding) *(i) If $\omega > \frac{E[\theta]-\underline{\theta}}{\eta-E[\theta]}$, there will exist a local optimum at which there is no tariff overhang. The optimal tariff binding is $t^B = \frac{E(\theta)}{\eta-E(\theta)}$, which is increasing in $E(\theta)$ and decreasing in η.*

(ii) If $\omega \leq \frac{E[\theta]-\underline{\theta}}{\eta-E[\theta]}$, there exists a local optimum at which there is tariff overhang for some states of the world. The optimal tariff binding is decreasing in ω and increasing in $E(\theta|\theta \geq \theta^B)$. The effect of η on the binding is ambiguous.

Proposition 1 establishes comparative statics results in the neighborhood of a local maximum. If the solution to this problem is unique, it provides testable implications about the relationship between market power and the level of the tariff binding. In particular, it predicts that a country's tariff binding is non-increasing in its market power, and strictly decreasing if there is tariff overhang. [20]

Proposition 1 also yields a prediction about the relationship between market power and the probability that a country's applied tariff is at the binding. The probability that a

[20] Since both the cost and benefit loci in Figure 1 are positively slope, this stronger result requires additional restrictions on the behavioral parameters and the distribution of political shocks. In the special case of linear supply and demand discussed above, $f'(\theta) \leq 0$ is a sufficient condition for uniqueness for all values of country size and comparative advantage. With $f'(\theta) > 0$, uniqueness requires that the country not be too large. Our empirical predictions thus also require that conditions of this type be satisfied.

country's applied tariff is at the binding is given by $1 - F(\theta^B(t^B, \omega, \eta))$. Therefore, in the region that t^B is decreasing in the inverse export elasticity, the likelihood of a zero overhang should be increasing in ω because both the direct and indirect (through the change in tariff binding) effects of an increase in market power will reduce θ^B.

Corollary 1 *Under the optimal tariff binding agreement with tariff overhang, the likelihood of zero overhang is increasing in ω. For $\omega > \frac{E[\theta]-\underline{\theta}}{\eta - E[\theta]}$, we always have zero overhang under the optimal agreement.*

Tariff Binding Overhang

Optimum tariff theories predict that absent international trade policy commitments, i.e., when countries have 'full' flexibility in choosing their trade policies, the adopted import tariff is an increasing function of a countries international market power in the concerned sector. What is the relationship between applied tariff and international market power when countries are subject to tariff binding commitments that may provide a 'limited' flexibility? Since in practice a large fraction of tariff lines are below their bindings, it would be useful to have predictions regarding applied tariffs and market power. The results above provide us with a framework in which we can address this question.

We start by considering the magnitude of tariff binding overhang, which is one of the most interesting features of applied tariffs under the WTO agreement. Given a tariff binding, t^B, the size of a tariff binding overhang as a function of the state of the world, denoted by $g(\theta)$, is given by

$$g(\theta) = \begin{cases} t^B - t^N(\theta) & \text{if } \theta < \theta^B \equiv \min[\underline{\theta}, t^{N^{-1}}(t^B)], \\ 0 & \text{if } \theta \geq \theta^B, \end{cases}$$

where, θ^B was defined in (II.6), i.e., θ^B. The average overhang, g, can be written as $E(g) = \int_{\underline{\theta}}^{\theta^B} \left[t^B - t^N(\theta)\right] f(\theta)\, d\theta$, with the impact of the importing country's market power, as measured by ω, on the average size of overhang given by

$$\begin{aligned}\frac{dE(g)}{d\omega} &= \int_{\underline{\theta}}^{\theta^B}\left[\frac{dt^B}{d\omega}-\frac{dt^N(\theta)}{d\omega}\right]f(\theta)\,d\theta+\left[t^B-t^N\left(\theta^B\right)\right]f\left(\theta^B\right)\\ &= \int_{\underline{\theta}}^{\theta^B}\left[\frac{dt^B}{d\omega}-\frac{dt^N(\theta)}{d\omega}\right]f(\theta)\,d\theta.\end{aligned}$$

But since $t^N_\omega(\theta)>0$ and $\frac{dt^B}{d\omega}<0$ for $\omega<\frac{E[\theta]-\theta}{\eta-E[\theta]}$, it must be the case that $\frac{dg}{d\omega}<0$. Formally,

Proposition 2 (Overhang) *Under an optimal tariff binding agreement, the average size of overhang is strictly decreasing in the international market power if and only if* $\omega<\frac{E[\theta]-\theta}{\eta-E[\theta]}$. *For* $\omega>\frac{E[\theta]-\theta}{\eta-E[\theta]}$, *the overhang is always zero*

Figure 6 illustrates this point for two levels of international market power parameters ω_0 and ω_1, such that $\omega_0<\omega_1$. In this example the optimal binding for either market power level allows for overhang, i.e., $\theta^B(\omega_0),\theta^B(\omega_1)>\underline{\theta}$. As seen in this figure, an increase in the market power parameter from ω_0 to ω_1 lowers the binding and increases the applied tariff in states where there is overhang. As a result, the average overhang under the optimal tariff binding agreement decreases as ω increases. Figure 6 also shows that there will be conflicting effects of international market power on the average level of the tariff, which is given by

$$E\left[t^A\right]=\int_{\underline{\theta}}^{\theta^B}t^N(\theta)f(\theta)d\theta+(1-F(\theta^B))t^B.$$

The applied tariff of the larger country is higher in the region where both countries have overhang, but is lower in the region where both countries are at the binding.[21] Differentiating this expression with respect to ω yields

$$\frac{d}{d\omega}E\left[t^A\right]=\int_{\underline{\theta}}^{\theta^B}t^N_\omega(\theta)f(\theta)d\theta+\left(1-F(\theta^B)\right)t^N_\theta\left(\theta^B\right)\frac{d\theta^B}{d\omega}. \quad \text{(II.11)}$$

[21] We refer to the case where the market power paramter is given by ω_1 (ω_0) as the large-country (small-country) case.

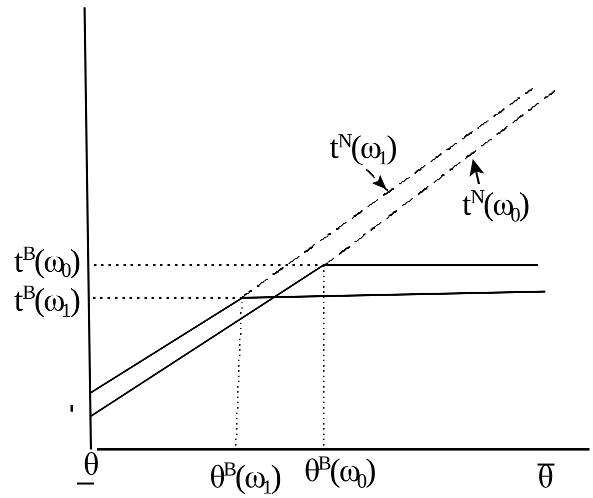


Figure 6. Agreement Tariff Schedules (Solid Lines) and Market Power: $\omega_1 > \omega_0$

The first term must be positive, because an increase in the market power increases the Nash tariff. The second term will be negative by Proposition (1). The former effect must dominate in the neighborhood of $\omega = 0$, since $\theta^B \to \bar{\theta}$ as $\omega \to 0$. The latter effect will dominate in the neighborhood of $\omega = \frac{E[\theta]-\underline{\theta}}{\eta - E[\theta]}$, since $\theta^B \to \underline{\theta}$ as $\omega \to \frac{E[\theta]-\underline{\theta}}{\eta - E[\theta]}$. Formally,

Proposition 3 (Applied Tariff) *The average applied tariff is an increasing (decreasing) function of ω for sufficiently small (large) values of ω.*

The non-monotonicity result of this paper may be understood by noting two conflicting forces that determine the size of the applied tariffs under an optimal agreement. On one hand, greater international market power increases the size of unilaterally optimal tariff, which tends to increase the average applied tariff. On the other hand, as shown in Proposition (1) and depicted in Figure (6), the optimal agreement features a lower binding for sectors with greater international market power, which reduces the maximum allowed tariff under the agreement. The former effect dominates when market power is small and the tariff binding is very high, while the latter effect dominates for sufficiently large levels of market power.

Data and The Empirical Model

In the rest of the paper we provide empirical observations regarding the main predictions of our theory. To study tariff bindings and overhang, we utilize data on Tariff Bindings and MFN-Applied Tariffs for WTO members that is available from WTO (2010) for the period 1995-2009. The number of years for which applied tariff data is available varies substantially across members. Most members report applied tariff data for at least one year during this period, but a complete time series is available for only 14 countries. The current tariff bindings were set at the time of the WTO agreement in 1995, and have remained essentially unchanged since that time.

Applied tariffs, on the other hand, show considerable variation. This adjustment falls into two parts. In the period immediately following the agreement, there was significant reduction in applied tariff rates as countries reduced their tariffs to meet their new binding obligations, Interestingly, these reductions included both reductions in tariffs that were over the binding as well as reductions in tariffs that were already under the binding. Once the phase-in period ended, adjustments in applied rates have continued, but the frequency of adjustments varies substantially across countries and does not show a significant upward or downward trend.

Our theoretical model does not attempt to address the phase-in of applied tariff rates following the negotiation of a trade agreement. Therefore, we will focus primarily on using a cross section for a particular year in our estimations. We use cross sectional data from year 2007, because the phase-in period for original WTO members was completed by that time.[22] Applied tariff data for 66 members accounting for 76% of world import

[22]Virtually all of the phase-in periods for countries that were members in 1995 were completed by 2003-2005. In addition, the data for 2007 was not affected by the financial crisis. Since our model focuses on sector-specific and country-specific shocks, we avoided the financial crisis years where there were significant systemic shocks.

is available for 2007.[23] Our selection criteria resulted in a total of 66 WTO members, including 52 original members and 14 new members. The data on applied tariff provides tariff information on approximately 5,200 sectors at the HS 6-digit level for each of the members, resulting in a sample of over 300,000 tariff lines.

Table 14 (in the introduction) reports the fraction of all tariff lines and the fraction of all imports that fall under one of three categories with respect to the overhang and tariff binding: zero overhang (the applied rate equals the bound rate), tariff overhang (applied rate strictly less than bound rate) and unbound (no tariff binding negotiated).[24] Although tariff lines with a zero overhang account for only 16.53% of all tariff lines, they account for 65% of world imports. Thus, a zero overhang is much more likely to be found in tariff lines that account for the largest fractions of world trade. Table 16 (in Appendix A) provides a summary of tariff binding status across countries. This table shows a substantial cross-country variations in the binding status: more than 90% of the applied tariffs are at their bindings for 5 members (EU,China, Japan, Switzerland, and the US), while there are less than 5% of tariff lines at their binding for 25 members.[25]

We test the predictions of Proposition 1 using the following Tobit model:[26]

[23]We used data from 2006 for Belize, Nicaragua, Turkey, and 2008 for Morocco, Sri-Lanka, and Tunisia, as these countries did not report their applied tariffs in 2007.

[24]Table 14 also reports the fraction of tariff lines in which applied tariff is greater than the binding. These cases, which account for less than 3 percent of tariff lines (less than 6 percent of world trade), are related to the breach of the agreement or the use of contingent protection measures such as safegards.

[25]These countries include Brazil, India, Columbia, Philippine, Chile, Peru, Bangladesh, Kuwait, Dominican Republic, Uruguay, Guatemala, Costa Rica, Kenya, El Salvador, Trinidad and Tobago, Bahrain, Jamaica, Honduras, Ghana, Mauritius, Madagascar, Zambia, Mongolia, and Guyana.

[26]According to the theory, at a corner solution, which prevails if $\omega > \frac{E[\theta]-\theta}{\eta-E[\theta]}$, the optimal binding is given by $t^B = \frac{E[\theta]}{\eta-E[\theta]}$. Therefore, contrary to the underlying assumption in this Tobit model, the corner solution for t^B is not necessarily zero and it is a function of η. In fact, the Tobit specification presumes that any observation with $t^B > 0$ represents an interior solution in which case t^B must depend negatively on ω. Therefore, if the theory is true, the Tobit specification will be biased against the prediction of our theory by making the parameter estimates smaller and less statistically-significant.

$$\begin{aligned} t_{ij}^{B*} &= \alpha_1 \omega_{ij} + \beta_1 \eta_{ij} + X_j \boldsymbol{\gamma}_1 + \varepsilon_{ij}, \\ t_{ij}^{B} &= t_{ij}^{B*} \text{ if } t_{ij}^{B*} > 0, \\ t_{ij}^{B} &= 0 \text{ if } t_{ij}^{B*} \leq 0. \end{aligned} \tag{II.12}$$

In this model, i and j are sector and country subscripts, t^B and t^{B*} are the observed tariff binding and its associated latent variable, ω is international market power, η is the product of import elasticity and import penetration ratio, and X_j is a vector of country-level variables that we discuss below. Proposition 1 implies that $\alpha_1 < 0$, while the sign of β_1 is ambiguous.

In cases where we have explanatory variables that are available at the HS 6-digit level, the dependent variable is the bound tariff from the WTO database.[27] In cases where we have variables that are only available at the HS 3-digit level, the dependent variable is the simple average of the bound tariffs over the 6-digit HS lines within the relevant 3-digit HS category.[28]

We also use a Tobit model to test whether there is a negative relationship between the size of the overhang observed in the data and the measure of international market power as predicted by Proposition 2:

$$\begin{aligned} g_{ij}^{*} &= \alpha_2 \omega_{ij} + \beta_2 \eta_{ij} + X_j \boldsymbol{\gamma}_2 + \varepsilon_{ij}, \\ g_{ij} &= g_{ij}^{*} \text{ if } g_{ij}^{*} > 0, \\ g_{ij} &= 0 \text{ if } g_{ij}^{*} \leq 0. \end{aligned} \tag{II.13}$$

[27]As will be discussed below, we use two alternative measures of international market power, namely, import ratio and inverse export elasticity. The former (latter) is available at the 6-digit (3-digit) HS tariff lines.

[28]Similar results were obtained when we used trade weighted tariff binidngs as the dependent variable.

In this model $g = t^B - t^A$ is the observed overhang and g^* is the associated latent variable. The explanatory variables are the same variables that were included in II.12. Proposition 2 implies that $\alpha_2 > 0$, but no clear prediction is established for β_2.

A final testable prediction is that of Corollary 1 that the likelihood of zero overhang is increasing in the measure of international market power. In cases where we have a market power measure that is available at the HS 6-digit level, the prediction can be tested using a Probit model, where the dependent variable is a dummy variable whose value is equal to one if the applied tariff equals (or is greater than) the bound tariff.[29] The probit model can be expressed as

$$\Pr\left(t_{ij}^A \geq t_{ij}^B | \omega_{ij}, \eta_{ij}, X_j\right) = \Phi\left(\alpha_3 \omega_{ij} + \beta_3 \eta_{ij} + X_j \gamma_3\right). \tag{II.14}$$

Corollary 1 implies that $\alpha_3 < 0$. In cases where some explanatory variables are available only at the HS 3-digit level, we aggregated the 6-digit HS data by calculating the share of the 6-digit HS lines in the 3-digit HS category that were at the binding. We then used OLS to estimate the effects of the explanatory variables on the share of 3-digit HS lines that were at the binding.

International Market Power Measure

International market power plays a central role in our theory. We use two measures of market power: the inverse of the export supply elasticity and the member's import volume as a share of world imports in the sector. There are advantages and disadvantages to each of these measures, so we chose to use both in testing the role of market power.

[29] As was shown in Table 14, in 2.76% percent of tariff lines the applied tariff is greater than the binding. We include such cases in the zero-overhang category.

Broda and Weinstein provide estimations of export supply elasticity using a methodology derived by Feenstra (1994) and extended by themselves in Broda and Weinstein (2006). Although the export supply elasticity is the market power measure suggested by our theory, there are two limitations in the use of these measures. First, these estimated elasticities are only available at the HS 3-digit level and for only 42 of the countries in our sample. Second, as noted by Broda, Limao and Weinstein (2008), much of the variation in the estimated elasticities is across goods by construction. In other words, the estimated inverse export elasticities mostly capture variations of market power across sectors within each country. Therefore, when we use inverse export elasticity as the measure of market power, we will focus on a cross-sector and within-country analysis by including country fixed effects.

As an alternative measure of international market power, we will also use the member's import volume as a share of the world imports in the concerned sectors. As is well-known, the true elasticity of export supply faced by country i for a given good can be expressed as[30]

$$\varepsilon_i^* = \left(\varepsilon^X + \sum_{k\neq i} \varepsilon_k W_k\right) / W_i,$$

where, W_i is country i's share of world imports in that good, ε^X is the world export supply elasticity, and ε_k the import demand elasticity for country k. Therefore, a country's share of the world import is inversely related to that country's true export supply elasticity.[31] This measure has the advantage of being available at the HS 6-digit level for all of the countries in our data set, and also provides a measure that can better capture the variation in market

[30]Letting X and X_i denote the world export supply and the export supply function facing country i, we have $X_i = X - \sum_{k\neq i} m_k$, which implies $\frac{dX_i}{dp^*} = \frac{dX}{dp^*} - \sum_{k\neq i} \frac{dm_k}{dp^*}$. This can be written as $\varepsilon_i^* \frac{X_i}{p^*} = \varepsilon^X \frac{X}{p^*} + \sum_{k\neq i} \varepsilon_k \frac{m_k}{p^*}$, or $\varepsilon_i^* = \left(\varepsilon^X + \sum_{k\neq i} \varepsilon_k W_k\right) / W_i$, where W_k is country k's share of the world import.

[31]In our data, as in Broda, Limao and Weinstein (2008), there is a positive and statistically significant relationship between inverse export elasticity and import share.

power across countries.

A concern about the use of market share data is that it is also an endogenous variable in our regressions because it is related to the applied tariffs. We therefore take an instrumental variable approach by using GDP and per-capita endowment of several productive resources of the economy, including productive capital, intangible capital, natural (agricultural) capital, and natural minerals as instruments for import ratio.[32] This choice of instrumental variables is motivated by the factor-content-of-trade methodology developed by Romalis (2004), in which relative resource endowment determines comparative advantage and, hence, the structure of trade in the world. Fitted values of import ratio are calculated for six-digit product category of the Harmonized System. This entails running 4466 separate regressions (one for each HS 6-digit product category) in the first stage. In 97% of these regression there are at least two coefficients with statistically significant estimates. Moreover, the result of an F-test shows that 97.8% of these sectoral regressions are significant at a 10% level.

Other Explanatory Variables

Political factors also play a role through their impact on the conditional mean of the political shock, $E[\theta - 1|\theta \geq \theta^B]$. Unfortunately, we do not have a good measure of political influence at the sectoral level that is available across countries. A potential proxy for the importance of political shocks at the country level is an index of political instability that is constructed by the the Economist Intelligence Unit. This index ranks countries on a scale of 0 to 10, with 10 being the highest level of instability. The index is constructed using factors such as the number of outbreaks of violent conflicts, type of regime, and level

[32]The data on productive resources of the member countries is obtained from World Bank (2010).

of economic development. Our hypothesis is that countries that are politically unstable are more likely to suffer from extreme values of the political shocks, and thus should have a greater demand for flexibility to deal with those shocks. If this hypothesis is correct, our model then implies that a higher political instability number is associated with greater tariff bindings and overhang.

Finally, as suggested by the theory, import demand elasticity and import penetration ratio are other determinants of the optimal tariff. We have data on import demand elasticities, ε in the notation of (II.2), obtained from Broda and Weinstein (2006) for 42 of the countries at the HS 3-digit level. Unfortunately, production data was available for an even smaller set of industries and countries. As a result, in regressions that include $\eta = \varepsilon m/y$ as an explanatory variable, we were limited to using data from manufacturing sectors for 24 countries.[33] As noted above, the theory does not establish unambiguous comparative statics results for these variables in most cases. Therefore, we constructed estimates of the model both with and without these variables.

Table 15 reports summary statistics for our key explanatory variables. GDP is highly skewed, reflecting the presence of a few members with very large markets (United States, European Union, and Japan) among the 66 countries. We also included GDP per capita as an explanatory variable, as a proxy for an alternative hypothesis that poor countries are generally given high bindings and not expected to make significant market access concessions. Since market power variables are correlated with GDP per capita in the data, we check if the significance of the international market power measures in our estimation is robust to inclusion of GDP per capita.

[33]Manufacturing output data is available for 4 digit ISIC categories from UNIDO. These production data were matched to the HS 3-digit categories to obtain the import ratio variable.

Table 15. Descriptive Statistics

Name	Average	Median	Min.	Max.
GDP (bil.$)	528	32	0.8	11,670
per capita GDP($)	8831	3683	171	41904
Political Instability Index	3.95	4.1	0.2	6.8
Bound tariff rate (%)	28.56	25	0	800.3
Applied tariff rate (%) (in bound sectors)	8.165	5	0	800.3
Tariff Overhang (percentage point)	21.41	15	0	454.2
Import share(%)	1.35	0.056	0	99.91
Inverse Export Elasticity	62.39	1.12	0.0004	1645.96
Import Elasticity	8.45	3.27	1.074	821.89

Note: Cross sectional data from year 2007 for 66 WTO members. Tariff rates are the average of tariff lines at the HS 6-digit level. Import and export elasticities are measured at HS 3-digit level. Number of observations: 300179. Source: WTO, World Bank, United Nation, and the Economist Intelligence Unit.

Empirical Results

Table 17 shows the results for the Tobit regression (II.12) of the tariff binding against market power and other variables. In the first two columns a country's share of world imports in a sector is used as the measure of market power. This measure is available at the HS 6-digit level for all of the 66 WTO members in our sample, resulting in more than 247,000 observations. Our estimation shows a negative and statistically significant relationship (at the 1% level) between import share and the level of the tariff binding, which is consistent with the prediction of Proposition 1. Standard errors were calculated assuming two-way clustering at the country and sectoral level. The impact of international market power, as measured by import share, is also economically significant: a one-standard-deviation, equal to 4.6 percentage points, increase in the import share, reduces the tariff binding by 3.5-4.46 percentage points.[34]

The results also indicate that the political instability measure has a positive and statistically significant relation to the tariff binding, which is also consistent with the theory if we assume that political instability is positively related to the average magnitude of

[34]Standard deviation of the import share variable is 4.7. Multiplying this number with the coefficient of the import share in column 1 and column 2 of Table 17 yields 3.5 and 4.46, respectively.

political pressure. GDP per capita is also included to control for the possibility that the level of development plays a role in determining bindings.

Column 3 uses the Broda-Weinstein's estimated inverse export elasticities as a measure of international market power. In this specification we also include import demand elasticity, ε, as an explanatory variable.[35] As noted in the discussion above, the use of this measure restricted our analysis to the use of weighted tariff bindings at the HS 3-digit level for 42 countries. Using country fixed effects, we find a negative relationship between the inverse elasticity and the level of the binding that was significant at the 1%-level. The estimated coefficient for ε was not statistically significant, which is in line with lack of an unambiguous theoretical relationship between ε and the level of optimal tariff binding.

The remaining columns in Table 17 report tests on subsets of the sample of countries or industries. These tests serve as robustness checks on our estimates for the entire sample of countries. Columns 4 and 5 report results for the original WTO members (52 countries) and those that were admitted after 1995 (14 countries), respectively. These regressions indicate a negative and statistically significant relationship between market power (measured by import share) and the level of the bindings, although the magnitude is smaller for the new entrants and is only significant at the 10%-level.

Columns 8 and 9 report results where separate equations were estimated for manufactured products and agricultural goods. There are reasons to believe that the political economy of manufacturing and agricultural sectors are substantially different. First, a greater variability in output levels and prices is likely to be observed in agriculture than in manufacturing, which is likely to lead to more extreme political shocks in agriculture. Furthermore, the trade liberalization process in manufacturing has generally made far more

[35] In other specifications (not reported) we used η instead of ε. The estimated coefficients have the expected sign but show a lower level of statistical significance.

progress than in agriculture. The results indicate similar negative and statistically significant impacts of import share on the level of bindings in both sectors. One significant difference for the agricultural sectors is that there is a negative and statistically significant effect of GDP per capita on bindings in agriculture. The results using export supply elasticities to measure market power have a negative effect, but the result is not statistically significant.

Table 18 reports the results of the Tobit model (II.13) for tariff overhang. The results are broadly similar to those obtained for the tariff binding equations, although in this case the significance of the market power effects is even stronger. Both market power measures have coefficients that are negative and significant at the 1% for the equations involving all countries, as well as in the original member/new member subgroups and for the manufacturing sectors. These estimated effects are also economically important. In particular, a one-standard-deviation, equal to 4.6 percentage point, increase in import share results in an 8-17 percentage-point decrease in the magnitude of the tariff binding overhang. The results for the political instability variables are also positive for the equation involving all countries, although the statistical significance is somewhat reduced. GDP per capita also plays a role in the determination of overhang in the agricultural sector, which is also consistent with the findings on tariff bindings.

Table 19 reports the marginal effects of the explanatory variables of the Probit regression (II.14) of the likelihood of zero overhang against a measure of market power and other explanatory variables. The results for this regression are also consistent with the theory, such that sectors with greater import market power are more likely to have an applied tariff at the binding. This result holds across all specifications when import share is used as the measure of market power (Columns 1, 2, 4-6, and 8). To illustrate the magnitude of these effects, compare the marginal of ω in column 1, which is 0.014 at the mean of import share (1.32%), and 0.013 at the median of import share (0.06%). This numbers indicate that a one-standard-deviation increase in import share makes it 7 percentage-points more likely to have an applied tariff that is at the binding, i.e., a zero overhang.

In columns 3, 7, and 9, we use inverse export elasticity as the measure of international market power. As explained above (subsequent to the Probit model II.13), we use an OLS specification when export elasticity is used. Column 3, which reports the result of the OLS regression on the entire sample, shows a statistically and economically significant coefficient for inverse export elasticity. These coefficient estimates, however, are statistically insignificant when the agricultural and manufacturing subsamples are studied separately. As in previous regressions, political instability has a negative and highly significant effect on tariff overhang in the HS 6-digit regressions, which is consistent with the notion that countries with greater variability in political shocks will require greater flexibility in tariff bindings and, as a result, are less likely to be at the binding.

Conclusion

The aim of this paper is to derive and examine predictions of the terms-of-trade theory when governments value flexibility in setting their policies. We model the trade-off between curbing beggar-thy-neighbour motivations and flexibility in the design of trade agreements, and argue that recognizing this trade-off is the key to explain the observed patterns in the tariff binding commitments and applied tariffs under the WTO.

We provide a systematic account of the empirical relationship between tariff commitments, applied tariffs, and measures of international market power. As predicted by the theory, the level of tariff binding and the size of tariff binding overhang are both inversely related to measures of import market power.

Our theoretical model abstracts away from some important elements that are relevant in trade agreements. First, we ignore the possibility of including an 'escape clause' in the agreement, which allows the signatories to set tariffs above their committed tariff bindings. There are at least three approaches to introduce an incentive-compatible and welfare-improving escape clause in a trade agreement. In one approach, explored by Feenstra and Lewis (1991), Sykes (1991), Ludema (2001), Beshkar(2012), Beshkar (2010a), Beshkar(2010b), and Maggi Staiger (2011b), Maggi and Staiger (2011a), parties can breach the contract if they compensate the affected parties according to a pre-specified remedy system. A second approach, which is under study by Beshkar and Bond (2012), assumes the availability of a costly state-verification process, in which parties may set tariffs above the binding if they can verify publicly that their current contingency justifies higher tariffs. A third approach is to impose a dynamic constraint on the use of contingent protection, as in Bagwell and Staiger (2005) and Martin and Vergote (2008).

We also abstract from the issues regarding the non-discrimination clause and the related flexibility measures. Nondiscrimination is an important element of the GATT/WTO. However, the member countries are given some flexibility to violate the non-discrimination clause under the anti-dumping agreement. The literature on trade agreements still lacks a convincing model that explains the merits of including a discriminatory flexibility measure such as anti-dumping. In particular, we lack a formal model to study the interaction between discriminatory and non-discriminatory flexibility measures in practice. For example, Prusa and Li (2009) argue that due to the flexibility provided by tariff binding overhangs, the use of anti-dumping measures as a contingent protection measure is less critical for the governments and, hence, may be excluded from the WTO.

Appendix: proofs and tables

Lemma 1 *Nash and Efficient tariffs are given by* $t^N(\theta) = \frac{\eta\omega+\theta}{\eta-\theta}$ *and* $t^E(\theta) = \frac{\theta}{\eta-\theta}$*, respectively, where* $\eta \equiv \varepsilon\frac{m}{y}$.

Proof. The world market clearing condition satisfies $m(p^*(1+t)) + m^*(p^*) = 0$.

Letting $\tau = 1+t$, totally differentiating the world market clearing condition yields

$$\begin{aligned}\frac{dp^*}{d\tau} &= -\frac{m'(p)p^*}{m'(p)\tau + m^{*\prime}(p^*)} = \\ &= -\frac{p^*}{\tau}\frac{\varepsilon}{\varepsilon+\varepsilon^*},\end{aligned}$$

where, $\varepsilon^* = p^*\frac{m^{*\prime}}{m^*}$ is the elasticity of foreign export supply and $\varepsilon = -\frac{pm'}{m}$ is the elasticity of import demand. The home price change can then be written as

$$\frac{dp}{d\tau} = p^*\left(1 + \frac{dp^*}{d\tau}\frac{\tau}{p^*}\right) = p^*\frac{\varepsilon^*}{\varepsilon^*+\varepsilon}.$$

The non-cooperative tariff of the importing country may be obtained by setting $\frac{dV}{d\tau} \equiv 0$. Taking derivative of V in **??** yields

$$\begin{aligned}\frac{dV}{d\tau} &= \frac{\partial V}{\partial p}\frac{\partial p}{\partial \tau} + \frac{\partial V}{\partial p^*}\frac{\partial p^*}{\partial \tau} \\ &= \left[(p-p^*)m' + \theta y\right]\frac{\partial p}{\partial \tau} - m\frac{\partial p^*}{\partial \tau} \\ &= \left[tp^*m' + \theta y\right]p^*\frac{\varepsilon^*}{\varepsilon^*+\varepsilon} + \left(\frac{p^*}{\tau}\right)\frac{m\varepsilon}{\varepsilon^*+\varepsilon}.\end{aligned}$$

Thus, importing country's optimality condition, $\frac{dV}{dt} \equiv 0$, may be written as

$$\left[-t\frac{\varepsilon}{1+t} + \theta\frac{y}{m}\right]\varepsilon^* + \frac{\varepsilon}{1+t} = 0.$$

Solving for t in this equation yields:

$$t^N(\theta) = \frac{1}{\eta-\theta}(\eta\omega+\theta), \qquad \text{(II.15)}$$

where, $\eta \equiv \varepsilon\frac{m}{y}$ and $\omega = \frac{1}{\varepsilon^*}$.

Defining the joint political welfare of the two governments as $W \equiv V(p, p^*, \theta) + V^*(p^*)$, the necessary condition of world welfare maximization is

$$\frac{dW}{dt} \equiv \frac{\partial W}{\partial p}\frac{\partial p}{\partial t} + \frac{\partial W}{\partial p^*}\frac{\partial p^*}{\partial t} = 0. \tag{II.16}$$

As shown by Bagwell and Staiger (1999), this condition reduces to $\frac{\partial V}{\partial p} = 0$,[36] which implies

$$\frac{t}{1+t}pm' + \theta y = 0,$$

or,

$$-\frac{t}{1+t}\varepsilon + \theta\frac{y}{m} = 0. \tag{II.17}$$

Rearranging this equation yields the importing country's politically efficient tariff

$$t^E(\theta) = \frac{\theta}{\eta - \theta}.$$

■

Lemma 2 $-\frac{dW\left(t^B;0\right)/dt}{d\pi\left(t^B\right)/dt} = \frac{t^B}{1+t^B}\eta$.

Proof. The effect of tariff on the unweighted joint welfare can be expressed as ■

$$\begin{aligned}
\frac{dW(p,p^*,0)}{dt} &= \frac{dV(p,p^*,0)}{dt} + \frac{dV^*}{dt} \\
&= \frac{\partial V(p,p^*,0)}{\partial p}\frac{dp}{dt} + \frac{\partial V(p,p^*,0)}{\partial p^*}\frac{dp^*}{dt} + \frac{\partial V^*}{\partial p^*}\frac{dp^*}{dt} \\
&= tp^*m'(p)\frac{dp}{dt} - m\frac{dp^*}{dt} - m^*\frac{dp^*}{dt}.
\end{aligned}$$

Noting that $m + m^* = 0$ and $\varepsilon = -p\frac{m'}{m}$, the impact of home tariff on the unweighted world

[36] To obtain this result, note that $\frac{\partial W}{\partial p} = \frac{\partial V}{\partial p}$ and $\frac{\partial W}{\partial p^*} = \frac{\partial V}{\partial p^*} + \frac{\partial V^*}{\partial p^*} = m + m^* = 0$. Therefore, $\frac{dW}{dt} = \frac{\partial V}{\partial p}\frac{\partial p}{\partial t} = 0$ if and only if $\frac{\partial V}{\partial p} = 0$.

welfare can be written as

$$\frac{dW\left(p,p^{*},0\right)}{dt}=-\frac{t\varepsilon m}{1+t}\frac{dp}{dt}. \tag{II.18}$$

Moreover, the effect of tariff on profits of import-competing producers in the home country is

$$\frac{d\pi}{dt}=y(p)\frac{dp}{dt} \tag{II.19}$$

Therefore, the marginal deadweight loss of tariff when $t=t^{B}$ may be written as

$$-\frac{dW\left(t^{B};0\right)/dt}{d\pi\left(t^{B}\right)/dt}=\frac{t^{B}}{1+t^{B}}\eta, \tag{II.20}$$

where, $\eta=\frac{m}{y}\varepsilon$.

Table 16. Binding Status Across WTO Members in the Sample

Member	Average Binding	Average Applied	Zero Overhang	Member	Average Binding	Average Applied	Zero Overhang
US	3.73	3.74	94.1%	Tunisia	58.93	21.49	5.7%
EU	4.16	4.23	92%	Croatia	6.13	4.67	64.5%
Japan	2.91	2.94	89.4%	Oman	12.44	4.60	8.9%
China	10.04	10.03	93.2%	Uruguay	31.56	10.54	0.2%
Canada	5.20	3.72	47.1%	Guatemala	42.40	5.52	0.1%
Brazil	31.40	12.43	1.0%	Costa Rica	43.29	6.43	2.0%
India	50.37	12.95	3.7%	Sri Lanka	29.11	13.04	0.4%
Korea	16.37	11.66	35.4%	Ecuador	21.79	11.92	9.0%
Mexico	34.95	11.94	7.1%	Panama	23.38	7.27	8.9%
Australia	10.09	3.49	27.1%	Kenya	95.01	12.995	0.1%
Turkey	30.35	10.31	18.6%	El Salvador	36.88	7.05	2.3%
Argentina	31.86	11.17	0.7%	Trin. Tob.	55.61	7.19	1.3%
Switzerland	0	0	100%	Jordan	16.34	11.13	28.8%
Saudi Arabia	10.81	4.60	7.3%	Bahrain	34.10	4.60	1.8%
Hongkong	0	0	100%	Iceland	13.25	2.85	42.3%
Indonesia	37.20	6.90	1.6%	Bolivia	39.97	8.29	0%
Norway	3.07	0.684	50.6%	Jamaica	49.73	7.35	0.5%
S. Africa	17.97	7.58	22.7%	Honduras	31.94	5.55	1.8%
Thailand	25.41	8.95	23.6%	Ghana	92.57	13.07	0%
Israel	18.18	5.33	19.7%	Gabon	21.37	17.85	0.2%
Singapore	6.99	0	21.6%	Mauritius	104.88	3.09	7.7%
Columbia	42.84	12.53	0.02%	Georgia	7.20	1.03	28.1%
Malaysia	14.63	7.33	23.4%	Albania	6.98	5.21	39.1%
Philippine	25.57	6.25	3.8%	Nicaragua	40.70	5.57	1.9%
Pakistan	59.68	13.41	10.9%	Madagascar	27.34	12.35	2.5%
Chile	25.07	5.99	0%	Zambia	106.52	13.59	0%
Peru	29.54	8.62	1.3%	Niger	44.57	12.02	9.5%
Bangladesh	162.68	16.98	1.0%	Moldova	6.73	4.38	63.3%
New Zealand	10.17	2.94	42%	Mongolia	17.52	4.96	0.7%
Kuwait	100	4.60	0.02%	Togo	80	12.02	0%
Vietnam	11.43	16.81	28.3%	Belize	57.97	10.38	1.2%
Morocco	41.26	21.45	15.8%	Cape Verde	15.79	10.29	15.4%
Dom. Rep.	34.95	7.19	0.8%	Guyana	56.80	10.73	1.4%

Note: Members are ranked based on their GDP in 2007.

Table 17. Tariff Binding Commitments and Market Power

Dependent Variable	Tariff Binding								
Sectors	All Sectors					Manufacturing		Agriculture	
WTO members (#)	All (66)		All (42)	Original (52)	new (14)	All (66)	All(42)	All (66)	All (42)
Estimation Method	Tobit	IV Tobit	Tobit	IV Tobit	IV Tobit	IV Tobit	Tobit	IV Tobit	Tobit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Import share	−0.76***	−0.95***		−0.93**	−0.37*	−0.91***		−0.94**	
	(0.23)	(0.28)		(0.36)	(0.20)	(0.29)		(0.44)	
$\log(\omega)$			−0.47***				-0.009		−0.42
			(0.15)				(0.04)		(0.49)
ε			0.01				−0.01***		0.003
			(0.01)				(0.004)		(0.04)
$\log\left(\frac{GDP}{Capita}\right)$	−2.00	−1.85		−6.95	−3.38	0.72		−10.09**	
	(3.39)	(3.37)		(4.73)	(3.43)	(3.23)		(4.67)	
Pol. Instability	5.01**	4.80**		3.00	2.83	5.19***		3.83	
	(2.04)	(2.00)		(2.62)	(1.51)	1.90		(3.36)	
Country dummy	No	No	Yes	No	No	No	Yes	No	Yes
Two Way Clustering	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No
R-squared	0.0171	0.0170	0.04	0.0289	0.0160	0.0237	0.2032	0.0159	0.0390
# of observations	247742	228481	6050	170649	57832	210107	4443	37635	1607

Note: Robust standard error in the regression with country dummy.

Table 18. Tariff Overhang and Market Power

Dependent Variable	Binding Overhang								
Sectors	All Sectors					Manufacturing		Agriculture	
WTO members (#)	All (66)		All (24)	Original (52)	new (14)	All (66)	All(24)	All (66)	All (24)
Estimation Method	Tobit	IV Tobit	Tobit	IV Tobit	IV Tobit	IV Tobit	Tobit	IV Tobit	Tobit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Import share	-1.73^{***}	-3.73^{***}		-3.65^{***}	-4.45^{***}	-1.61^{***}		-1.94^{**}	
	(0.52)	(0.95)		(0.92)	(1.59)	(0.52)		(0.49)	
$\log(\omega)$			-0.41^{***}				-0.15***		-0.13
			(0.06)				(0.04)		(0.16)
ε			0.01^{**}				-0.007*		0.01
			(0.006)				(0.004)		(0.01)
$\log\left(\frac{\text{GDP}}{\text{Capita}}\right)$	-1.15	-0.73		-5.78	-2.78	1.28		-9.37^{*}	
	(3.65)	(3.61)		(4.88)	(3.48)	(3.50)		(4.82)	
Pol. Instability	4.50^{**}	3.98^{*}		2.07	2.16	4.89^{**}		3.20	
	(2.18)	(2.12)		(2.68)	(1.43)	2.11		(3.35)	
Country dummy	No	No	Yes	No	No	No	Yes	No	Yes
Two Way Clustering	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No
Psuedo R-squared	0.0191	0.0216	0.1294	0.0347	0.0225	0.0239	0.2063	0.0182	0.1563
# of observations	247742	228481	6050	170649	57832	210107	4443	37635	1607

Note: Robust standard error in the regression with country dummy.

Table 19. Likelihood of Tariff at the Binding

Dependent Variable	Zero-Overhang Dummy								
Sectors	All Sectors					Manufacturing		Agriculture	
WTO members (#)	All (66)		All (42)	Original (52)	new (14)	All (66)	All(42)	All (66)	All (42)
Estimation Method	Probit	IV Probit	OLS	IV Probit	IV Probit	IV Probit	OLS	IV Probit	OLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Import share	0.014***	0.037***		0.019***	0.12***	0.039***		0.023***	
	(0.01)	(0.02)		(0.02)	(0.09)	(0.03)		(0.03)	
$\log(\omega)$			0.002**				0.001		−0.00
			(0.001)				(0.001)		(0.49)
ε			-0.00				0.0003**		−0.00
			(0.00)				(0.0001)		(0.00)
$\log\left(\frac{GDP}{Capita}\right)$	0.015	0.008		0.051***	−0.025	0.006		0.024	
	(0.10)	(0.10)		(0.11)	(0.18)	(0.10)		(0.11)	
Pol. Instability	−0.049***	−0.045***		−0.019*	−0.02	−0.045***		−0.044**	
	(0.06)	(0.06)		(0.07)	(0.11)	(0.00)		(0.08)	
Country dummy	No	No	Yes	No	No	No	Yes	No	Yes
Two Way Clustering	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No
(Psuedo) R-squared	0.1536	0.1891	0.6447	0.3507	0.0721	0.1975	0.6918	0.1444	0.7277
# of observations	291878	269039	6431	211049	57990	235687	4824	33172	1607

Note: Robust standard error in the regression with country dummy. In OLS regression, dependent variable is the ratio of strong binding in HS 3-digit sectors. Marginal effect is reported in the probit regression.

CHAPTER III

FIRM-LEVEL INVESTMENT AND EXPORT DYNAMICS

with Joel B. Rodrigue

Introduction

We develop a dynamic model of heterogeneous firms who make investment and export decisions through time. Consistent with our data, it shows that new exporters invest heavily in new capital as they enter and grow into export markets. Moreover, the model emphasizes that firm-level investment and export decisions evolve endogenously with firm-specific productivity and export demand shocks. We show that failing to account for endogenous responses to differential demand shocks across markets leads to biased productivity estimates due to quasi-fixed factors of production, such as capital stock. We structurally estimate the model using detailed information on export and investment decisions among Indonesian manufacturing firms. Allowing firms to endogenously invest in new capital substantially improves the model's ability to match numerous features of firm-level data; namely: differential investment and revenue growth rates across exporting and non-exporting firms, the export entry and survival rates among new exporters, and the distribution of new exporters across productivity and capital stock. Counterfactual experiments assess the impact of trade liberalization and financial reform on the evolution of aggregate exports and investment over time.

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, do new exporters begin investing before entry or only once they have successfully penetrated 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, 2010). 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.

Allowing firms to endogenously invest in new capital substantially improves the model's ability to match numerous features of firm-level data have proven difficult for modern models of firm-level trade to match. Specifically, the endogenous capital adjustment model rationalizes why many new exporters are small (underinvestment prior to exporting), why export revenues grow rapidly over the first few years of initial exporting (rapid new

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

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). Remarkably, the model is able to replicate these features of firm-level behavior even though this information *is not used to estimate the model parameters*. Recent contributions by Luttmer (2007) and Arkolakis (2010a) 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.[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 (2011), 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 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

[2]Riano (2011) has calibrated a related model of firm-level investment and exporting in Columbia. His model does not account for convex and non-convex for capital adjustment costs or the impact the export demand shocks have on productivity estimation. Moreover, Riano (2011) focusses on the impact of exporting on firm-level volatility while we emphasize the impact on firm dynamics and the impact that allowing for capital accumulation has export and investment growth through time.

[3]Similarly, Soderbery (2011) presents a model with constant marginal costs and a constant firm-level production capacity to capture the sales correlation across markets.

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 for both convex and non-convex investment costs and allows us to capture the extent to which investment frictions deter entry into export markets.

In our framework, as in much of the preceding literature, both export and investment are direct functions of the heterogeneous productivity and export demand shocks which evolve over time. A key step in our exercise is the estimation of firm-level productivity. Previous methods to estimate firm-level productivity tend to focus on a single market when developing productivity estimates and abstract away from the fact that firms may face different sets of shocks in different markets. In line with Demidova, Kee and Krishna (2011), we argue that failing to account for heterogeneous demand shocks across markets will likely lead to biased productivity estimates in export-oriented industries. We develop a method to consistently estimate firm-level productivity in this context which can be applied to most firm-level manufacturing data sets. In particular, our method needs to allow for differential shocks across markets and firms which evolve over time. 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. Further, we show ignoring these effects has a sizable impact on estimated production function coefficients; among the Indonesian manufacturing industries under study the capital share coefficient falls substantially across industries (8-32 percentage points). This is particularly important for productivity estimation: our productivity estimates suggest that accounting for differential shocks across markets increases productivity estimates for small, capital constrained firms. We find that new exporters, who are often small, and build capital holdings slowly over time, and often mistakingly characterized as generally unproductive. Our findings suggest that standard estimates of firm-level productivity are downwards biased for new exporters by 14-15 percent across industries. While numerous papers find that most new exporters are small and unproductive (e.g. Arkolakis 2010b), we conclude that largely new exporters are small, but very productive.

We structurally estimate the model's 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 83-94 percent. Further, although numerous papers suggest that fixed export costs are a key factor in determining export entry and persistence, we use simulation methods to argue that these costs are likely to have a relatively small role in determining firm entry decisions and dynamics in export markets.

We use the simulated model to study the impact of trade liberalization or financial reform on aggregate export and investment behavior. We find that a 10 percent increase in export market size leads to a 5-9 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.[4] In contrast, we find that trade liberalization has a relatively small impact

[4]The contribution of the extensive margin to aggregate exports is studied in Evenett and Venables (2002), Hummels and Klenow (2002), Ruhl (2003), Alelssandria and Choi (2007), Kehoe and Ruhl (2009), Arkolakis

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 financial reform. We find that reducing investment costs by 10 percent has a small impact on aggregate exports initially, but after 10 years the aggregate export growth rate are 5-12 percentage points higher than the benchmark model. Consistent with the evidence in Manova (2010) we find that this effect is particularly strong in industries where capital-constraints are most severe. Moreover, 10 years after the reduction in investment costs aggregate investment remains 24-28 percent higher than the baseline model and exporters account for 9-10 percent of the annual investment growth.

The next two sections present our model of investment and exporting and describe the data we use to estimate firm-level productivity and the model's structural parameters. Sections 3 and 4 describe the estimation methodology and present the results. The fifth section discusses the policy implications of our work and the sixth section concludes.

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

(2010b), and Alessandria and Choi (2011).

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:

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

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. This assumption is common in both theoretical models of heterogeneous firms and trade and empirical applications.[5] Equation (III.1) implies that firms with larger capital stocks incur lower marginal costs, *ceteris paribus*. This implies that 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

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

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 $1[\cdot]$ is an indicator function. Fixed investment costs are captured by ψ_2 which is drawn from the distribution G^{ψ}. 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 returns to retraining and restructuring of production activity. Both convex and

[5] See Melitz (2003), Atkeson and Burstein (2010) and Manova (2011) for theoretical models with constant marginal costs and Kasahara and Lapham (2007), Aw, Roberts and Xu (2011), Rodrigue and Soumonni (2011) for examples of empirical models with constant marginal costs.

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^D_{jt} at home and export demand curve q^X_{jt} abroad:

$$\begin{aligned} q^D_{jt} &= Q^D_t (p^D_{jt}/P^D_t)^{\eta} = \Phi^D_t (p^D_{jt})^{-\eta} \\ q^X_{jt} &= Q^X_t (p^X_{jt}/P^X_t)^{\eta} e^{z_{jt}} = \Phi^X_t (p^X_{jt})^{-\eta} e^{z_{jt}} \end{aligned} \tag{III.3}$$

where Q^D_t, Q^X_t, P^D_t and P^X_t are the industry aggregate output and price indices, Φ^D_t and Φ^X_t are demand aggregates, η is the (constant) elasticity of demand, p^D_{jt} and p^X_{jt} are the prices chosen in each market and z_{jt} is a shock to firm j's export demand in year t.[6]

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.[7] 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).

[6]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.

[7]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.

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:

$$\ln r_{jt}^D \quad = \quad -(\eta+1)\lambda[\Gamma_t + \alpha_k \ln k_{jt} - (1-\alpha_l)\ln(1+\Lambda_t^X e^{z_{jt}})d_{jt} + \omega_{jt}] \qquad \text{(III.4)}$$

where 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.[8] We define d_{jt} to be binary choice variable that takes a value of 1 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 (III.4) 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

$$\ln r_{jt}^X = \ln r_{jt}^D + \ln \Lambda_t^X + z_{jt} \qquad \text{(III.5)}$$

which is the export counterpart to the domestic revenue function (III.4). The export specific demand shock z_{it} captures the difference in export intensities across exporting firms with similar productivity levels.

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

Firm-specific productivity captures various sources of heterogeneity, and as such, it is important to interpret their effects cautiously. Specifically, ω_{it} 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.[9]

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

$$\pi_{jt} \quad = \quad -\left(\frac{1}{\lambda\eta}\right) r_{jt}^{D}(\Phi_t^D, \Lambda_t^X, k_{jt}, d_{jt}, \omega_{jt}, z_{jt}) \tag{III.6}$$

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.

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

$$k_{jt} = (1-\delta)k_{jt-1} + i_{jt-1} \tag{III.7}$$

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 process that depends

[9]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 (2011) 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.

on the firm's participation in the export market, and a random shock:

$$\begin{aligned} \omega_{jt} &= g(\omega_{jt-1}) + \xi_{jt} \\ &= \alpha_0 + \alpha_1 \omega_{jt-1} + \xi_{jt} \end{aligned} \quad \text{(III.8)}$$

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.[10] 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.

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 (2011) 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

[10]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.

cost of investment this period, ψ_{2jt}, and decides how much to invest in the current year.[11]

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

$$V_{jt}(s_{jt}) = \int \max_{d_{jt}}\{\pi_{jt}(s_{jt}, d_{jt}=1) - d_{jt-1}\gamma_{jt}^F - (1-d_{jt-1})\gamma_{jt}^S + V_{jt}^E(s_{jt}), \pi_{jt}(s_{jt}, d_{jt}=0) + V_{jt}^N(s_{jt})\}dG^\gamma \tag{III.9}$$

where $s_{jt} = (\omega_{jt}, z_{jt}, k_{jt}, d_{jt-1}, \Phi_t^D, \Lambda_t^X)$ 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 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 (III.2), 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,

[11] 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.

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

$$\psi_0 + 2\psi_1 \left(\frac{i_{jt}}{k_{jt}} \right) = \beta E_t \frac{\partial V_{jt+1}(s_{jt+1}|d_{jt}, i_{jt})}{\partial i_{jt}} \quad \text{(III.10)}$$

The left side of (III.10) is the marginal cost of adjustment and is independent of the firm's export decision or history.[12] 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).[13] 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.[14] Rather we would expect that small exporters 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,

[12]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.

[13]The RHS of (III.10) 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.

[14]While it is beyond the scope of this paper to detail all of these patterns across heterogeneous firms and industries, we refer the interested reader to Rho and Rodrigue (2012) for further broad, reduced-form evidence on the nature of capital holdings among new exporters over time.

for any firm as:

$$MBE_{jt} = \underbrace{\pi_{jt}(s_{jt}, d_{jt} = 1) - \pi_{jt}(s_{jt}, d_{jt} = 0) - d_{jt-1}\gamma_{jt}^{F} - (1 - d_{jt-1})\gamma_{jt}^{S}}_{\text{Initial Gain/Loss}} + \underbrace{V_{jt}^{E}(s_{jt}) - V_{jt}^{D}(s_{jt})}_{\text{Future Gain/Loss}} \quad \text{(III.11)}$$

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 (III.11) 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.

The Data

Data Source and Construction

The primary 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 record detailed plant-level information on over 100 variables 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.[15]

[15] 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 online appendix available at https://my.vanderbilt.edu/joelrodrigue.

Key to our analysis the data also include a measure of the market value of capital holdings along with the value of new investment in each year. Specifically, the data contain annual observations on 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 a wholesale price indices for construction, imported electrical and non-electrical equipment and imported transportation equipment. To construct the capital stock deflator we weight each price index by the average reported shares of buildings and land, machinery and equipment and fixed vehicle assets, respectively. In years following 1990 we use the perpetual inventory method to construct a measure of capital holdings as

$$k_{jt+1} = (1 - \bar{\delta})k_{jt} + i_{jt} \tag{III.12}$$

where $\bar{\delta}$ is the industry-specific, average depreciation rate reported in the data.[16]

Because the Indonesian manufacturing sector covers a wide scope of industries, we choose to focus on two specific industries so industrial differences do not contaminate

[16] 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 (2011) 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

$$\epsilon^k_{jt} = \ln(\tilde{k}_{jt+1} - (1 - \bar{\delta})\tilde{k}_{jt} - i_{jt}) \tag{III.13}$$

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^k_{jt} is 25 percent of the mean value of log capital. Similarly, the standard deviation of ϵ^k_{jt} 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.

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. 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. In each industry we follow a balanced panel of continuing firms over time. Our main samples follow 343 and 302 firms in the plastics and fabricated metals industries between 1990 and 1995, respectively.[17]

Sample Moments

Figure 7 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. However, 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 20.[18] In each industry we compute the variable input share as the ratio of total variable inputs (wages, materials, electricity, fuel) to total sales. Of the two industries we examine the variable input share is substantially larger among fabricated metal producers, on average. Further, investment rates and frequencies are also larger in the fabricated metals industry.

[17] Our data includes information on export status, inputs and revenues in 1989 which allows us to construct the firm's initial conditions in 1990. Further, 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.

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

In either industry we observe sharp differences between exporters and non-exporters. Consistent with the evidence presented in Rho and Rodrigue (2012) 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.

The last two rows examine the correlation between exporting and investment. We observe current export and investment status are positively correlated, but the correlation coefficient ranges between 0.14 and 0.22. If we restrict our attention to firms that both investing and exporting in the same year, we observe that the correlation coefficient on the log of export sales and the log of net investment rises to 0.28-0.29.[19]

Although we observe some positive contemporaneous association between investment and export behavior, it is plausible that firms would optimally choose to build up capital stock before penetrating export markets (or wait until they have successfully entered export markets to invest in new capital). Table 21 presents an investment and exporting transition matrix for each industry. In either industry we observe that among non-exporting firms, those which were actively building up capital stock in the previous year are 2.0-2.5 times more likely to export in the subsequent year. Similarly, non-investing exporters are 1.2-2.5 times more likely to invest in physical capital in subsequent years relative to firms that don't engage in either activity.

While Tables 20 and 21 suggest an inherent complementarity between investment and exporting, it is unclear to what extent these are determined by each other or other factors. For instance, both investment and exporting highly persistent activities, possibly reflecting the persistence in unobservable, firm-level productivity. We explore these issues

[19]As discussed below, in our data approximately 10 percent of firms export in each year and industry. Likewise, 27-39 percent of firms are actively investing in physical capital in any year.

below.

Estimating 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. To do this we draw on the control-function literature pioneered by Olley and Pakes (1996). Below we specify precisely how we recover estimates of firm-level productivity that we will later use to structurally estimate the model's dynamic parameters.

We begin by first recovering an estimate of the mark-up. 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}:

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

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 domestic revenue function is

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

where we have added an *iid* error term to equation (III.4). Using our definition of λ and the estimate of β from equation (III.14) we can rewrite the composite error term as[20]

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

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

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

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

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

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

which is a function of capital, productivity and export demand. Inserting φ_{jt} into (III.8) we can write the following equation of the capital, export demand and the composite residual

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

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

We cannot yet take equation (III.17) to the data since we will not be able to identify the parameters on the productivity process without knowledge of the unobservable z_{jt} or the parameter Λ^X_t whenever the firm chooses to export. Fortunately, equation (III.5) 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

$$z_{jt} = \ln\left(\frac{r^X_{jt}}{r^D_{jt}}\right) - \ln\Lambda^X_t \Rightarrow \hat{z}_{jt} \equiv \ln(1+\Lambda^X_t e^{z_{jt}})d_{jt} = \ln\left(\frac{r^T_{jt}}{r^D_{jt}}\right) \qquad \text{(III.18)}$$

where $r^T_{jt} = r^D_{jt} + r^X_{jt}$.[21] 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, $\ln(1+\Lambda^X_t e^{z_{jt}})d_{jt}$, always takes a value of 0 whenever the firm does not export (regardless of the value of z_{jt}).[22] Substituting equation (III.18) into equation (III.17) we can then write the estimating equation as

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

[21] Readers may be concerned that domestic revenues may not always be positive. However, in our sample all firms always report positive domestic sales.

[22] A second concern may arise from the fact that $\hat{z}_{jt}$ is a function of the error term u_{jt} in equation (III.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. 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 $\tilde{u}_{jt}$.

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

Under these conditions the input demand for materials or electricity will only depend on the export shock among exporting firms. In particular, among non-exporters

$$\begin{aligned} m_{jt} &= m_t(k_{jt}, \omega_{jt}) \\ n_{jt} &= n_t(k_{jt}, \omega_{jt}) \quad \text{if } d_{jt} = 0 \end{aligned} \tag{III.20}$$

while among exporting firms

$$\begin{aligned} m_{jt} &= m_t(k_{jt}, \omega_{jt}, z_{jt}) \\ n_{jt} &= n_t(k_{jt}, \omega_{jt}, z_{jt}) \quad \text{if } d_{jt} = 1 \end{aligned} \tag{III.21}$$

This is crucial 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 inputs will reflect differences in productivity alone. Because of this the inverted input demand among non-exporters is a bijection in productivity. As illustrated in equation (III.21), 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.[23]

Our approach is similar to that in Demidova, Kee and Krishna (2011) who use an investment proxy combined with measurements of export intensity to control for export

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

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.[24] 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.[25] Since static input demand should only reflect the firms current export decision, our approach, though similar, is much less demanding of the firm-level data and more appropriate to our economic environment.

A second interesting feature of our method worth highlighting 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 and represents an important robustness check for key estimates in many economic models.

Clearly, estimating equation (III.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 (III.19) by GMM and recover the parameters governing

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

[25] As noted in Demidova, Kee and Krishna (2011) 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.

the evolution of productivity and the shape of the marginal cost function. Using these parameters we construct an estimated productivity series for each firm $\omega_j = (\omega_{j0}, ...\omega_{jT})$ where

$$\omega_{jt} = \frac{(1-\beta)\alpha_l}{\beta}\hat{\varphi}^*_{jt} + (1-\alpha_l)\hat{z}_{jt} - \alpha_k \ln k_{jt}. \tag{III.22}$$

Note the productivity measure is increasing in export intensity, $\hat{z}$, 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.

Structural Estimation

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.[26] 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.[27]

The estimated structural parameters are those that minimize the weighted average distance between the simulated statistics and the statistics from the data. Intuitively, since

[26]In contrast, to much of the literature on export dynamics we choose to pursue indirect inference instead of likelihood based methods since the firm's investment decision greatly complicates the construction of any potential likelihood function. Specifically, because investment is a continuous variable, solving for the conditional choice probabilities while allowing a sufficient number investment choices greatly increases the computational burden associated with estimating the model.

[27]Since Φ^D_t and Λ^X_t were almost always nearly constant over years we restricted these parameters to be the same in all years, $\Phi^D_t = \Phi^D$ and $\Lambda^X_t = \Lambda^X$, 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 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.

The statistics we match are listed in Tables 22 and 23. They include both OLS regression coefficients and summary statistics from the data. The first four moments are chosen to capture basic features of investment and export behavior in the data. The first two moment describe investment patterns in the data. In particular, the first moment captures the average number of firms which actively invest in any given year while the second is the mean investment rate in the data. Analogously, moments three to six correspond to moments describing export behavior. These 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.[28]

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

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

OLS regressions:

$$\frac{i_{jt}}{k_{jt}} = \varrho_0 + \varrho_1 \omega_{jt} + \varrho_2 d_{jt} + \nu_{jt}^k \tag{III.23}$$

$$\omega_{jt} = \varsigma_0 + \varsigma_1 d_{jt} + \nu_{jt}^x \tag{III.24}$$

$$\tilde{z}_{jt} = \vartheta_0 + \vartheta_1 z_{jt-1} + \nu_{jt}^z \tag{III.25}$$

where $\tilde{z}_{jt} = \ln(r_{jt}^T / r_{jt}^D)$.[29] The variable $\tilde{z}_{jt}$ captures export intensity at the firm-level and corresponds to export intensity term in the firm's revenue equations $\tilde{z} \equiv \ln(1 + \Lambda_t^X e^{z_{jt}})$.

The first equation (III.23) captures the relationship between investment, productivity and exporting. The second equation (III.24) 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 (III.25) 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, it is straightforward to simulate export demand shocks for each firm in the simulated model. We then use these shocks in simulating the model, constructing the simulated $\tilde{z}_{jt}$ measures for each firm and evaluating equation (III.25) on the simulated data. Table 23 lists all of the regression coefficients we focus on matching.[30]

[29] 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 (III.23). Since it was always imprecisely estimated we dropped it from our specification.

[30] Year dummies were excluded since they were generally insignificant and very small in magnitude.

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.

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 random grid points. We discretize capital stock and investment with 50 fixed grid points over the distribution of capital and investment respectively.[31]

Results

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 24. We observe that 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

[31] Capital grid points are the mean capital level within every two percentiles of the capital distribution. Similarly, the first investment choice is set to 0 and remaining 49 choices are chosen by first sorting the positive investment data into 49 equally sized bins from smallest to largest and then choosing the mean investment level in each bin as a grid point. 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 and investment grid points fixed as above depreciation will lead firms to move to a lower capital grid point if they choose not to invest.

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.[32] 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 repeat our experiment under the assumption that marginal costs are constant in the short-run. In particular, we set $\alpha_l = 1$ in each market and repeat the estimation exercise described in section 2.3.[33] Most of the models parameters are estimated to be substantially different under the assumption of constant marginal costs. In particular, we highlight an increase in the capital share parameter and an increase in the estimated variance of the productivity shock process. Examining equation (III.19) it is straightforward to see why we recover these results. Suppose initially that all firms are non-exporters (so that $d_{jt} = d_{jt-1} = 0$) 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

[32] These are well within the estimated range of mark-ups for manufacturing industries. See De Loecker and Warzynski (2011) for an example.

[33] 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 uncommon in the literature. See Aw, Roberts and Xu (2011) or Rodrigue and Soumonni (2011) for examples.

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.

A similar exercise provides an intuitive explanation for the difference in the standard error in the productivity evolution equation, σ_ξ. By incorrectly assuming that $\alpha_l = 1$, the predicted residual in equation (III.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.

Last, this exercise helps clarify the identifying mechanism through which we are able to capture the variable input share and the shape of the marginal cost function. Specifically, we rely exclusively on the correlation between changes in domestic performance and export performance.[34] We are not aware of any other work which exploits this variation in export status to identify the shape of the marginal cost curve.[35] A key advantage in this scenario is that we do not need to observe all the firms variable inputs (labour, materials,

[34]Nguyen and Schaur (2011), Soderbery (2011), and Vannoorenberghe (2012) use similar variation to explain correlation between domestic and export sales.

[35]Ahn and McQuoid (2012) provide additional micro-evidence that confirm that capacity constrained exporters in Indonesia tend to behave in a fashion which is consistent with increasing marginal costs.

fuel, energy, etc) or make strong assumptions regarding whether these are fixed or variable in nature when identifying the production function parameters.[36]

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 (III.22) 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:

$$\omega_{jt} = \beta_0 + \beta_1 \ln k_{jt} + \beta_2 d_{jt} + \Gamma_t + \varepsilon_{jt} \tag{III.26}$$

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. Previous work emphasizing that most new exporters tend to be small and not particularly productive are likely to underestimate the productivity difference between exporting and non-exporting firms.[38]

Export Market Size, Export Costs and Investment Costs

The remaining structural parameters, estimated by indirect inference, are presented in Table 25. To fully illustrate the impact of omitting the dynamic capital adjustment process on models of heterogeneous firms and trade we also repeat the second stage

[36] We do need to assume that any inputs which are fixed in nature are used in a fashion which is complementary to physical capital. For inputs such as skilled labor, which we might expect to behave like a quasi-fixed input, research also suggests that adjustments in skilled labour hires are likely to change in step with capital holdings. See Krusell et al. (2000) for an example.

[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 (2010b) for an example of a model where most new exporters are both small and unproductive.

estimation exercise in two restricted models. First, we re-estimate the model without any capital dynamics and investment costs. In this case, firms are still subject to increasing marginal costs. However, we assume that capital is fixed over time. 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. Second, 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.

We observe substantial differences in the parameter estimates across industries and models. 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 3) predicts very large sunk entry costs to export markets; the parameter γ_S implies that the mean sunk cost draw is 51.5 and 92.9 million Indonesian rupiahs in the fabricated metals and plastics industries, respectively. It is clear from Table 25 that sunk export costs are much lower in Models 1 and 2.[39] Simply by allowing firms to have an increasing marginal cost curve we observe that the estimated sunk export costs fall to 15.5 and 7.5 million rupiahs; these represent an 83-85 percent reduction in the firm-level sunk entry costs. Allowing capital adjustment cost reduces export entry costs even further. We find that under Model 1 γ_S is estimated to be 3.3 and 6.8 million Indonesian rupiahs in the fabricated metals and plastics industries, respectively. Relative to the model with constant marginal costs, this represents a 93-94 percent decline in the export entry cost parameter. As we will outline below, the smaller size of the sunk cost parameter is indicative of the fact that it will have a much smaller role to play in determining firm-level

[39]These parameters will generally be greater than the average incurred export costs, since many firms only export when the receive a low cost draw. We report incurred export costs below.

outcomes over time.

The fixed export cost parameter is similarly smallest in Model 1 and largest in Model 3. 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, as noted above, 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. In the plastics industry we observe that the mean fixed export costs draw falls from 4.0 million rupiahs in Model 3 to 1.0-1.1 million rupiahs in Models 1 and 2. Likewise, in fabricated metals industry the mean fixed export costs draw falls from 2.5 million rupiahs in Model 3, 2.1 million rupiahs in Models 2 and 1.0 million rupiahs in Model 1.

The third, fourth and fifth parameters in Table 25, 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.[40] Export markets are generally much smaller than domestic markets; across models the size of export markets are estimated to be 5-8 percent of the domestic market in the fabricated metals industry and 10-16 percent of plastics industry.

The last three parameters are the convex investment cost parameters (ψ_0, ψ_1)

[40] As documented in Demidova, Kee and Krishna (2011) and Rodrigue and Soumonni (2011) export demand shocks vary widely across firms and can be key determinants of export behavior.

and the fixed investment cost parameter (ψ_2). These parameters imply that investment is quite costly in Indonesia. For the median level of capital holdings in the fabricated metals industry, the cost of increasing capital holdings by 32.1 percent, the average investment rate among investors, is 4.0 million Indonesian rupiahs before fixed investment costs. This is approximately 52 percent of the median total revenues among firms which choose to invest. Nearly identical results are found in the plastics industry.

Although the above results suggest that investment is extremely costly in Indonesia, there are at least two reasons that this result is arguably reasonable. First, investment *is* costly in Indonesia; prime lending rates among state and private banks were often well above 20 or 30 percent per year between 1990 and 1995. Moreover, it is well established that access to credit markets is particularly limited among small producers in developing countries and loans are often characterized by interest several times higher than market rates. 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.

Numerous papers have suggested that the parameter ψ_2 is a key parameter for determining investment behavior. Estimates range from a high of 22 in Hayashi (1982) to a low of 0.05 in Cooper and Haltiwanger (2006). Our results are close to the Cooper and Haltiwanger (2006) estimates for the US economy in the fabricated metals industry, but somewhat higher in the plastics industry. This is intuitive since the capital share parameter, α_k, is relatively high in the plastics industry and constrained plastics producers will have a relatively strong incentive to make larger investments. The model predicts relatively modest fixed investment costs. Across industries the average fixed investment cost draw ranges from 10 to 53 thousand Indonesian rupiahs. The fixed investment costs are roughly 1 to 2 percent of median total revenues across industries.

Although it is clear that adding capital adjustment significantly changes the estimates of key parameters in a standard heterogeneous firms and trade model, it is not obvious whether the estimates allow the model to better fit the data. Moreover, the estimates along do not provide a clear indication of the economic significance of the change in the model's dynamics. We turn to these issues next.

Model Performance

We simulate all three models to assess their predictive ability relative to the observed empirical patterns exporting, investment and productivity. We take each firm's initial year status $(\omega_{j1}, z_{j1}, k_{j1}, d_{j1})$ 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.

Estimated Investment and Export Moments

The first set of moments we consider are those used to estimate the model. Tables 26 and 27 demonstrate that the model is able to capture the basic export and investment patterns in both industries relatively well. In Table 26 we observe that there is more persistence in export status 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.[41] We abstract from this possibility

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

here in order to focus on the interaction of investment and exporting.

Likewise, in Table 27 we find that the investment rate is increasing in productivity in both the actual and simulated data. However, the coefficient on productivity is somewhat larger in the actual data relative to the simulated 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. We repeat this exercise for the models without capital adjustment. Since the models perform similarly we relegate these results to the appendix.

Investment and Export Dynamics

In this section we consider the model's ability to match investment behavior across exporting and non-exporting firms. In particular, Figure 8 plots the average investment rate, i_t/k_t, in both the model and the data among new exporters and non-exporters. The dashed blue and red lines represent the investment rates among exporting and non-exporting firms in the data, respectively, while the solid blue and red lines capture the model's predictions. For clarity, note that we only study the *surviving* exporters in each year and non-exporting firms that never choose to export. This is true both in the actual and simulated data.[42]

In each industry and for each type of firm we observe that the model matches the data relatively well. Although the estimation exercise does try to match the mean difference in investment between exporters and non-exporters, our estimation routine does not exploit any moments which capture the investment of new exporters over time. As expected we find that the investment rate among new exporters is well above that of non-exporting firms and

[42]Changing the selection of firms does not materially affect the performance of the model, but does make the figures harder to interpret.

this is particularly true in the window immediately around the firm's export entry date. In the fabricated metals industry where both the model and the data suggest that investment rates spike up the year before exporting and continue to be relatively high during the year of initial entry. A similar pattern is found in the plastics industry, although the data suggests that investment rates do not respond as strongly until firms enter export markets in this industry. As expected the investment rate among fabricated metals producers is substantially higher than that in the plastics industry. In both industries, investment rates remain well above that of non-exporters for several years after initial entry into export markets.

Non-exporting firms, in contrast, exhibit almost no change in their average investment behavior over time. Investment are relatively low and constant, suggesting that investment activity among these firms is largely aimed at replacing depreciated capital. As we study next, this differential investment behavior has important implications for both exit and entry decisions and observed patterns of revenue growth.

Exit and Entry Dynamics

It is well known that many new exporters are small and the average duration of exporting is very short. At the same time, entry rates into exporting are low. These features are prevalent in our data. Table 28 documents the average entry rate into exporting over all years in our data, while Figure 9 plots the survival rate among new entrants into exporting over time. Across industries the survival rate is lowest in the first year after entry reflecting the fact that many firms exit immediately after entering export markets for one year. After the first year of exporting, the survival rate grows gradually as only firms with greater productivity, capital holdings and export demand remain in export markets.

Likewise, Table 28 shows that entry rates range between 3 and 4 percent across industries.[43]

Standard models of heterogeneous firms and trade are unlikely to be able to match these features of the data. Large, sunk export entry costs create a strong incentive for new entrants to remain in export markets beyond the initial year of entry. Reducing the size of sunk entry costs can generate too much entry into export markets and a sharp reduction in the persistence in exporting among later exporters. Moreover, as we will document later, this will create distortions in the predicted productivity distribution of exporting firms.

Table 28 presents the predicted entry in both the actual and simulated data for all three models. All models are able to capture this basic feature of the data reasonably well. In contrast, Figure 9 shows that only the model with capital adjustment (Model 1) is able to reasonably replicate the survival pattern of exporters over time. In both industries the model with constant marginal costs, but no capital adjustment (Model 3), predicts only a small decline after initial entry and a survival rate which is almost constant over time. Due to large entry costs new entrants are generally large, productive and are very profitable on export markets. Moreover, when sunk costs are large even small firms are unwilling to exit when facing relatively large export shocks in order to avoid paying the sunk entry cost in the future.

The model with increasing marginal costs, but no capital adjustment (Model 2), predicts larger initial exits than Model 3, but also cannot match the survival rate over time. In the plastics industry smaller sunk costs make future entry less costly than in Model 3, which encourages a larger number of firms to exit export markets immediately after initial entry. However, the sunk and fixed export costs are still large enough to prevent the model from matching the observed exit rates, particularly in the initial years after entry. In the

[43] See Ruhl and Willis (2007) for an example from Columbia which documents very similar patterns.

fabricated metals industry, the sunk and fixed costs of entry are sufficiently small to generate enough initial exit from export markets, but remain too after the initial year. The reason for this is that current exporters have no way to reducing the opportunity costs of foregone domestic sales over time. As such, exporting is far less profitable over time and the model cannot match the persistence in exporting among new entrants.

Allowing capital to adjust 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 exit will often create excess capacity (relative to a model with frictionless capital-adjustment over time). In this sense, capital-adjustment inherently builds persistence into the standard heterogeneous firms and trade model.

Domestic Revenue Dynamics and Exporting

Numerous authors document that domestic revenue growth among new exporters is generally slower than comparable non-exporters.[44] This is true in our data as well. Consider the following regression where we regress the change in log domestic revenues ($\Delta \ln r_{jt}^{D}$) on the change in export status (Δd_{jt}), the change in productivity (ω_{jt}) and the change in capital holdings ($\Delta \ln k_{jt}$) in our data:

$$\Delta \ln r_{jt}^{D} = \beta_0 + \beta_d \Delta d_{jt} + \beta_\omega \Delta \omega_{jt} + \beta_k \Delta \ln k_{jt} + \varepsilon_{jt} \quad \text{(III.27)}$$

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

where ε_{jt} is an error term.[45] In Table 29 the OLS coefficient on β_d is always negative and highly significant. Our estimates suggest that domestic revenue grows 43-47 log points slower among exporters relative to comparable non-exporters.[46]

We repeat this exercise on the simulated data from all three models. Both models with increasing marginal costs (Model 1 and Model 2) match the estimated coefficients in the data closely. The only exception is third column in the plastics industry where the coefficient on the change in exporting is relatively small and insignificant. However, once we add productivity and capital to the equation the coefficient on the change in exporting falls substantially and becomes strongly significant. In contrast, the coefficient on the change in exporting in the model with constant marginal costs (Model 3) is always positive and sometimes insignificant.[47]

Export Revenue Dynamics

Conversely, export revenue grows strongly in the years after initial entry among surviving exporters. There are arguably a number of mechanisms which might explain this phenomenon. As emphasized in Eaton et al. (2009) 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. While we agree that these mechanisms are likely important features, capital growth over time can also explain an important part of the observed export revenue growth.

[45] As in Nguyen and Schaur (2011), Soderbery (2011) and Vannoorenberghe (2012) we do not include any measure of export intensity in equation (III.27). 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.

[46] To see this note that $1 - \exp(-0.628) = 0.466$ and $1 - \exp(-0.554) = 0.425$.

[47] The first two coefficients in the last column of Table 10 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.

Figure 10 documents the actual export revenue growth in the data and the simulated revenue growth all three models among surviving exporters. Before discussing the performance of each model it is important to recognize that there are two effects on export revenues which tend to offset each other in all three models. First, we examine revenue growth among surviving exporters and since firms with stronger export revenue growth are more likely to continue exporting, this *selection effect* would tend to increase the export revenue growth over time. Second, all of our estimates suggest that export shocks decline on average across firms since $\rho < 1$. We'll refer to this as the *depreciation effect*.

In the plastics industry all three models predict export revenue growth below that in the data. However, the model with dynamic capital adjustment predicts positive export revenue growth in the first after entry, while the models without capital adjustment suggest that export growth tends to decline rather than rise over time. In Models 2 and 3 we observe that the depreciation effect outweighs the selection effect. In contrast, by allowing the depreciation effect to be offset by capital growth, we observe an initial rise in export revenues among continuing exporters in the plastics industry. Similarly, beyond the first year the model with capital adjustment performs as well or better than the other models in matching the observed growth in export sales.

In the fabricated metals industry the results are even more striking. In this case, the model with capital adjustment matches the observed export revenue in the data closely in the first three years after initial entry. However, again both models without capital adjustment predict much stronger declines in export growth rates over time. While there are important differences across industries, in either case, allowing capital to adjust over time significant improves model performance along this dimension.

Discussion

The model with capital adjustment (Model 1) performs as well or better than comparable models along a number of relevant dimensions. Remarkably, this result is achieved even though little of the information used to evaluate the model is used to estimate the model's key parameters. Specifically, the model with capital adjustment captures differences in exporter investment rates over time, export entry and exit rates over time, movements in domestic revenues in response to exporting and growth in export revenues over time relatively well even though the model does not directly use any of this information to pin down model parameters. In contrast, the models without capital adjustment (Models 2 and 3) are not able to match these features of the data. Although differences across models may not appear to be dramatically large, it is worth noting that these differences are important for the predicting how firms will respond to changes in the economic environment. For instance, we document below that allowing for capital adjustment has important quantitative and qualitative implications regarding how we expect firms to respond to policy changes (e.g. trade liberalization).

The Determinants of Exporting

Incurred Export Costs

Export entry costs have played a particularly important role in determining the predicted firm-level responses to policy change in a number of settings.[48] Tables 30 and 31 present the average export fixed and sunk costs across the distribution of heterogeneous firms in each industry. In particular, we consider the costs incurred by firms in each quartile of the productivity distribution and each quartile of the capital distribution. We first determine

[48] See Das, Roberts and Tybout (2007) or Alessandria and Choi (2011) for examples.

productivity thresholds in the actual data so as to divide *all firms* into four quartiles. We repeat the exercise for capital. We then study the costs incurred by exporters that fall into each productivity-capital quartile combination. The capital quartiles vary along the horizontal dimension of Tables 30 and 31, while the productivity quartiles vary along the vertical dimension. A key issue in this exercise is that the distribution of productivity varies according to our initial assumption on the shape of the marginal cost function. In this case, we are careful to apply the thresholds from the actual productivity series which were produced under the same marginal cost assumption.

For instance, the average fixed export cost incurred by a plastics producer that is in the first quartile of the (empirical) productivity and the first quartile of the capital stock distribution is 150 thousand 1983 Indonesian rupiahs (approximately 165 US dollars). While these figures seem small it is important to recognize that most firms in the plastics industry are also relatively small; median total revenues are 3.4 million 1983 Indonesian rupiahs. Likewise, the average fixed export cost incurred by a fabricated metals producer that is in the first quartile of both the productivity and capital stock distributions is 108 thousand 1983 Indonesian rupiahs. Across industries this would represent 4.1-4.5 of total revenues for the median firm.

As we would expect, the fixed and sunk export costs are generally increasing in both productivity and capital stock across models. Moreover, the fixed and sunk export costs are generally smallest in the model with capital adjustment (Model 1) and largest in the constant marginal cost model without capital adjustment (Model 3). There is an important exception to this rule. Among small and/or unproductive firms the incurred fixed and sunk costs of exporting in Model 1 are often larger than those in Model 2 (increasing marginal costs without capital adjustment). This is striking since the average sunk and fixed cost draw in Model 2 is larger than that in Model 1. The explanation for this result is straightforward: by allowing firms to expand their capacity, exporting has a greater value to small firms and, as such, they are willing to incur greater costs to begin or continue exporting.

Similarly, we observe that relative to the other models, Model 1 predicts a relatively moderate degree of variation in the fixed or sunk costs incurred across firms. To see this, choose any row in the either Table 30 or 31 and compare the increase in the fixed/sunk cost of exporting along the distribution of capital. We observe that the increase in the incurred fixed costs is always smallest in Model 1 relative to the models without capital adjustment. Similarly, choose any quartile of the capital distribution and compare the increase the incurred fixed along the productivity distribution. The increase in fixed or sunk costs is again most moderate in Model 1.

Finally, we note that while the differences in the incurred fixed and sunk costs are generally quite small in Model 1, export sunk costs are typically much greater in Model 3. Interestingly, Models 1 and 2 suggest that the incurred export sunk costs are smaller than export fixed costs among small and unproductive producers. Consistent with our intuition, many small or unproductive firms will only enter export markets when it is particularly inexpensive to do so.[49]

Exporter Productivity Implications

As documented here and elsewhere many new exporters are relatively small.[50] We find a similar pattern in our data. Table 32 presents the distribution of new exporters in both the actual and simulated data. The first two panels of Table 32 compare the percentage

[49] We omit further discussion of investment fixed costs since these do not vary much across the distribution of firms.

[50] See Arkolakis (2010b) for an example.

of new exporters in each quartile of the empirical capital-productivity distribution. It is immediately obvious that there are some important differences across the initial marginal cost assumption. Note that the capital distribution does not change across each of the first two panels and, as such, the same percentage of firms is contained in each of the corresponding columns across panels (up to rounding error). For example, in the plastics industry, the first column of the first panel suggests that 9 percent of all new exporters are found in the first quartile of the capital distribution. The second panel shows the exact same result, though these firms are divided up differently across the productivity distribution.

There are a number of interesting and important differences across the first two panels. First, the new exporters again appear relatively more productive under the assumption of increasing marginal costs, relative to that of constant marginal costs. In the plastics industry, the productivity data constructed under the assumption of increasing marginal costs suggests that 65 percent of new exporters are in the top quartile of productivity distribution. In contrast, under the assumption of constant marginal costs only 42 percent of new exporters are in the top quartile of the productivity distribution. Likewise, within columns a higher percentage of new exporters are always in the top quartiles of the productivity distribution under the assumption of increasing marginal costs. Analogous results are found in the fabricated metals industry.

Across industries we observe that the model with capital adjustment matches the joint distribution of capital and productivity among new exporters relatively well. In the plastics industry there is a substantial improvement achieved by allowing capital to adjust relative to both models without capital adjustment. In particular, the models without capital adjustment predict too many high productivity exporters relative to the data. The reason for this that cost of exporting in both cases is relatively high, either in terms of direct export entry costs (Model 3) or foregone domestic sales which cannot be mitigated through capital growth (Model 2).

The fabricated metals industry displays much smaller differences in model performance along this dimension. This is precisely what we would expect since α_l is closer to 1 and the constant marginal assumption is not as restrictive. Nonetheless, Model 3 predicts that the percentage of exporters in the top quartile of the productivity distribution is 8 percent higher than that found in the data.

Counterfactual Experiments

Export promotion has often been a key component of many developing countries plan for economic growth (Fernandes and Isgut, 2007). In many instances, reform packages aimed at liberalizing trade in goods markets have been coupled with larger economic and financial reforms, often occuring within the same year.[51] Our objective is to quantify the impact of increased market access or reduced investment costs on export and investment behavior over time. To evaluate the impact of these policy changes we consider two counterfactual policy experiments: trade liberalization and financial reform. In each experiment we consider the firm's initial state in 1990 and simulate the model forward 10 years after a change in one or more parameters aimed at capturing a change in the economic and policy

[51]See Manova (2008) for further discussion. A similar pattern occurred in Indonesia, though not for the same reasons. Indonesia joined the WTO in 1995 encouraging greater exports abroad. By the fall of 1997 the Asian financial had severely affected the Indonesian economy and by 1998 large structural and financial reform was undertaken (IMF, 1998). Disentangling the effects of trade liberalization, financial reform and the broader economic crisis are clearly questions of substantial economic importance. Unfortunately, they are beyond the scope of this paper.

environment.

Trade Liberalization

The first experiment aims to provide insight on the effect of trade liberalization on Indonesian producers. In 1995 Indonesia joined the WTO which broadly allowed Indonesia to gain greater access in world markets. In our model variable trade costs, such as tariffs, are embedded in the parameter capturing export market size, Λ_t^X. We attempt to capture this effect by increasing the value of Λ_t^X by 10 percent. We can then re-simulate the model before and after the policy and compare the growth in exports and investment.[52] We repeat this exercise for Models 1-3 to highlight how different assumptions lead to different policy conclusions in this context.

Table 33 documents the growth in exports and investment in each model. The first row of each panel in Table 33 reports the annual aggregate growth in total exports induced by the policy changes. 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 in our preferred specification, Model 1. Aggregate exports increase by 9.3 and 10.7 percent in the first year after the change in policy in the fabricated metals and plastics industry. However, after the first year the percentage increase in exports over the benchmark models declines. This occurs for two reasons. First, the expansion of the highly productive exporters is offset by greater investment costs. Second, the change in policy initially induces a strong response along the extensive margin. Many firms with relatively large capital holdings choose to enter export markets immediately after the change in policy. However, many of these firms exit immediately since they are

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

unwilling to maintain a higher level of capital. Nonetheless, ten years after the change in policy we observe that annual exports are 5.1-8.9 greater than they would have been under the benchmark model.

Across models there are a number of striking patterns. First, Model 3, the workhorse model with constant marginal costs and no capital adjustment, suggests by far the largest response to trade liberalization. In the first year after the change in policy aggregate exports grow by 13 percent in each industry and remain 11-12 percent than the benchmark simulations 10 years after the change in policy. Relative the model with increasing marginal costs and capital adjustment (Model 1) we observe that aggregate export growth is approximately 3 percentage points lower in all years among plastics producers and 3 to 6 percentage points lower among fabricated metals producers. While these differences may seem small, they are in fact very large relative to the moderate degree to trade liberalization; the response of export growth among fabricated metals producers is more than twice as large in Model 3 as it is Model 1 after 10 years. In this sense, a model with constant marginal costs and no capital adjustment is likely to lead to broadly overestimate the impact of trade liberalization on export growth.

The second row of Table 33 indicates the contribution from the extensive margin and provides an explanation for these results. That is, the second row calculates "new exporters" the percentage of total exporters attributable to firms that were induced to begin exporting because of the change in policy. Model 3 has by far the smallest contribution from new exporters across models. The reason for this is that large, productive, current exporters firms expand quickly into larger export markets increasing the contribution from the intensive margin. At the same time, smaller, less productive firms continue to restricted from export markets by overestimated export entry costs. This effect is reinforced by the fact that most estimates of productivity for small firms are likely to be biased downwards, as they are here. Not surprisingly, we observe that extensive margin plays a very small role in Model 3 relative to Model 1. The contribution from new exporters is 5-7 percentage points higher in plastics industry and 4-8 percentage points higher in the fabricated metals industry in the model increasing marginal costs and capital adjustment (Model 1) relative for the workhorse model (Model 3).

Comparing Model 2, the model with increasing marginal costs and no capital adjustment, with Model 3 we observe much smaller difference in short-run aggregate export growth. This is to be expected since capital adjustment occurs slowly over time. In the plastics industry annual aggregate export growth is 1-2 percent higher in Model 1 relative to Model 2, while in the fabricated metals industry we observe export growth rates which are nearly identical across models.[53] Although these differences in aggregate exports are relatively small, the two models are achieving them in very different ways. Initially, there is a smaller response along the extensive margin in the model without capital adjustment. The model with capital adjustment initially encourages greater export entry through smaller export entry costs and a mechanism ease the tradeoff between domestic and export sales (investment). However, as productive exporters grow their capital stocks the contribution from the extensive margin falls in the model with capital adjustment. Conversely, since capital is fixed in Model 2 the contribution from the extensive margin remains very high. Ten years after the change in policy the contribution from the extensive margin is estimated to be as much as 8 percentage points too high in the model without capital adjustment.

Overall, these results from our first experiment have important implications for the literature studying the implications of trade liberalization for heterogeneous producers.

[53] Industrial differences are largely reflecting differences in the capital and variable input shares of production, α_k, and α_l.

First, models which assume constant marginal costs will likely provide misleading policy predictions, particularly in the short-run. Second, considering only the small class of models the increasing marginal costs, we observe that models without capital adjustment are likely to have to similar short-run implications for aggregate export growth to those with capital-adjustment. However, the qualitative mechanism through which these estimates are achieved are likely to differ substantially.

The third row of each panel in Table 33 studies the growth in aggregate investment induced by the change in policy. For ease of interpretation we present the growth in annual investment flows. It is worth noting, however, that the cumulative growth in capital holdings is somewhat larger than that presented in Table 33 since new capital depreciates slowly. Since capital is fixed in all but the first model new investment is clearly zero in both Models 2 and 3. However, even in Model 1 we observe a relatively small response of investment to trade liberalization. Trade liberalization immediately increases new investment by 1.6 percent in the plastics industry and 6.3 percent in the fabricated metals industry. After the initial increase in investment flows, the annual increase in investment falls over time. Five years after the initial increase in investment the additional growth is 1.1-1.2 percent higher than the benchmark model across industries. There are two mechanisms behind this pattern. The change in policy increases the return to investment encouraging firms to invest more than before. It also encourages firms to invest *earlier* than otherwise. Due to fixed investment costs, early investors refrain from investing later and the aggregate investment, relative to the benchmark model, falls. In fact, in the fabricated metals industry, where aggregate investment initially rose by 6.3 percent, we find that it is 0.5 percent lower than the benchmark model 10 years after the change in policy. Across industries, cumulative investment, net of depreciation, is 1.4-2.2 percent greater after 10 years.

The fourth row of each panel in Table 33 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 we observe strong growth in the exporter contribution to aggregate investment; in the plastics industry the fraction of investment due to exporters grows by 9.1 percent in the first year after trade liberalization, while it grows by 35.7 percent in the fabricated metals industry. Over time the contribution from exporters falls as less productive firms exit the export market.

In sum, small changes in the trade environment have very small effects on aggregate investment behavior. This is predictable for a number of reasons. First, 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 is policy, exporting and investment behavior is typically dominated by a relatively small number of large firms.

Financial Reform

The second experiment we consider is financial reform of the Indonesian credit markets. We interpret this policy as a reduction in firm-level investment costs. In this case, we reduce the investment cost function parameters, ψ_0, ψ_1 and ψ_2, by 10 percent. Since Models 2 and 3 do not allow for any change in capital holdings, we only perform this experiment on our preferred specification, Model 1. Given our previous results, we expect that a reduction in investment costs will lead to both a rise in investment and exporting. However, to fully examine the interaction of trade and financial reform we also consider the impact of contemporaneous trade and financial liberalization simultaneously reducing the investment cost parameters by 10 percent and increasing the export market size parameter by 10 percent. 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. The results are reported in Table 34.

The first four columns of Table 34 report results for our financial reform experiment while the last four columns consider the experiment where both policies are applied simultaneously. As we would expect there is a jump in aggregate investment in both industries immediately after financial reform. 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. Again, we observe that the growth in annual investment falls over time, though in this case, it remains substantially higher than the benchmark model. Ten years after the change in policy annual aggregate investment is 27.7 percent higher than the benchmark model in the fabricated metals industry and 23.8 percent higher in the plastics industry. The rise in capital holdings in turn has a substantial impact on exports over time. Among fabricated metals producers, exports are predicted to be 6.1 percent greater than that in the benchmark model after 10 years, while in the plastics industry they are 13.2 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.

The last experiment combines the trade liberalization exercise with a simultaneous reduction in investment costs. Not surprisingly we find that the combination of the two policies has the largest impact on both aggregate investment and exports. Initially, aggregate export behavior closely resembles that under trade liberalization alone, while aggregate investment behavior is 2.9-3.4 percent higher than it was under the financial reform experiment. While aggregate investment again falls over time, it is always above the observed investment rate in the second experiment reflecting the additional gain from exporting. After 10 years the annual aggregate investment rate is 1.6-2.2 percent higher in the last experiment relative to the financial reform experiment without contemporaneous trade liberalization. Over the entire 10 year period the plastics and fabricated metals industry experience a cumulative growth in investment, net of depreciation, which is 1.9-4.4 percent higher, respectively, under the last experiment relative to the second experiment.[54]

While these are relatively small differences the predicted growth rates of aggregate investment, the addition of simultaneous trade liberalization increases represents an annual aggregate investment growth rate increase of 6-9 percent across industries. In capital-scarce developing countries these differences represent key differences in policy outcomes. Even more starkly, we observe that simultaneous trade or financial reform leads to much greater growth in exports relative to scenarios where each policy is applied individually. In either industry we observe that after 10 years the aggregate growth rate of exports is approximately double what it was in the preceding experiments.

[54]Note that the cumulative growth in aggregate investment from the second experiment is 28.9-45.9 percent in the plastics and fabricated metals industries, respectively.

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 14-15 percent in the Indonesian plastics and fabricated metals industries.

We structurally estimate the model using detailed information on export and investment decisions among Indonesian manufacturing firms. Accounting for capital-adjustment substantially alters the performance of the model. We find that sunk (first-time) export costs are reduced by 93-94 percent while fixed (per-period) export costs fall by 83-85 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. Comparing the model with capital adjustment to standard models without investment dynamics we find that the model with investment dynamics outperforms the standard models on numerous dimensions. In particular, the model with investment dynamics is able to simultaneously differential investment and revenue growth rates across exporting and non-exporting firms, the export entry and survival rates among new exporters, and the distribution of new exporters across productivity and capital stock.

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 a 10 percent increase in export market size increases annual aggregate exports by 5-9 percent and cumulative aggregate investment (net of depreciation) by 1.4-2.2 percent across industries. Similarly, reducing investment costs by 10 percent increases annual aggregate exports by 6-13 percent and cumulative aggregate investment by 29-46 percent across industries.

Appendix: tables and fugures

Table 20. Investment and Export Moments

	Plastics	Fabricated Metals
Median Variable Input Share	0.784	0.849
Average investment rate (I/K) (all firms)	0.078	0.130
Average investment rate among exporters	0.199	0.316
Inaction frequency	0.720	0.598
Inaction frequency among exporters	0.428	0.377
Average export intensity among exporters	0.401	0.419
Correlation of export and investment status	0.218	0.142
Correlation of log export sales and log investment	0.291	0.278

Table 21. Annual Transition Rates

	Status in $t+1$							
	Plastics				Fabricated Metals			
Status in t	Neither	only Inv.	only Exp.	Both	Neither	only Inv.	only Exp.	Both
All Firms	0.682	0.213	0.045	0.061	0.579	0.326	0.037	0.058
Neither	0.900	0.080	0.014	0.006	0.868	0.106	0.019	0.007
only Inv.	0.295	0.655	0.008	0.043	0.236	0.713	0.011	0.041
only Exp.	0.141	0.028	0.647	0.183	0.360	0.000	0.500	0.140
Both	0.108	0.118	0.118	0.657	0.060	0.202	0.107	0.631

Table 22. Moments Used For Estimation

Summary Statistic	Plastics	Fab. Metals
Mean frequency of investment	0.271	0.386
Mean investment rate (i_t/k_t) among firms where $i_t > 0$	0.251	0.309
Mean frequency of exporting	0.104	0.096
Fraction of year t exporters who exported in year $t-1$	0.763	0.655
Mean log export sales among exporting firms	8.675	8.841
Variance of export intensity	0.391	0.665

Table 23. OLS Regression Coefficients Used For Estimation

Regression Coefficient	Plastics		Fabricated Metals	
	Estimate	Std. Error	Estimate	Std. Error
ϱ_1	0.044	0.008	0.230	0.025
ϱ_2	0.098	0.018	0.098	0.035
ς_0	-2.291	0.017	-0.495	0.011
ς_1	0.661	0.053	0.429	0.034
ϑ_1	0.744	0.020	0.580	0.024

Notes: The squared productivity term in equation (III.23) 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 A.1.

Table 24. 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 based 200 bootstrap replications.

Table 25. Export Market Size, Export Costs and Investment Costs

	Plastics			Fabricated Metals		
Model No.	1	2	3	1	2	3
γ^F	1.037	1.084	3.969	1.100	2.131	2.461
	(0.004)	(0.003)	(0.011)	(0.003)	(0.015)	(0.017)
γ^S	6.688	15.508	92.852	3.273	7.590	51.508
	(0.014)	(0.048)	(0.109)	(0.006)	(0.021)	(0.573)
ρ	0.779	0.795	0.782	0.936	0.885	0.828
	(0.002)	(0.003)	(0.002)	(0.005)	(0.012)	(0.001)
$\ln \sigma_\mu$	0.144	0.183	0.191	0.307	0.319	0.317
	(0.0003)	(0.0004)	(0.001)	(0.001)	(0.002)	(0.001)
$\ln \Lambda^X$	-2.293	-1.843	-1.989	-2.835	-2.496	-2.632
	(0.009)	(0.010)	(0.007)	(0.010)	(0.035)	(0.010)
ψ_0	64.089			17.278		
	(0.153)			(0.072)		
ψ_1	3.551			0.051		
	(0.017)			(0.0001)		
ψ_2	0.053			0.010		
	(0.0001)			(0.0002)		
Endogenous k-Adjust.	Yes	No	No	Yes	No	No
Marginal Costs	Increasing	Increasing	Constant	Increasing	Increasing	Constant

Notes: Asymptotic standard errors are in parentheses.

Table 26. Data and Model Based-Moments

	Plastics		Fab. Metals	
Summary Statistic	Data	Model	Data	Model
Mean frequency of investment	0.271	0.274	0.386	0.302
Mean investment rate (i_t/k_t) among firms where $i_t > 0$	0.251	0.198	0.309	0.332
Mean frequency of exporting	0.104	0.119	0.096	0.083
Fraction of year t exporters who exported in year $t-1$	0.763	0.584	0.655	0.524
Mean log export sales among exporting firms	8.675	8.064	8.841	8.965
Variance of export intensity	0.391	0.237	0.665	0.895

Table 27. Data and Model Based OLS Parameter Estimates

Parameter	Plastics Actual	Plastics Simulated	Fabricated Metals Actual	Fabricated Metals Simulated
ϱ_1	0.044	0.080	0.230	0.217
ϱ_2	0.098	0.025	0.098	0.011
ς_0	-2.291	-2.360	-0.495	-0.508
ς_1	0.661	0.716	0.429	0.549
ϑ_1	0.744	0.641	0.580	0.797

Notes: The squared productivity term in equation (III.23) 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 28. Entry Rates in Export Markets

	Plastics				Fabricated Metals			
	Data	Model 1	Model 2	Model 3	Data	Model 1	Model 2	Model 3
	0.027	0.056	0.053	0.045	0.036	0.040	0.027	0.037
Endog. k-Adjust.	—	Yes	No	No	—	Yes	No	No
Marginal Costs	—	Increasing	Increasing	Constant	—	Increasing	Increasing	Constant

Table 29. Exporting and Domestic Revenue

	Data		Model 1		Model 2		Model 3	
Plastics								
Constant	0.022	-0.042	0.026	-0.009	0.063	-0.011	0.088	0.000
	(0.015)	(0.012)	(0.013)	(0.004)	(0.014)	(0.004)	(0.014)	(0.000)
Δd_{jt}	-0.356	-0.628	-0.049	-0.241	-0.139	-0.321	0.194	0.000
	(0.112)	(0.082)	(0.048)	(0.023)	(0.057)	(0.033)	(0.051)	(0.000)
$\Delta\omega_{jt}$		1.282		1.389		1.391		0.745
		(0.038)		(0.007)		(0.009)		(0.000)
$\Delta \ln k_{jt}$		0.305		0.488				
		(0.070)		(0.029)				
Fabricated Metals								
Constant	0.059	0.006	0.028	-0.018	0.052	0.012	0.059	0.000
	(0.016)	(0.011)	(0.014)	(0.006)	(0.014)	(0.005)	(0.014)	(0.000)
Δd_{jt}	-0.346	-0.554	-0.342	-0.483	-0.329	-0.479	0.138	0.000
	(0.128)	(0.102)	(0.080)	(0.063)	(0.090)	(0.069)	(0.061)	(0.000)
$\Delta\omega_{jt}$		2.963		3.369		3.376		2.610
		(0.158)		(0.035)		(0.029)		(0.000)
$\Delta \ln k_{jt}$		0.215		0.284				
		(0.062)		(0.035)				
Endog. k-Adjust.	—		Yes		No		No	
Marginal Costs	—		Increasing		Increasing		Constant	

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

Table 30. Export Fixed Costs

	Plastics											
Quartiles	Model 1				Model 2				Model 3			
$\omega_t \backslash k_t$	1	2	3	4	1	2	3	4	1	2	3	4
1	0.150	0.220	0.333	0.520	0.094	0.175	0.236	0.625	1.630	2.148	2.175	2.970
2	0.303	0.420	0.487	0.622	0.205	0.382	0.403	0.725	3.058	2.916	2.673	3.415
3	0.345	0.536	0.579	0.660	0.352	0.448	0.470	0.790	3.624	2.472	3.154	3.482
4	0.580	0.718	0.766	0.815	0.717	0.684	0.892	0.912	3.318	3.185	4.693	3.615

	Fabricated Metals											
Quartiles	Model 1				Model 2				Model 3			
$\omega_t \backslash k_t$	1	2	3	4	1	2	3	4	1	2	3	4
1	0.108	0.082	0.162	0.531	0.061	0.079	0.090	0.345	1.185	1.561	1.507	1.729
2	0.292	0.313	0.348	0.347	0.148	0.286	0.550	0.617	1.141	1.454	1.486	1.717
3	0.230	0.641	0.555	0.641	0.488	0.494	0.811	0.963	1.499	1.475	1.752	1.902
4	0.125	0.630	0.763	0.816	0.907	0.949	1.270	1.527	1.552	1.894	1.983	2.161

Endog. k-Adj.	Yes	No	No
Marg. Costs	Increasing	Increasing	Constant

Table 31. Export Sunk Costs

	Plastics											
Quartiles	Model 1				Model 2				Model 3			
$\omega_t \backslash k_t$	1	2	3	4	1	2	3	4	1	2	3	4
1	0.076	0.122	0.234	0.606	0.114	0.126	0.160	0.734	3.690	3.820	5.359	9.889
2	0.170	0.285	0.504	0.903	0.354	0.161	0.205	1.249	5.646	9.448	12.618	15.549
3	0.350	0.566	0.697	1.227	0.685	0.653	0.701	1.857	8.668	9.682	7.338	18.354
4	0.778	1.159	1.447	2.027	1.482	1.537	1.582	3.232	10.721	20.883	23.691	22.981

	Fabricated Metals											
Quartiles	Model 1				Model 2				Model 3			
$\omega_t \backslash k_t$	1	2	3	4	1	2	3	4	1	2	3	4
1	0.077	0.056	0.073	0.245	0.030	0.047	0.076	0.133	1.372	1.677	2.575	4.568
2	0.097	0.170	0.163	0.260	0.064	0.118	0.190	0.372	2.396	3.242	3.128	4.869
3	0.271	0.321	0.395	0.527	0.270	0.396	0.532	0.741	4.076	4.101	4.854	6.136
4	0.347	0.634	0.895	1.001	0.916	1.039	1.402	1.875	5.667	6.892	8.261	11.136

Endog. k-Adj.	Yes	No	No
Marg. Costs	Increasing	Increasing	Constant

Table 32. Distribution of New Exporters Across Capital and Productivity

New Plastics Exporters																				
Quartiles	Data								Model 1				Model 2				Model 3			
$\omega_t \backslash k_t$	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	0.01	0	0.01	0.02	0.01	0.01	0.02	0.04	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.03
2	0.02	0	0.01	0.03	0.03	0.01	0.01	0.08	0.01	0.01	0.02	0.05	0.01	0.01	0.01	0.10	0.01	0.01	0.01	0.11
3	0.03	0.03	0.03	0.16	0.04	0.03	0.07	0.22	0.01	0.02	0.04	0.13	0.01	0.01	0.01	0.21	0.01	0.01	0.01	0.21
4	0.03	0.04	0.08	0.50	0.01	0.02	0.03	0.36	0.02	0.06	0.14	0.44	0.01	0.01	0.01	0.58	0.01	0.01	0.01	0.56

New Fabricated Metals Exporters																				
Quartiles	Data								Model 1				Model 2				Model 3			
$\omega_t \backslash k_t$	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	0	0.01	0	0.01	0	0.02	0.01	0.03	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.02
2	0	0.01	0.03	0	0	0	0.08	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.03
3	0	0.06	0.09	0.05	0	0.10	0.09	0.09	0.02	0.03	0.05	0.06	0.02	0.02	0.03	0.05	0.01	0.02	0.09	0.11
4	0.02	0.05	0.19	0.46	0.02	0.02	0.14	0.39	0.01	0.02	0.19	0.51	0.02	0.04	0.16	0.51	0.02	0.04	0.16	0.43
Marg. Costs	Increasing				Constant				Increasing				Increasing				Constant			

Table 33. Trade Liberalization: Counterfactual Export and Investment Growth

Plastics

Experiment	Model 1				Model 2				Model 3			
Year	1	3	5	10	1	3	5	10	1	3	5	10
Aggregate Exports (%)	10.7	9.3	8.8	8.9	9.2	9.1	8.0	7.4	13.2	12.0	11.9	11.6
Extensive Margin (%)	24.6	22.7	19.0	18.1	21.6	28.9	22.8	19.6	18.1	15.4	14.2	12.4
Aggregate Investment (%)	1.6	1.5	1.2	1.6	—	—	—	—	—	—	—	—
Exporter Contribution (%)	9.1	7.3	6.2	5.3	—	—	—	—	—	—	—	—

Fabricated Metals

Experiment	Model 1				Model 2				Model 3			
Year	1	3	5	10	1	3	5	10	1	3	5	10
Aggregate Export (%)	9.3	7.7	6.1	5.1	9.3	7.6	6.4	6.0	12.4	11.8	11.1	11.3
Extensive Margin (%)	18.0	21.3	15.6	14.2	16.2	18.5	18.3	22.5	13.1	12.9	9.3	10.1
Aggregate Investment (%)	6.3	3.4	1.1	-0.5	—	—	—	—	—	—	—	—
Exporter Contribution (%)	35.7	11.8	7.4	7.5	—	—	—	—	—	—	—	—

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

Table 34. Financial Reform: Counterfactual Export and Investment Growth (Model 1)

Plastics								
Experiment	Financial Reform Alone				Trade and Financial			
Year	1	3	5	10	1	3	5	10
Aggregate Exports (%)	0.3	4.0	6.2	13.2	11.1	13.7	15.7	23.0
Extensive Margin (%)	100.0	23.5	20.1	18.1	26.8	24.4	20.7	18.5
Aggregate Investment (%)	46.8	32.5	28.2	23.8	50.2	34.3	30.4	26.0
Exporter Contribution (%)	11.8	10.5	5.0	8.8	18.6	16.2	11.1	13.7

Fabricated Metals								
Experiment	Financial Reform Alone				Trade and Financial			
Year	1	3	5	10	1	3	5	10
Aggregate Export (%)	0.1	3.2	4.1	6.1	9.4	10.7	10.2	12.2
Extensive Margin (%)	100.0	12.8	12.6	6.5	18.5	20.1	16.3	13.2
Aggregate Investment (%)	61.7	46.8	40.8	27.7	64.6	51.4	43.2	29.3
Exporter Contribution (%)	43.3	26.7	16.7	10.3	57.7	38.7	23.5	15.2

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

Additional Model-Performance Results

This section documents the model's performance matching the empirical moments and regression coefficients in the models without capital adjustment. Model 2 is the model with increasing marginal costs, while Model 3 is the model with constant marginal costs. The investment moments and regression coefficients are omitted since the there is no capital adjustment in these models and they are not used for estimation. Like the model with capital adjustment we observe slightly less persistence in export status in the simulated data than in the actual data. Unlike the model with capital adjustment we also tend to observe that the model predicts an export productivity premium , ς_1, that is too high. This tension due to the sunk cost feature of the model. Larger sunk export costs create higher persistence in export status, but prevent small, less productive firms from entering export markets. In the model with capital adjustment, this was not the case since export entry costs were relatively small.

Table 35. OLS Regression Coefficients Under Constant Marginal Cost Assumption

Regression Coefficient	Plastics		Fabricated Metals	
	Estimate	Std. Error	Estimate	Std. Error
ς_0	-4.373	0.034	-0.735	0.013
ς_1	0.679	0.104	0.299	0.043
ϑ_1	0.744	0.020	0.580	0.024

Notes: We drop equation (III.23) from the structural estimation routine since there is no investment decision estimated in this context.

Table 36. Data and Model Based-Moments

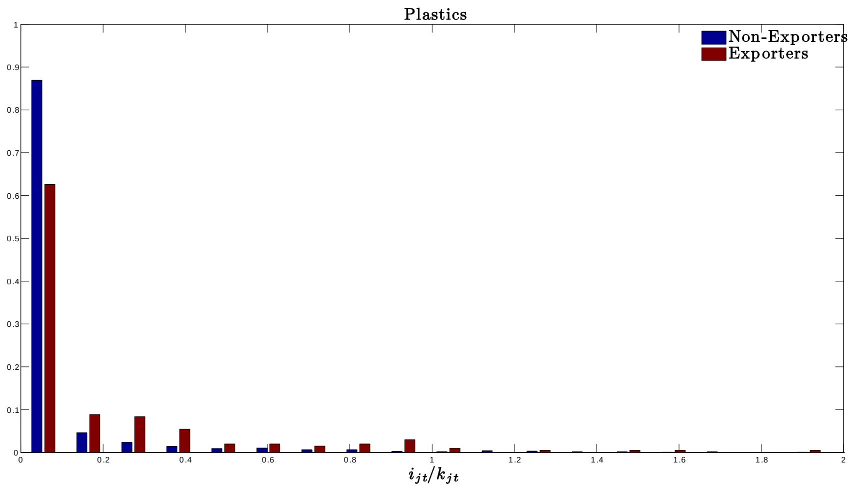
Model 2: Increasing Marginal Costs, No Capital-Adjustment				
	Plastics		Fab. Metals	
Summary Statistic	Data	Model	Data	Model
Mean frequency of exporting	0.104	0.115	0.096	0.057
Fraction of year t exporters who exported in year $t-1$	0.763	0.662	0.655	0.534
Mean log export sales among exporting firms	8.675	8.293	8.841	9.198
Variance of export intensity	0.391	0.375	0.665	0.800

Model 3: Constant Marginal Costs, No Capital-Adjustment				
	Plastics		Fab. Metals	
Summary Statistic	Data	Model	Data	Model
Mean frequency of exporting	0.104	0.119	0.096	0.095
Fraction of year t exporters who exported in year $t-1$	0.763	0.678	0.655	0.674
Mean log export sales among exporting firms	8.675	8.252	8.841	8.621
Variance of export intensity	0.391	0.364	0.665	0.513

Table 37. Data and Model Based OLS Parameter Estimates

Model 2: Increasing Marginal Costs, No Capital-Adjustment				
	Plastics		Fabricated Metals	
Data Source	Actual	Simulated	Actual	Simulated
ς_0	-2.291	-2.337	-0.495	-0.500
ς_1	0.661	0.686	0.429	0.603
ϑ_1	0.744	0.700	0.580	0.720

Model 3: Constant Marginal Costs, No Capital-Adjustment				
	Plastics		Fabricated Metals	
Data Source	Actual	Simulated	Actual	Simulated
ς_0	-4.347	-4.513	-0.735	-0.769
ς_1	0.679	1.126	0.299	0.523
ϑ_1	0.744	0.714	0.580	0.772



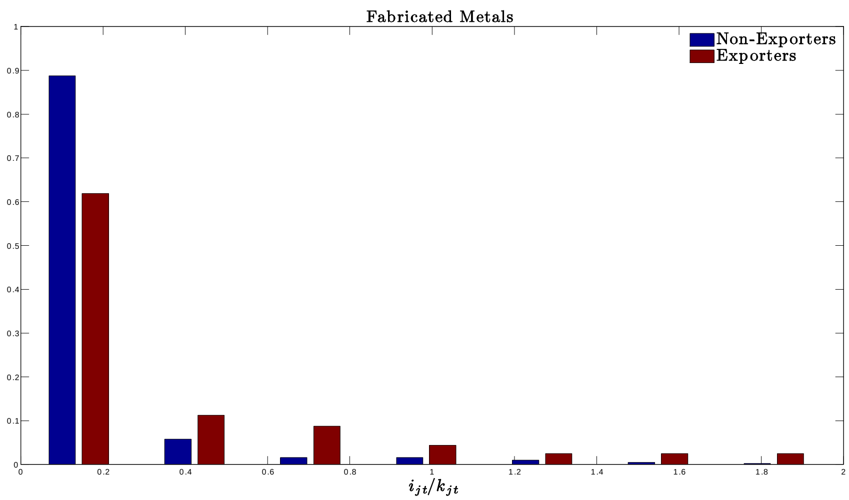
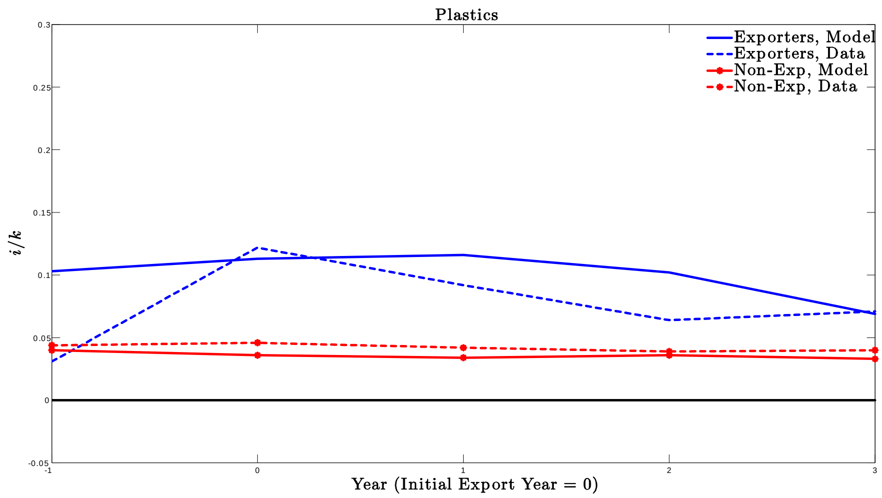


Figure 7. Investment Rate Histogram



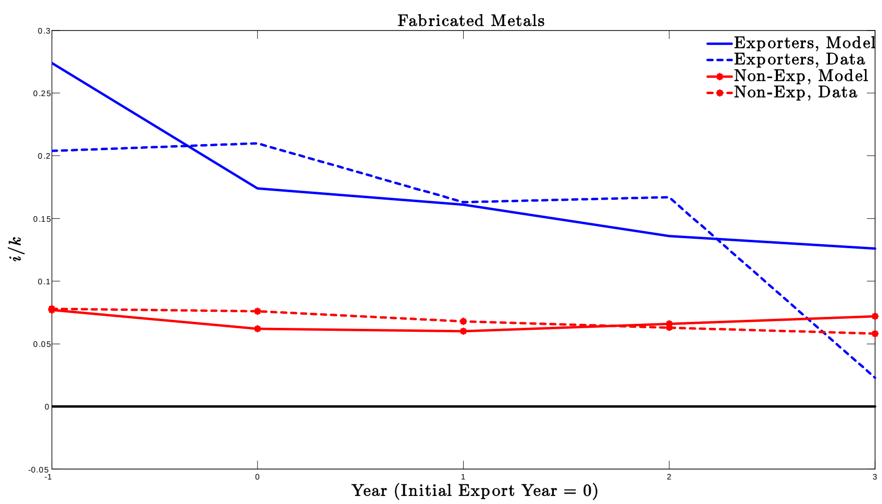
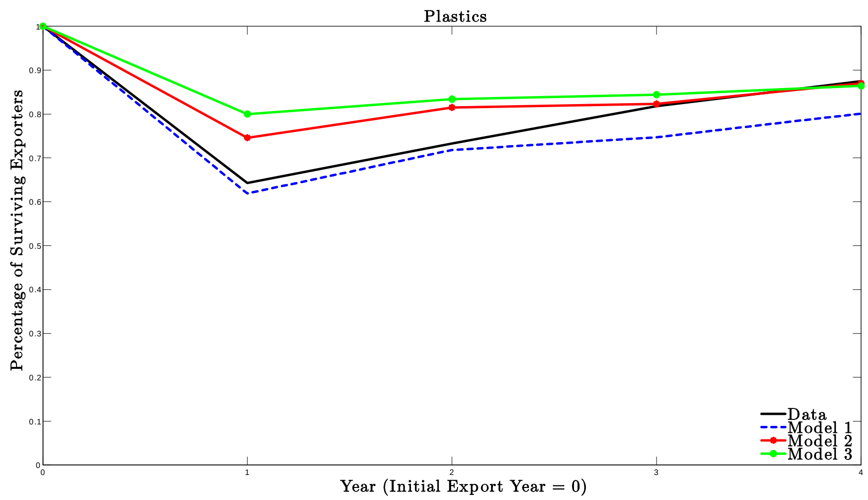


Figure 8. Investment Rate across Exporting and Non-Exporting Firms



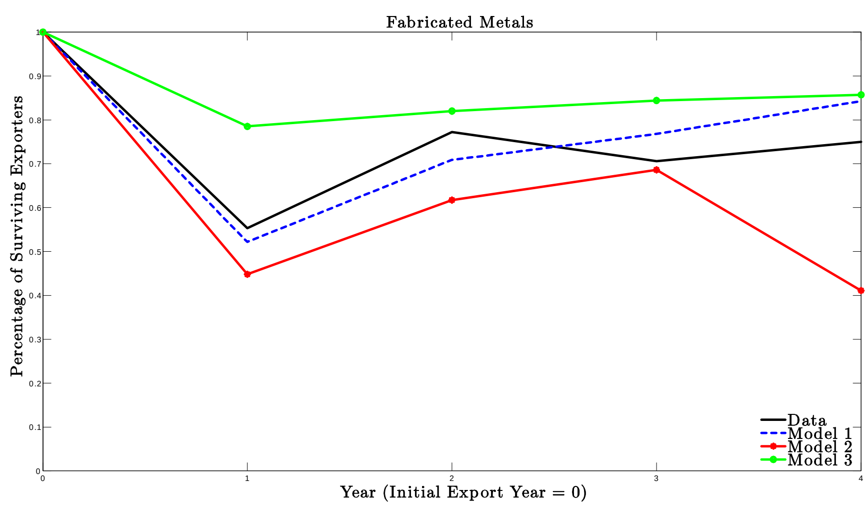
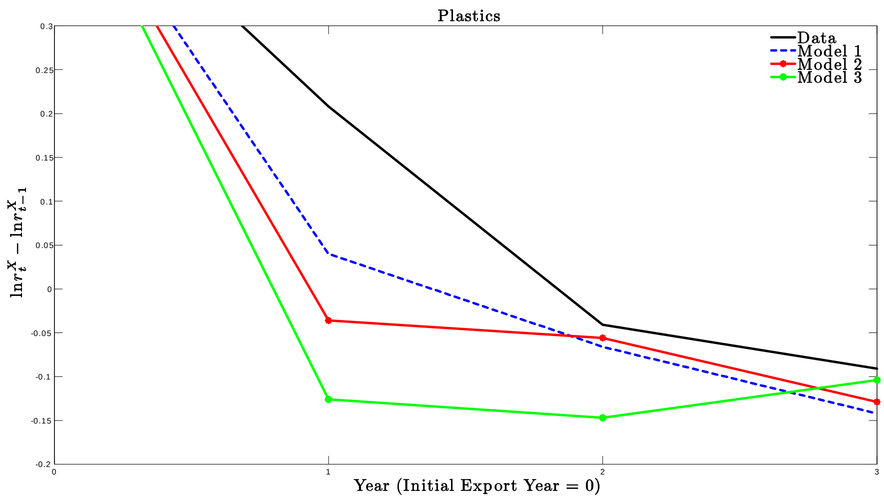


Figure 9. Survival Rate among New Exporters



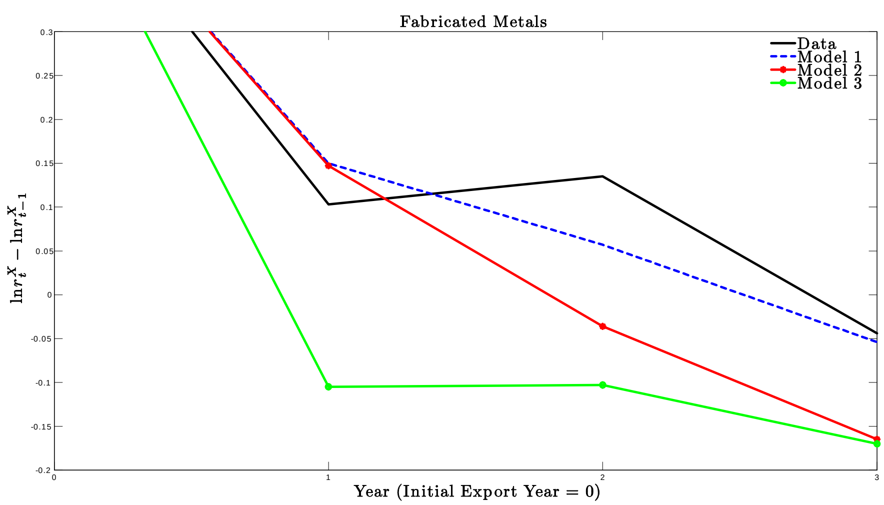


Figure 10. Export Revenue Growth among Surviving Exporters

CHAPTER IV

GROWING INTO EXPORT MARKETS: THE IMPACT OF EXPORTING ON FIRM-LEVEL INVESTMENT IN INDONESIA

with Joel B. Rodrigue

Introduction

Since the 1960s numerous East Asian countries have witnessed unprecedented economic growth rates. Not surprisingly, international success in a variety of manufactured goods markets has lead numerous researchers to study the determinants of export growth among East Asian manufacturers and the consequent impact of exporting on manufacturing efficiency. This paper contributes to this literature by studying the causal link between exporting and capital growth. A emerging line of research strongly argues that new exporters are often restricted by a lack of physical and working capital and, because of this, make systematically small entries into export markets. Further, imperfect credit markets constrain the ability of new exporters to grow into new markets, limiting the gains from export promotion in developing countries.

Our study differs from the existing literature in three important respects. First, we study changes at the firm level during and after entry into export markets. This allows us to characterize how firms build up capital holdings over time and the length of time required to adjust to exporting. Second, our study has an explicit focus on the causal impact of exporting on firm-level investment. While preceding research has convincingly argued that working capital is a key determinant of export outcomes, very few studies have the extent to which exporting affects the incentive to invest as they grow into export markets.

For instance, Manova and Yu (2012) argue strongly that firm-level working capital plays a key role in determining the nature firm-level entry into export markets. We provide complementary evidence which suggests that as firms enter into export markets, there investment reflect key changes in the demand for existing capital. Third, our firm-level data from Indonesia allow us to characterize the role of credit constraints on new investment among exporting firms in Indonesia. Specifically, our data allows us to study the impact of exporting on investment across firm ownership (foreign and domestic) and lending regimes (pre- and post- financial crisis). We find that firms with better access to credit markets make consistently larger investments in physical capital when entering export markets. While existing evidence indicates that firms with better access to credit markets much better export performance (see Manova, Wei and Zhang (2011) for example), we provide evidence that of changes *within* firms which are consistent with the interpretation that new exporters are often credit constrained.

It is well known that across countries exporting firms are typically among the largest and most productive firms in a given industry and, not surprisingly, more likely to invest. In this context disentangling correlation and causality is of utmost importance for policymakers, but also poses numerous challenges for researchers. If high productivity firms are more likely to export, exporting becomes an endogenous variable and simple least-squares estimation is invalid. To address this issue we use propensity score matching to assess the causal effect of exporting on investment. The matching technique allows us to create the missing counterfactual of an acquired firm had it not entered export markets. It does so by pairing each firm that chooses to export in the future with a similar firm that never exports.

We then combine propensity score matching with a difference-in-difference approach. The causal impact of exporting is inferred from the average divergence in the investment paths between each new exporter and its matched control firm. Our approach directly addresses concerns with reverse causality and omitted variable biases. Specifically, by matching new exporters and non-exporters in the year prior to initial entry into export markets, we control for firm characteristics that affect investment activity equally in across firms, such as productivity, capital-intensity, labor force quality, past investment, or access to foreign distribution networks. Our results are thus identified purely from the variation in investment outcomes across similar firms within narrowly defined industries.

Our analysis, covering the period between 1990-2000, is based on detailed firm-level data from the Census of Indonesian Manufacturing Plants. We find that Indonesian manufacturers actively increase physical capacity faster than comparable firms as they enter export markets and continue investing faster than comparable firms for at least three years after entry. We document that the investment rate among new exporters is 40 percent higher than non-exporters in the year of initial entry into export markets, 48 percent higher in the first year after entry and 23-34 percent higher in the second and third years after entry. We provide further evidence on the degree to which these results are robust to length of time after entry we study, the endogenous selection of firms in and out of export markets, the initial firms size, initial capital holdings and the type of investment (e.g. machinery investment vs. all physical capital) firm undertake, among other checks. In each case we find that new exporters are strongly increasing their capital holdings upon entry into export markets.

Despite the large estimated impact of exporting on investment, our most striking results pertain to the differences across similar firms with different types of ownership. We exploit observed differences in firm ownership to capture idiosyncratic variation in access to foreign credit markets. We find that foreign firms increase the capital holdings by much larger amounts and over a much shorter time period relative to domestic firms. In the year of initial entry, we find that exporting increases investment 98 percent faster among foreign firms, relative to domestic firms. Consistent with our interpretation, the estimated differences across foreign and domestic firms is largest during the period of the Asian financial crisis when domestic lending was very tight in Indonesia. The rapid decline in international trade during the 2007-2009 global financial crisis has renewed interest in these questions, and the Asian financial crisis provides a useful window to study the effects of credit tightening on world trade.

There is near universal evidence that exporting firms are substantially more capital intensive and productive than their non-exporting counterparts across a wide variety of industries and countries.[1] Likewise, there exists a rich literature suggesting that exporting affects numerous firm-level decisions over time.[2] In particular, Bustos (2011) and Lileeva and Trefler (2011) suggest that new exporters have a strong incentive to invest as they enter export markets though neither paper quantifies the extent firm-level capital holdings evolve with entry into export markets. We add to this literature by quantifying the extent to which *affects the rate* of within-firm capital growth and subsequent firm-level investment decisions and outcomes.

[1]Early contributions include those from Aw and Hwang (1995), Aw and Batra (1998), Chen and Tang (1987), Bernard and Jensen (1995), Tybout and Westbrook (1995), Clerides, Lach and Tybout (1998), Bernard and Jensen (1999) and Aw, Chung and Roberts (2000) among others. Likewise, increasing the scale of production has played a key role in "infant-industry" arguments for tariff protection dating back to Alexander Hamilton and Friedrich List at the beginning of the 19th Century.

[2]Ekholm and Midelfart (2005), Yeaple (2005), and Bustos (2011) all highlight the link between firm-level exporting and hiring decisions. Similarly, Atkeson and Burstein (2009), Ederington and McCalman (2008), Costantini and Melitz (2008), Lileeva and Trefler (2010) and Aw, Roberts and Xu (2010) study the impact of firm-level innovation on productivity evolution and exporting over time. Similarly, much attention has been paid to the impact of productivity, financial frictions, or institutional development on export growth. See Nunn (2007), Helpman, Melitz and Rubenstein (2008) and Manova (2008) for examples.

Rho and Rodrigue (2012) and Ahn and McQuoid (2012) argue that there exists strong empirical evidence that many new exporters are subject to increasing marginal costs, largely arising from a lack of physical capital upon entry. Further, Riano (2011) and Rho and Rodrigue (2012) demonstrate this feature is important for capturing firm-level investment behavior, survival and revenue growth in dynamic models of exporting and investment. Likewise, a large number of recent papers have strongly argued that new exporters are restricted from fully entering export markets because they are under-capitalized at the time of desired entry. A number of studies have demonstrated that allowing for a fixed input, such as physical capital, has an important role in heterogeneous firm models of international trade. In particular, Vannoorenberghe (2010), Blum, Claro and Horstmann (2011), Nguyen and Schaur (2011) and Soderbury (2010) all study firm-level export decisions in an environment where capital or production-capacity are fixed over time. They find that the assumption of a fixed production input (such as capital) or fixed short-run capacity allow their models to rationalize the correlation of domestic and export sales and/or the volatility of sales among exporting firms. They do not document, however, the extent to which these market trade-offs encourage firms to expand capital holdings as they grow into export markets.

The degree to which capital-constraints affect firm performance naturally depends upon the degree to which firms need to upgrade capital holdings and on the length of time required to accomplish these changes. Unfortunately, none of these papers present broad evidence of the extent to which capital accumulation changes when firms enter export markets. We contribute to this literature by quantifying the degree to which new Indonesian exporters increase capital holdings at a faster rate upon entering export markets. If new exporters are constrained by a lack of physical capital at the time of entry into export markets, we expect that this will encourage investment in new capital among those that wish to grow into export markets. This naturally raises a number of questions. How much investment is required for new exporters to adjust to serving multiple markets? Does the investment occur entirely in one year or do new exporters adjust slowly over time? We aim to complement the existing literature by providing an answer to these questions.[3]

Although few papers have studied capital accumulation and exporting in this context, a number of recent related papers have emphasized the importance of financial frictions in determining export outcomes across firms, industries and countries. Manova (2010), Manova, Wei and Zhang (2011), Aisen et al. (2011), Ahn and McQuoid (2012), Kohn, Leibovici and Szkup (2012) and Manova and Yu (2012) all suggest that the presence of firm-level financial frictions affect export decisions and the growth of export sales. We provide evidence that financial frictions further influence the rate at which capital stock grows, further reinforcing the impact of financial frictions on firm growth over time.

Similarly, Blalock, Gertler and Levine (2008) use observable differences in ownership structure to demonstrate that foreign owned firms in Indonesia are likely to invest at a higher rate than similar domestic firms. They argue that a key reason for the observed difference in investment rate arises naturally since foreign owned firms are likely to have much better access to foreign credit markets. Similarly, Manova, Wei and Zhang (2011) use observable ownership differences among Chinese exporters to study the impact of financial frictions on the growth of firm-level exports. They conclude that better access to credit markets allows foreign owned firms to enter a larger number of markets, export a larger number of products and grow export sales faster.

[3]We are not aware of any other paper studying the dynamics of capital accumulation as firms enter export markets. In a companion piece Rho and Rodrigue (2012) structurally estimate a dynamic model of exporting, firm survival in export markets and capital accumulation. While this paper studies the interactions of investment and export costs on firm behavior, it does not provide direct evidence on firm-level investment responses to trade liberalization or financial frictions.

This paper provides complementary evidence to these findings. In particular, we find that foreign-owned exporters in Indonesia enter export markets very differently than domestic Indonesian firms. We document that foreign owned firms often increase their capital holdings much faster rate than similar domestic firms in the year of entry. Specifically, while domestic firms grow capital holdings slowly over time, foreign firms tend to invest heavily in one or, at most, two years after initial export entry. We find that the impact of exporting on investment among foreign firms is nearly double that of similar domestic firms in the year of entry into export markets. However, we do not generally find statistically significant differences across foreign and domestic firms in any year around entry other than the year of initial entry. Both of these results are consistent with foreign owned firms having better access to financing for exports. In particular, in the presence of fixed (non-convex) investment costs we expect that investment will tend to be lumpy. As such, we would expect that unconstrained firms would choose to optimally adjust their capital holdings by a relatively large amount in a small number of years, while credit-constrained firms are more likely to have to self-finance investment over time. We confirm that differences across foreign and domestic firms are strongest during periods of tight domestic credit in Indonesia and indicative of impact of credit market imperfections on export behavior.

Our results are not simply of academic interest, but have key policy implications, particularly in a developing country. Manova and Yu (2012) indicate that firm-level differences in capital structure strongly influence the mode and nature of firm-level exporting. Our findings complement this result and strongly indicate that firms are actively changing their capital structure as they enter export markets. Likewise, a large literature documents that changes in firm-level investment behavior has important impacts on aggregate economic performance.[4] Crucini and Kahn (1996, 2007) demonstrate that accounting for capital accumulation at an aggregate level is key to evaluating trade policy changes. We complement this literature by documenting similar differences in a developing country and studying the interaction of firm-level investment with export decisions. Finally, understanding the role of financial frictions for firmsÕ export growth is of particular importance to developing countries which often rely on extensive cross-border trade for economic growth. Given the difficulties of associated with institutional and financial reform, our results also shed light on potential benefits of better access to foreign credit markets arising from foreign direct investment.

In the next section we provide a simple model of investment and exporting to motivate our empirical approach. Section two describes our empirical strategy and section three describes the Indonesian manufacturing sector and the data used to study firm-level investment and export behavior. The fourth section presents our empirical model, while section five presents both our main results and robustness checks. Section six examines the differential investment behavior of new foreign and domestic exporters and the extent to which this can be attributed to credit constraints. The last section concludes.

A Simple Model of Investment and Exporting

To facilitate our empirical analysis we present a simple model of investment and exporting. Our objective here is to outline one particular channel through which exporting may affect investment over time and the impact of investment cost differences on firm behaviour. A number of recent models argue that new exporters tend to be capacity constrained (Ahn and McQuoid (2012), Soderbury (2010), Nguyen and Schaur (2012), Blum, Claro and

[4] For instance, Doms and Dunne (1998), Caballero, Engel and Haltiwanger (1995), Cooper, Haltiwanger and Power (1999) and Cooper and Haltiwanger (2000).

Horstmann (2011)) . In most of these models capital stock or firm capacity is exogenous to the decision to export. In contrast, we present a stylized model in which investment and capital holdings endogenously depend on the firm's export decisions over time. Further, we explore the role of firm ownership and access to credit on investment and export outcomes.

Consider a set horizontally differentiated manufacturings firm in a developing country which each produce one variety which can be sold at home in the domestic market or abroad through export sales. 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.

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

$$\ln mc_{jt} = -\ln \alpha_l - \frac{\alpha_k}{\alpha_l} \ln k_{jt} - \frac{1}{\alpha_l}\omega_{jt} + \ln w_t + \frac{1-\alpha_l}{\alpha_l} \ln q^*_{jt} \quad \text{(IV.1)}$$

where w_t is a set of relevant input prices used in production and q^*_{jt} is the target, profit-maximizing level of output. Equation (III.1) implies that firms with larger capital stocks incur lower marginal costs, *ceteris paribus.* This will later imply that across two equally productive firms, the firm with the larger capital stock will produce at a lower cost. As such, more capital-intensive firms will be more likely to export. We assume that productivity evolves according to a separate Markov process:

$$\omega_{jt} = f(\omega_{jt-1}, k_{jt}) + \epsilon_{jt} \quad \text{(IV.2)}$$

where k_{jt} captures the firm's current holdings of capital. Likewise, we describe the evolution of capital by

$$k_{jt} = (1 - \delta)k_{jt-1} + i_{jt-1} \tag{IV.3}$$

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.

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

$$C(i_{jt}, k_{jt}, \xi_j) = c(i_{jt}, k_{jt}, \xi_j) + F(\xi_j)1[i_{jt} > 0] \tag{IV.4}$$

where ξ_j is an indicator variable capturing whether the firm is owned by foreign ($\xi_j = 1$) or domestic ($\xi_j = 0$) investors.[5] We maintain standard assumptions on the nature of convex investment costs, $c(0, k_{jt}, \xi_{jt}) = 0$, $c_1 > 0$, $c_2 < 0$, $c_{11} > 0$, $c_{22} > 0$. However, we allow foreign firms, which are commonly associated with better access to foreign credit (see Blalock, Gertler and Levine (2008) and Manova, Wei and Zhang (2011)) to potentially have lower convex, $c_3 < 0$, and non-convex investment costs, [6] $F(1) - F(0) < 0$.

Similarly, we assume that entering foreign markets may require additional fixed entry costs, $C_X(d_{jt}, d_{jt-1}, \xi_j)$, which may depend on the firm's export history:

$$C_X(d_{jt}, d_{jt-1}, \xi_j) = F_X(\xi_j)d_{jt}d_{jt-1} + S_X(\xi_j)d_{jt}(1 - d_{jt-1})$$

where d_{jt} takes a value of 1 if firm j exports in year t and is zero otherwise. We write sunk and fixed export costs as an explicit function of ownership to highlight the fact that foreign

[5] We abstract from changes in ownership status since we observe relatively few ownership changes over time in our sample data.

[6] 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)) and Indonesia (c.f. Rho and Rodrigue (2012)).

ownership will also likely affect the costs of entry into export markets. If the initial entry into export markets is more costly than subsequent entries into export markets we expect that $S_X(\xi_j) > F_X(\xi_j)$.

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. The maximized profit function for firm j at time t (before investment costs) is: $\pi_{jt} = \pi_t(k_{it}, \omega_{jt}, d_{jt}, d_{jt-1}, A, A^*)$ where A and A^* capture market-specific demand shifters (size, income, competitiveness) in the domestic and foreign market, respectively.

Denote the value of firm j in year t by V_{jt}:

$$V_{jt}(s_{jt}) = \max_{d_{jt}, i_{jt}} \pi_{jt}(s_{jt}, d_{jt}) - C(i_{jt}, k_{jt}, \xi_j) - C_X(d_{jt}, d_{jt-1}, \xi_j) + \beta E_t V_{jt+1}(s_{jt+1}) \quad \text{(IV.5)}$$

where $s_{jt} = (k_{it}, \omega_{jt}, d_{jt}, \xi_j, A, A^*)$ is a vector of state variables and

$$E_t V_{jt+1}(s_{jt+1}) = \int_{\omega'} V_{jt+1}(s') dF(\omega'|\omega_{jt}) \quad \text{(IV.6)}$$

If the firm does not choose to invest ($i_{jt} = 0$), the firm's capital stock will fall and the firm's marginal costs of production, for the same level of output, will 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 and non-exporters can be written as

$$c_1(i_{jt}, k_{jt}, \xi_j) + F(\xi_j) = \beta E_t \frac{\partial V_{jt+1}(s_{jt+1})}{\partial i_{jt}} \quad \text{(IV.7)}$$

The left side of (III.10) is the marginal cost of adjustment and is independent of the firm's export decision or history. 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).[7]

The expected marginal gain from investment depends upon the firms export decision. First, if entering export markets lowers the costs of future exporting, through sunk export costs for example, firms will expect to produce and sell in a larger number of markets and to a larger number of consumers. In our model this raises the marginal value of capital and in turn encourages greater investment. Second, if the cost of investment is lower for foreign owned firms then we expect that foreign firms will in turn respond by stronger investment when entering export markets.

The net benefit to exporting, conditional on the firm's investment decision, can be described by the value functions. We can write the marginal benefit from exporting, MBE, for any firm as:

$$\begin{aligned} MBE_{jt} &= \underbrace{\pi_{jt}(s_{jt}, d_{jt} = 1) - \pi_{jt}(s_{jt}, d_{jt} = 0) - C_X(d_{jt}, d_{jt-1}, \xi_j)}_{\text{Initial Gain/Loss}} \\ &\quad + \underbrace{\beta E_t[V_{jt+1}(\tilde{s}_{jt+1}, d_{jt} = 1) - V_{jt+1}(\tilde{s}_{jt+1}, d_{jt} = 0)]}_{\text{Future Gain/Loss}} \end{aligned} \tag{IV.8}$$

The marginal benefit to exporting captures both the current profits from exporting and the expected future gains or losses from exporting. The initial gain captures the difference in operating profits associated with exporting and any direct export entry costs. As emphasized in recent literature, capital constrained exporters are likely to have relatively small gains in the initial period of exporting since expansions into the export market may come at the cost of lost domestic sales. At the same time, however, these constraints create a stronger incentive to invest in the early years of exporting; not only do firms want to

[7] The RHS of (III.10) 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.

expand into export markets, but they also want to be able to optimally serve the domestic market. As such, capital constrained exporters may have large expected future gains from exporting since growth in capital holdings may allow them to expand both at home and abroad.

Model Predictions

Our model, though simple, presents a number of key, testable predictions. We enumerate four predictions which we proceed to examine in our empirical model:

1. Exporting firms will increase investment upon entry into export markets.

2. The adjustment of capital stock to exporting occurs over time, particularly among firms with poor access to credit markets.

3. Across similar foreign and domestic firms, new foreign exporters will invest more heavily upon entry into export markets.

4. Differences across foreign and domestic exporters are largest when the costs of acquiring domestic credit are high.

We proceed by first examining whether exporting has an impact on firm-level investment among new Indonesian exporters. Once we have established the relationship between exporting and firm-level investment we investigate the role of foreign investment and the extent to which ownership differences can be associated with credit constraints across firms. The following section lays out our empirical strategy to test the validity of our model's predictions.

Empirical Strategy

The aim of our empirical strategy is to identify the causal impact of exporting on investment. As such, a primary concern is endogeneity of the decision to export on the estimated impact on investment. As a first step we choose to focus on firms which enter export markets for the first time during the 1990-2000 period. Specifically, we eliminate all plants which export during 1990 and/or 1991 to focus on the sample of initial non-exporters. Consequently, we greatly reduce the number of firms under consideration. However, by focussing on firms which are entering export markets for the first time we can then use differencing over time to eliminate the influence of all observable and unobservable elements of the export decision that are strongly persistent over time. Our strategy is to use a difference-in-difference technique to compare the performance of new exporters with that of similar firms who choose not to export. Naturally, the comparison is likely to suffer from non-random sample selection since exporting firms endogenously choose to enter export markets. We use propensity score matching, in combination with difference-in-difference methods, to address the selection issue. The matching procedure controls for the selection of bias by restricting the comparison to differences within carefully selected pairs of firms of firms who possess similar observable characteristics. Specifically, each pair of firms consists of an exporting firm and a non-exporting firm with similar characteristics in the year preceding entry into export markets.

Our objective is to measure the causal effect of exporting on the physical investment rate, $r_t = \frac{i_t}{k_t}$, where i_t captures the current net investment rate (new investment minus capital sales) and k_t is the firm's stock of capital in year t. Letting $d = 1$ for a new exporter and 0 otherwise, this effect is defined as

$$E[r_t(d=1) - r_t(d=0)|d=1] = E[r_t(d=1)|d=1] - E[r_t(d=0)|d=1]$$

which captures the difference between the performance paths of firms which started exporting (the first term) and the performance paths of the same firms should they not have started exporting (the second term). Clearly, we observe each firm as an exporter or non-exporter in any year and never both, so that the second outcome is an unobserved counterfactual. The objective of matching methods is to construct the missing counterfactual by drawing comparisons conditional on a vector of observable characteristics, X. It has been shown that as long as relevant differences between two firms can be captured by the observable (pre-treatment) variables, matching methods yield an unbiased estimate of the treatment impact (Dehejia and Wahba, 2002). The key underlying assumption is that conditional on the observable characteristics that are relevant for the export decision, potential outcomes for exporting (treated) and non-exporting (untreated) are orthogonal to treatment status.

$$(r_t(d=1), r_t(d=0)) \perp d|X$$

The implication is that both firms of our matched pairs exhibit similar performance under the same circumstances

$$\begin{aligned} E[r_t(d=1) - r_t(d=0)|d=1] &= \Big[E[r_t(d=1)|X, d=1] - E[r_t(d=0)|X, d=0]\Big] \\ &- \Big[E[r_t(d=0)|X, d=1] - E[r_t(d=0)|X, d=0]\Big] \\ &= \Big[E[r_t(d=1)|X, d=1] - E[r_t(d=0)|X, d=0]\Big] \quad \text{(IV.9)} \end{aligned}$$

The second difference in equation (IV.9) captures the selection bias. The key assumption in our method is that this term is assumed to be zero conditional on X. It represents the difference between the exporting firms, should they not have exported, and those that did not export, in the same state (non-exporting). The first difference in equation (IV.9) captures the causal effect of exporting on physical investment. It follows that under the matching assumption the performance difference between new exporters and non-exporting control observations is an unbiased estimate of the causal effect.

In our setting, the propensity score is the predicted probability of entry into export markets. Given the predicted probability of export entry we compare the performance of firms matched on the basis of their propensity score. This technique is particularly attractive in this context as there are a large number of observable variables with significant predictive power for determining whether a firm will enter into export markets. Specifically, although our simple model provides an intuitive and concise description of the firm's investment and export decisions, we observe (and document) that a wide set of observable firm-level characteristics have strong predictive power even after controlling for observed firm-level productivity. Further, it is unclear how to condition on a large number of variables when *a priori* we do not have a strong guide on which dimensions firms should be matched. As noted by Rosenbaum and Rubin (1983) propensity score matching provides a natural weighting scheme that yields unbiased estimates of the treatment impact. Conditioning on the propensity score is equivalent to conditioning on all of the available information, but reduces the dimensionality problem. Blundell and Costa Dias (2000) highlight the benefits of combining matching with difference-in-difference methods for controlling observable and unobservable differences between treatment and control units. In particular, they emphasize that matching accounts for differences in observable characteristics while difference-in-differences methods allows for an "unobserved determinant of participation as long as it can be represented by separable individual and/or time-specific components of the error term." In our case, examples would include a particular firm entering export markets because of its knowledge of foreign markets or the superior performance of the firm manager.

Data

The primary source of data is the Indonesian manufacturing census between 1990 and 2000. Collected annually by the Central Bureau of Statistics, *Budan Pusat Statistik* (BPS), the survey covers the population of manufacturing plants in Indonesia with at least 20 employees. The data capture the formal manufacturing sector and record detailed plant-level information covering industrial classification, revenues, capital stock, new investment in physical capital, capital sales, intermediate inputs, exports, and foreign ownership. Data on revenues and inputs are deflated with wholesale price indices.[8]

Key to our analysis the data also include a measure of the market value of capital holdings along with the value of new investment in each year except 1996. Specifically, the data contain annual observations on the estimated value of fixed capital, 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 a wholesale price indices for construction, imported electrical and non-electrical equipment and imported transportation equipment. To construct the capital stock deflator we weight each price index by the average reported shares of buildings and

[8]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.

Table 38. Investment and Export Moments

	All	Non-Exporters	New-Exporters
Average investment rate (I/K)	0.056	0.039	0.088
Inaction frequency	0.735	0.774	0.570
Fraction of observations with negative investment	0.002	0.002	0.003
Average export intensity	0.092	0	0.643
Export frequency	0.131	0	1
Correlation of export and investment status	0.168	—	—
Correlation of log export sales and log investment	—	—	0.593

land, machinery and equipment and fixed vehicle assets.[9]

Investment and Export Moments

The main features of the investment and export sales distributions are summarized in Table 38. In 1990, there are 13,641 manufacturing plants that contain a full set of information, while by 2000 the data covers 18,211 plants. We omit any firms for which there is missing investment and capital information and choose to focus exclusively on firms which are initially non-exporters in the first year of the sample.

Few firms are actively investing in any year. Approximately, 73.5 percent of the (firm-year) observations report no new investment or capital sales and only 0.2 percent report any capital sales. This suggests that in only 26.3 percent of observations do we observe positive net investment. Moreover, only 13.9 percent of firms report investment rates greater than 11 percent, the average reported depreciation rate in the sample.

[9] Our measure of capital has several advantages. First, using a market value of capital the measure accounts for variation in depreciation and changes in the productivity of the current capital stock across firms. We observe that, like other data sets that provide direct estimates of depreciation (e.g. Schündeln, 2011), this value varies substantially in the cross-section, particularly in particularly in developing countries. Second, we observe that across industries there is large cross-sectional variation in the degree to which firms invest in physical capital that is not classified in one of the four main classes of capital. To the extent that the nature of this capital varies across firms we might expect that the temporal variation in its productivity, market value and depreciation to be an additional source of variation over time not otherwise captured. Third, the data has excellent coverage across firms. It is often difficult to get reliable estimates of firm-level capital holdings in developing countries, particularly in cases where small firms do not have accurate recording of the book value of capital. Alternatively, we also construct a capital series for each firm using perpetual inventory methods. This results in a distribution of capital across firms which is nearly identical to that from our preferred measure of capital. We do, however, have to drop numerous firms from the data set because of missing investment data from year to year. As such, we present results from the first measure of capital here. We have checked our results using the measure of capital constructed by perpetual inventory and find very similar estimates.

The investment rate and frequency documented in Table 38 are somewhat lower than those reported in the US (Cooper and Haltiwanger, 2006), Norway (Nilsen and Schiantarelli, 2003) and even Columbia (Huggett and Ospina, 2001). This can largely be attributed to the fact that in each of the above papers, the authors study a balanced panel of manufacturing firms, whereas we keep all of the firms in our sample. Balancing our panel of manufacturing firms results in significant data loss during the 1997-1998 Asian crisis. If we examine comparable moments for a balanced sample in the pre-crisis period (1990-1995) we find an average investment rate of 10.9 percent, an inaction frequency of 63.9, and a positive investment frequency of 34.9 percent. Moreover, 17.4 percent of firms demonstrate new investment greater than 11 percent. These figures are closer to those found elsewhere, but continue to reflect the more restrictive investment environment in Indonesia relative to the US or Norway.

On average 13 percent of firms export in the sample while the average percentage of sales from exports is just more than 9 percent. As is typical in many firm-level manufacturing data sets, export revenues are often small compared to the domestic market. The last two rows examine the correlation between exporting and investment. We observe current export and investment status are positively correlated, but the correlation coefficient is just below 0.17. If we restrict our attention to firms that are both investing and exporting in the same year, we observe that the correlation coefficient on the log of export sales and the log of net investment rises to 0.59.

New exporters demonstrate much higher investment demonstrate markedly higher investment rates then non-exporters. We observe that the investment rate among new exporters is more than double that among non-exporters, while the inaction frequency is over 20 percentage points smaller among new exporters. However, as our model highlighted, both of these may be driven by productivity differences across exporting and non-exporting firms. As such, we turn next to estimating productivity across firms in order to compare similar exporting and non-exporting firms.

Estimating Productivity

As suggested by our model, total factor productivity is a key variable in our analysis since firm-level export and investment decisions are typically strongly correlated with measures of firm-level efficiency. We measure total factor productivity using a multilateral index developed by Caves et al. (1982) and Aw, Chen and Roberts (2001). The key advantage of this index is that it allows for consistent comparisons of total factor productivity (TFP) in firm-level panel data.[10] The idea underlying the index is that each firm's productivity is measured relative to a single reference point. Specifically, the index compares firm j's inputs (capital, labor, materials, energy) and output in year t to a hypothetical reference firm operating in the base time period ($t = 0$) with average input cost shares, average log inputs and average log output:

$$\begin{aligned}\ln TFP_{jt} \quad = \quad & (\ln Y_{jt} - \overline{\ln Y_t}) + \sum_{\tau=2}^{t}(\overline{\ln Y_\tau} - \overline{\ln Y_{\tau-1}}) \\ & - \left[\sum_{m=1}^{n}\frac{1}{2}(S_{jmt} + \overline{S_{mt}})(\ln X_{jmt} - \overline{\ln X_{mt}}) \right. \\ & \left. + \sum_{\tau=2}^{t}\sum_{m=1}^{n}\frac{1}{2}(\overline{S_{m\tau}} - \overline{S_{m\tau-1}})(\overline{\ln X_{m\tau}} - \overline{\ln X_{m\tau-1}})\right]\end{aligned}$$

[10] Van Biesebroeck (2007) compares the robustness of five commonly used measures of productivity (index numbers, data envelopment, stochastic frontier, GMM and semi-parametric estimation). He finds that the index number approach taken here tends to produce very robust results. Arnold and Javorcik (2011) similarly compute firm-level productivity on a similar set of Indonesian firms and report that this measure is strongly robust in their sample. Nonetheless, for robustness, we have also estimated a productivity series for each firm following the methods described in Olley and Pakes (1996) and applied to this data set as in Amiti and Konings (2007). We could not reject the hypothesis of constant returns to scale in any industry. Since the results from the matching exercise were very similar in all cases we have omitted them from the main text.

where m indexes the type of input. As noted above output Y is measured in real terms along with inputs, X: labor (the number of employees), materials (real value of materials costs), energy (real value of electricity and fuel) and capital. S captures input shares for each input other than capital. For example, the labor share is measured as the ratio of the real wage bill to output. The capital share is obtained by assuming constant returns to scale. Finally, $\overline{X}$, $\overline{Y}$ and $\overline{S}$ are the inputs, output and input shares of the hypothetical reference plant.

Export Premia

We document investment behavior across three different groups of firms: incumbent exporters, new exporters and non-exporters. We define an incumbent exporter as a firm which had positive export sales in years $t-1$ and t while new exporters, in contrast, capture firms that did not export in $t-1$. Non-exporters capture the remaining firms which did not export in the current year.

While table 39 suggests that exporting has a strong positive impact on investment it is not clear that these differences are significant or causal. To approach these issues we first consider a simple regression of the firm's investment rate on it's export status. We measure the investment rate, $r_{jt} = i_{jt}/k_{jt}$, as the firm j's net investment i_{jt}, new investment less capital sales, in year t divided by the existing capital stock, k_{jt}.[11]

$$r_{jt} = \beta_0 + \beta_x x_{jt} x_{jt-1} + \beta_n x_{jt}(1 - x_{jt-1}) + \epsilon_{jt} \quad \text{(IV.10)}$$

where $x_{jt} \in \{0, 1\}$ is a binary variable which takes a value of one if the firm exports in

[11] Alternatively, we considered the log of new investment as our dependent variable. While it yielded similar results, it's use required dropping many firms in our sample because the firm chose not to invest or was reducing its capital holdings. Moreover, we would be unable to perform analysis over time since only a small portion of our sample invests continuously over time.

year t and ϵ_{jt} is an error term. While our specification is purposefully simple, the estimated coefficients are an easily interpretable measure of the size and significance of the relationship between exporting and investment.

The first row of Table 39 presents OLS estimates of coefficients from equation (IV.10). In each case we include province, year and industry (ISIC 4-digit) dummies. The first column restricts the coefficients across incumbent and new exporters to be identical and suggests that the investment rate among exporters is 5.1 higher than non-exporting firms. While this is a moderate increase in the investment rate, it represents a drastic change in investment behavior. The average investment rate among exporting firms is 0.110. As such, the export premium for exporters, 0.051, represents nearly half of new investment among new exporters during the year of entry. Column (2) allows the export premium to vary across new and existing exporters. We observe very similar results; the export premium among new exporters is 4.7 percentage points, while it is 4.8 percentage points among incumbent exporters.

Table 39. Investment Rate and Exporting

	Total Investment		Inv. in Machinery		Domestic Firms		Foreign Firms		Pre-Crisis 1991-1996		Crisis/Post-Crisis 1997-2000		Small Firms	
OLS regressions with industry, province and year fixed effects														
All Exporters	0.051***		0.058***		0.043***		0.046***		0.051***		0.049***		0.060***	
	(0.002)		(0.003)		(0.002)		(0.007)		(0.003)		(0.003)		(0.005)	
Incumbent Exporters		0.048***		0.053***		0.040***		0.036***		0.048***		0.046***		0.063***
		(0.003)		(0.004)		(0.003)		(0.009)		(0.004)		(0.004)		(0.009)
New Exporters		0.047***		0.057***		0.040***		0.050***		0.042***		0.049***		0.036***
		(0.003)		(0.004)		(0.003)		(0.008)		(0.004)		(0.003)		(0.006)
R-squared	0.038	0.034	0.038	0.037	0.033	0.029	0.082	0.080	0.039	0.037	0.033	0.031	0.031	0.027
No. of obs.	150,477	121,648	119,598	96,631	142,396	114,815	8,081	6,833	84,177	60,412	66,300	61,236	72,265	56,119
Regressions with firm and year fixed effects														
All Exporters	0.015***		-0.004		0.010***		0.047***		0.004		0.019***		0.011**	
	(0.003)		(0.004)		(0.003)		(0.008)		(0.004)		(0.004)		(0.006)	
Incumbent Exporters		0.013***		-0.004		0.008**		0.038***		0.008		0.011**		0.004
		(0.003)		(0.004)		(0.003)		(0.010)		(0.005)		(0.005)		(0.009)
New Exporters		0.017***		0.008**		0.014***		0.047***		0.008		0.021***		0.010*
		(0.003)		(0.004)		(0.003)		(0.010)		(0.005)		(0.004)		(0.006)
R-squared	0.019	0.012	0.013	0.006	0.017	0.011	0.065	0.048	0.012	0.005	0.009	0.006	0.016	0.005
No. of obs.	144,721	118,018	113,566	92,438	136,479	111,055	7,608	6,489	77,899	57,453	63,179	58,154	24,182	20,581
OLS regressions with industry, province and year fixed effects														
Incumbent Exporters		0.011***		0.020***		0.010***		0.026***		0.009**		0.014***		0.010***
(> 3 years post entry)		(0.002)		(0.003)		(0.002)		(0.008)		(0.004)		(0.002)		(0.004)
New Exporters		0.028***		0.032***		0.023***		0.047***		0.017***		0.034***		0.021***
(Years 1- 3)		(0.002)		(0.003)		(0.002)		(0.007)		(0.004)		(0.002)		(0.003)
R-squared		0.032		0.036		0.028		0.091		0.032		0.035		0.034
No. of obs.		97,449		73,363		91,560		5,889		31,149		66,300		48,656

Notes: Robust standard errors, clustered at the firm-level, are in parentheses. ∗∗∗, ∗∗, ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

Columns (3)-(14) repeat the experiment for numerous subsamples and different dimensions in our data. Specifically, we separately examine the investment in machinery (columns 3-4), investment among domestic (columns 5-6) and foreign firms (columns 7-8), investment before (columns 9-10) and after the Asian crisis (columns 11-12), and among small firms (columns 13-14). Remarkably, we observe nearly identical, strongly significant export premia in each case. Further, the OLS regressions reveal little discernible difference across new and incumbent exporters.

Although these initial results are striking, there are a number of alternative explanations for the statistically significant relationship between exporting and investment. For instance, our estimates likely reflect unobserved differences across firms. As our model suggests more productive firms are likely to invest at a higher rate. Similarly, we might expect that new exporters may adjust capital holdings over numerous years and, as such, our definitions of new and incumbent exporters may be misleading. We take a first pass at addressing these concerns in the bottom two panels.

In the second panel we re-estimate equation (IV.10) with firm-level fixed effects. In this case the export premia coefficients are identified solely by within-firm variation. Moreover, to the extent that key firm-level differences, such as productivity, are persistent over time, we expect that the firm-level fixed effects will at least partially control for these factors. Across all columns the export premia coefficients are now estimated to be substantially smaller, though in most cases strongly significant. In the full sample, we find that exporters invest 1.5 percent faster than non-exporters overall. Although this coefficient is small, it represents 14 percent of overall investment among exporting firms.

The second panel also reveals small, but important differences across new and incumbent exporters. In particular, the point estimates of the export premia among new exporters tend to be larger and more strongly significant than those among incumbent exporters. This is to be expected since new exporters are likely to be smaller, more capital constrained and likely have had less time to adjust capital holdings. In the last panel, we redefine a new exporter as an exporter which has begun exporting in the past 3 years while an incumbent exporter is an exporter with at least 3 years of experience in export markets. Again we observe that both new and incumbent exporters tend to invest at a higher rate than non-exporting firms. However, we now observe larger differences between new and incumbent exporters.

A particularly striking result is that from foreign owned firms (column 8).[12] We observe that in each panel foreign-owned exporting firms tend to invest much more heavily than other foreign -owned non-exporters. New investment in developing countries is often plagued by numerous financial frictions and, as such, new financing can be difficult to secure. Differences in access to credit markets may be reflected in the observed investment rates; better access to credit may allow foreign firms the ability to adjust capital holdings to new export opportunities. In particular, if domestic firms have to finance a larger portion of investment through internal saving we might expect that new domestic exporters adjust by smaller amounts over a longer time period relative to foreign firms. Alternatively, the difference might simply reflect large differences in firm-level productivity, which are not adequately controlled for in our simple regressions. We examine these issues, among others, below.

An Empirical Model of Exporting and Investment

Our objective is to study the paths of investment before and after entry into export

[12]We define a foreign firm as one where at least 10 percent of equity is held by foreign investors.

markets. In order to implement propensity score matching we need an empirical model for the entry of firms into export markets. We begin by estimating a probit model of the binary decision to enter export markets. In general, the logarithm of observable plant-level characteristics are lagged one year and pertain to the pre-entry period. We believe that observable characteristics are a reasonable starting point since firm-level capabilities in terms of productivity, size, employment, capital or skill-intensity are likely to influence the extent to which firms are able and willing to enter export markets. Further, we observe detailed firm-level information which characterizes the degree to which non-exporting firms are integrated in world markets, either through foreign ownership or imported intermediate inputs. We choose to use variables which are lagged one year to control contemporaneous productivity shocks which affect both investment and exporting.

The results are presented in Table 40. We observe that the exporting firms differ strongly from non-exporters. In particular, firms with greater TFP are more likely to enter export markets; the coefficient on TFP is significant at standard levels. Further, younger and more capital intensive firms are more likely to export. Firms which are already internationally integrated, either by sourcing foreign inputs or having foreign ownership, are also much more likely to enter export markets. We are particularly interested in the large coefficient on lagged foreign ownership. If entry into new markets requires costly investments, we might expect that foreign owned firms - which are likely to benefit from access for foreign credit markets - may be better able to become successful exporters. We have also included the lagged net investment rate to ensure that matches assigned on the basis of propensity score will be homogeneous with respect to previous investment behavior. This is particularly important in our case since this helps control for any plants which begin

Table 40. Probit: Predicting Export Entry

TFP_{t-1}	0.077**
	(0.037)
Age	-0.024***
	(0.002)
Age^2	0.0002***
	(0.00002)
Capital per $Worker_{t-2}$	0.082***
	(0.009)
Average $Wage_{t-1}$	0.002***
	(0.001)
Skill $Intensity_{t-1}$	0.044
	(0.075)
Imported Input $Share_{t-1}$	0.338***
	(0.044)
Foreign $Ownership_{t-1}$	0.600***
	(0.047)
Investment $Ratio_{t-1}$	0.540***
	(0.047)
Time Trend	0.024***
	(0.004)
Industry Fixed Effects	Yes
Year Fixed Effects	Yes
Province Fixed Effects	Yes
No. of obs.	71,375
Chi^2	3,171.44
Prob > Chi^2	0.000
Pseudo R^2	0.151

Notes: The table reports the coefficients from a probit regression for the decision to export among first time exporters in Indonesia. Four-digit industry dummies, province dummies and year dummies are included but not reported. $***$, $**$, $*$ indicate significance at the 1%, 5%, and 10% levels, respectively. Squared variables, other than age, were generally insignificantly different from zero and are dropped from this specification.

accumulating capital in anticipation of future entry into export markets.

The only variable which is insignificant in Table 40 is our measure of firm-level skill-intensity. Our hypothesis is that average wage, as suggested by Fox and Smeets (2011), is strongly correlated with the average skill-level among employees. As such, after controlling for the average firm-level wage there is little independent variation in skill-intesenity measure which is not already captured by the other explanatory variables.

The predicted probability of exporting resulting from the model in Table 3 will form the propensity score and act as the metric for our matching procedure. We use one-to-one nearest neighbor matching.[13] We restrict that any two matched firms must be chosen from the same year and industry. To determine how successful our matching procedure is we compare the difference between the treated and control group in terms of each of the above variables and compute t-statitics for each of the reported variables across 8 bands of the propensity score. In no case do we find statistically significant differences.[14] In the full sample, our matched pairs of firms are only one percentage point apart in terms of propensity score. This suggests that our matches are very close along this measure and we can have confidence in the resulting comparisons.[15] Finally, in all of the specifications that follow, our results consistently suggest that there are no statistically significant differences in the investment rates across treated and control firms in the pre-entry year.

[13]We have repeated our experiment using alternative matching strategies such as increasing the number of control matches (10), local linear regression matching, spline matching and full Mahalanobis matching. Since the main results are very similar across matching strategies we do not present further results below.

[14]This exercise is often referred to as the balancing hypothesis (see Dehejia and Wahba, 2002). The results of this exercise are presented in the Appendix.

[15]Recall, that the propensity score measure is bounded by 0 and 100.

Results

Full Sample

We first examine the difference-in-difference results on the full sample of matched firms. We observe in Table 41 that the matching procedure appears to work very well; in the year before entry there is less than a 0.5 percentage point difference in the estimated investment rates between treated and control firms. Moreover, we observe that the difference in the propensity score is very small. However, although both treatment and control groups begin with similar investment rates, they diverge quickly. In particular, we observe that exporting firms maintain high investment rates during the entry period while investment rates among the non-exporting control group decline sharply over the same period. This pattern reflects the lumpiness of investment. New exporters are likely to be firms which are investing heavily before entry. Not surprisingly the matched control firms demonstrate similar investment behavior in the initial period. However, among exporters it is reasonable to expect that it will take several years to expand into export markets; in developing countries where access to credit is relatively tight we might expect that capital accumulation is stretched out over time since many firms have to finance capital expenditures internally. As such, it is not surprising that investment rates remain high among the treated group in all 3 years after initial entry. In contrast, among non-exporting firms, investment is likely to capture the normal replacement of depreciated capital. Since these firms are not expanding into new markets it is reasonable to expect that these investments would occur over a much-shorter time period among non-exporting firms.

The estimated investment rates are plotted graphically in Figure 11. The difference in investment rates between the treated and control groups grows during the year of entry

Table 41. Investment Rate and Exporting, Full Sample

	One Year Before Entry	Year of Entry[(a)]	One Year Later[(b)]	Two Years Later[(c)]	Three Years Later[(d)]
Treatment Group: $\bar{T}$	0.120	0.105	0.087	0.083	0.073
Control Group: $\bar{C}$	0.114	0.064	0.051	0.049	0.050
ATT	0.005	**0.042*****	**0.037*****	**0.034*****	**0.023*****
	(0.007)	(0.007)	(0.008)	(0.008)	(0.006)
ATT/$\bar{T}$		**0.400**	**0.481**	**0.410**	**0.315**
No. of matched pairs	2,387	2,094	1,825	1,329	1,235
Mean difference in propensity score	0.011	0.012	0.013	0.015	0.016

Notes: The first two lines present the outcomes observed in the given time period. The average treatment effect on the treated (ATT) is presented in the third row along with bootstrapped standard errors in parentheses. ∗ ∗ ∗, ∗∗, ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

(a) $ATT = \frac{1}{n}\sum_1^n\left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+0} - \left(\frac{i}{k}\right)^{control}_{entry\ year+0}\right] - \frac{1}{n}\sum_1^n\left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(b) $ATT = \frac{1}{n}\sum_1^n\left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+1} - \left(\frac{i}{k}\right)^{control}_{entry\ year+1}\right] - \frac{1}{n}\sum_1^n\left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(c) $ATT = \frac{1}{n}\sum_1^n\left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+2} - \left(\frac{i}{k}\right)^{control}_{entry\ year+2}\right] - \frac{1}{n}\sum_1^n\left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(d) $ATT = \frac{1}{n}\sum_1^n\left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+3} - \left(\frac{i}{k}\right)^{control}_{entry\ year+3}\right] - \frac{1}{n}\sum_1^n\left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

and then begins to shrink in the years that follow. The window immediately around entry suggests that the difference in investment rates rises with exporting. The average treatment effect on the treated (ATT) suggests that average investment rate spikes up by 4 percentage points in the year of entry, remains 3 percentage points higher for two years after entry and is 2 percentage points higher three years after entry among treated firms. These are all strongly significant at conventional levels and represent large increases in investment behavior. ÄTo get a sense of the relative change in investment behavior, we calculate the relative export effect as the ratio of the average treatment effect on the treated to mean investment rate among the treated firms in each year. Relative to the average investment rate among treated firms, the average treatment effects on the treated firms suggests that exporting accounts for a very large percentage of total investment; among treated firms exporting roughly accounts for 32 to 48 percent of total investment between the year of entry and three years afterwards.

Our results suggest that upon entry into export markets large firm-level changes, particularly in the physical composition and organization of the firms, are well underway. Our results suggest that these constraints are likely to alleviated within a small number of years since exporting firms are actively expanding capital stock. Further, physical capital constraints have been suggested as a mechanism through which export market shocks are transmitted to the domestic market. Our results suggest that if firms are actively accumulating capital to optimally serve both home and export markets the severity of this transmission mechanism should decline over time.

The reader will notice that the number of matched pairs varies over time. This occurs for two reasons. First, the survey does not collect investment information in 1996. This differentially affects the number of matches which are missing information in any two years; that is, the number of firms missing information for year $t = -1$ is different than that in year $t = 0$ and so on. Second, some firms endogenously exit our sample. To the extent that smaller, non-exporting firms are *more* likely to exit and *less* likely to invest, we might expect that the estimated ATT is downwards biased. Likewise, our main sample combines the effects across all types of ownership structure, size and time periods. This last effect is of particular concern in this context since it well known that Indonesia suffered a strong contraction during and after the onset of the Asian crisis in 1997. We consider these issues in our robustness checks.

Asian Crisis

One of the features of our sample is that it covers the period in which Indonesia was subject to the Asian financial crisis. The Asian financial crisis began in the fall of 1997 and continued well into 1998. There are two features of the Asian which are of particular interest in our study. First, the onset of the financial crisis was widely reported to have sharply restricted access to credit during the crisis years. Moreover, although the Indonesian economy had begun to recover by 1999, access to credit continued to be much more restricted in comparison the pre-crisis period (Ito and Sato, 2006). Second, it is well known that aggregate exports fell substantially during this period.

To the extent that the Asian crisis may have affected firm-level exporting and investment rates, we may expect that our estimates may be biased. What is less clear, however, is the direction of the bias. On one hand, smaller export opportunities and tighter investment regulation are likely to reduce investment and discourage large entries into export markets. As such, we might expect that our estimates in the full sample could be biased towards zero if the Asian crisis is not adequately controlled for in the full sample. On the other hand, if only the strongest firms are able to export during the Asian crisis we might expect that these exporting firms are very productive and have a particularly strong incentive to invest.

We investigate this possibility by repeating our exercise before the Asian crisis period (1990-1995) and on the period during and after the Asian crisis (1997-2000). Comparing the top and bottom panels of Table 42 we immediately observe a number of key differences across time periods. The mean investment rates among both treated and control firms are much higher before the crisis relative to the subsequent crisis period. We also observe that during the crisis period exporting appears to have a stronger impact on investment rates after entry. Exporting accounts for nearly twice as much of total investment after initial entry into export markets during the crisis period; for example, the $ATT/\bar{T} \times 100 \approx 30\%$ in year of entry during the pre-crisis period, while this same calculation jumps to 62% during the crisis period. Our results strongly suggest as the domestic market contracted sharply during the Asian crisis, export markets were a particularly important determinant

Table 42. Investment Rate and Exporting, Asian Financial Crisis

Pre-Crisis (1991-1995)					
	One Year Before Entry	Year of Entry[(a)]	One Year Later[(b)]	Two Years Later[(c)]	Three Years Later[(d)]
Treatment Group: $\bar{T}$	0.130	0.111	0.087	0.084	0.083
Control Group: $\bar{C}$	0.114	0.078	0.065	0.060	0.060
ATT	0.016	**0.033*****	**0.022*****	**0.025*****	**0.023****
	(0.009)	(0.009)	(0.006)	(0.008)	(0.010)
ATT/$\bar{T}$		**0.297**	**0.253**	**0.297**	**0.277**
No. of matched pairs	1,787	1,494	1,195	894	621
Mean difference in propensity score	0.012	0.013	0.013	0.016	0.019

Crisis and Post-Crisis (1997-2000)					
	One Year Before Entry	Year of Entry[(a)]	One Year Later[(b)]	Two Years Later[(c)]	Three Years Later[(d)]
Treatment Group: $\bar{T}$	0.090	0.092	0.061	0.080	0.063
Control Group: $\bar{C}$	0.099	0.034	0.040	0.040	0.035
ATT	-0.009	**0.057*****	**0.021***	**0.040*****	**0.028*****
	(0.016)	(0.016)	(0.011)	(0.013)	(0.010)
ATT/$\bar{T}$		**0.620**	**0.344**	**0.500**	**0.444**
No. of matched pairs	600	600	630	435	614
Mean difference in propensity score	0.010	0.010	0.011	0.012	0.012

Notes: The first two lines present the outcomes observed in the given time period. The average treatment effect on the treated (ATT) is presented in the third row along with bootstrapped standard errors in parentheses. $***$, $**$, $*$ indicate significance at the 1%, 5%, and 10% levels, respectively.

(a) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+0} - \left(\frac{i}{k}\right)^{control}_{entry\ year+0}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(b) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+1} - \left(\frac{i}{k}\right)^{control}_{entry\ year+1}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(c) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+2} - \left(\frac{i}{k}\right)^{control}_{entry\ year+2}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(d) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+3} - \left(\frac{i}{k}\right)^{control}_{entry\ year+3}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

Table 43. Investment Rate Across Large and Small Firms (Capital)

Large Firms ($K \geq \tilde{K}$)					
	One Year Before Entry	Year of Entry[(a)]	One Year Later[(b)]	Two Years Later[(c)]	Three Years Later[(d)]
Treatment Group: $\bar{T}$	0.127	0.111	0.084	0.089	0.084
Control Group: $\bar{C}$	0.112	0.064	0.060	0.058	0.055
ATT	0.015	**0.046*****	**0.024*****	**0.031*****	**0.029*****
	(0.008)	(0.007)	(0.008)	(0.008)	(0.009)
ATT/$\bar{T}$		**0.414**	**0.286**	**0.348**	**0.345**
No. of matched pairs	1,714	1,505	1,329	1,001	963
Mean difference in propensity score	0.009	0.009	0.010	0.011	0.011

Small Firms ($K < \tilde{K}$)					
	One Year Before Entry	Year of Entry[(a)]	One Year Later[(b)]	Two Years Later[(c)]	Three Years Later[(d)]
Treatment Group: $\bar{T}$	0.100	0.089	0.066	0.064	0.046
Control Group: $\bar{C}$	0.093	0.053	0.038	0.034	0.029
ATT	0.007	**0.037*****	**0.028****	**0.030****	**0.016**
	(0.015)	(0.013)	(0.011)	(0.013)	(0.012)
ATT/$\bar{T}$		**0.415**	**0.424**	**0.469**	**0.348**
No. of matched pairs	694	606	510	344	288
Mean difference in propensity score	0.005	0.005	0.007	0.004	0.005

Notes: The first two lines present the outcomes observed in the given time period. The average treatment effect on the treated (ATT) is presented in the third row along with bootstrapped standard errors in parentheses. $***$, $**$, $*$ indicate significance at the 1%, 5%, and 10% levels, respectively.

(a) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+0} - \left(\frac{i}{k}\right)^{control}_{entry\ year+0} \right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1} \right]$

(b) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+1} - \left(\frac{i}{k}\right)^{control}_{entry\ year+1} \right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1} \right]$

(c) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+2} - \left(\frac{i}{k}\right)^{control}_{entry\ year+2} \right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1} \right]$

(d) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+3} - \left(\frac{i}{k}\right)^{control}_{entry\ year+3} \right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1} \right]$

of investment behavior among exporting firms.

Small vs. Large Firms

In this section we investigate differences across firm size. We expect that we may observe differences across firm size for a number of reasons. On one hand, by virtue of being small, small firms may have a greater need to increase capacity as they enter export markets. On the other hand, large firms may have be able to secure cheaper financing and, as such, expand more rapidly into export markets.

How to distinguish large firms with access to credit markets from smaller, less-connected counterparts is unclear. We begin by calculating the median capital stock in each 4-digit industry. Then we define a "large firm" as any firm which has at least as much capital as the median firm in the industry two years prior to first entry into export markets. We choose to use capital stock as our metric for firm size since existing capital is most closely linked to a firm's ability to secure further financing.

The results are presented in Table 43. We find that the percentage point increase in investment rates are similar across samples, though the statistical significance is somewhat larger among large firms. This may reflect better credit access or simply more regular investment in order to maintain a larger capital stock. However, it is worth noting that the average investment rate among treated firms is substantially lower among small exporters. This implies that the ratio of the ATT to the average investment rate among small exporters is consistently greater than that among large firms, or that exporting has a relatively larger impact on capital expansion among small firms. In either case these differences appear to be modest.

Disaggregated Investment

Our data allows us to disaggregate each firm's capital stock and investment into a number of sub-categories. To get a sense of the nature of firm-level capital expansion during entry into export markets we repeat our matching exercise for three groups of capital holdings: machinery and equipment, buildings and land, and vehicles. Because the data for the individual components of investment tends to be much more volatile than that of total investment we trim the bottom and top one percent of each disaggregated investment before performing our analysis.

Among total capital holdings in our data set machinery and equipment, buildings and land, and vehicles account for nearly 19, 41, and 8 percent of recorded holdings, respectively. Likewise, among investing firms machinery and equipment, buildings and land, and vehicles account for nearly 40, 26, and 18 percent of new investment, respectively.[16] Our expectation is that the increase in the firm's productive capacity associated with entry into export markets is most closely associated with the holdings of the physical machinery and equipment necessary for production.

The results for machinery and equipment, buildings and land, and vehicles are presented in Table 44. As expected we observe highly significant results for investment in machinery and equipment both in the year of initial entry and in the two first years after entry. The point estimates suggest that exporting causes the investment rate for machinery and equipment to increase by 3.6 percentage points in the year of entry and 2.3-5.1 percentage points in the two years after entry. Relative to the average investment rate across firms, these estimates imply a 27-44 percent increase in machinery investment over those 3 years. Somewhat surprisingly, we observe similar, significant increases in vehicles, and buildings and land in both the year of entry and for at least 2 years after entry into export markets. In particular, the impact of exporting on investment relative to the average investment rate among exporting firms would suggest that exporting has similar across all types of capital holdings.

Discussion

Our results, thus far, have strongly indicated that exporting has a large impact on firm-level investment. This result was found to be true for both large and small firms,

[16] The remaining investment, capital sales or capital stock is classified as "other investment not classified elsewhere."

Table 44. Investment Rate and Exporting, Disaggregated Investment

Machinery and Equipment					
	One Year Before Entry	Year of Entry[(a)]	One Year Later[(b)]	Two Years Later[(c)]	Three Years Later[(d)]
Treatment Group: $\bar{T}$	0.115	0.116	0.116	0.084	0.080
Control Group: $\bar{C}$	0.099	0.0.081	0.065	0.061	0.064
ATT	0.016	**0.036****	**0.051*****	**0.023***	**0.017**
	(0.015)	(0.015)	(0.014)	(0.014)	(0.018)
ATT/$\bar{T}$		**0.310**	**0.440**	**0.274**	**0.213**
No. of matched pairs	809	575	604	493	360
Mean difference in propensity score	0.002	0.002	0.002	0.002	0.002

Buildings and Land					
	One Year Before Entry	Year of Entry[(a)]	One Year Later[(b)]	Two Years Later[(c)]	Three Years Later[(d)]
Treatment Group: $\bar{T}$	0.103	0.080	0.064	0.065	0.059
Control Group: $\bar{C}$	0.087	0.049	0.046	0.044	0.046
ATT	0.016	**0.031*****	**0.017****	**0.022*****	**0.013**
	(0.009)	(0.008)	(0.007)	(0.008)	(0.009)
ATT/$\bar{T}$		**0.388**	**0.266**	**0.338**	**0.220**
No. of matched pairs	1,858	1,694	1,500	1,110	951
Mean difference in propensity score	0.013	0.016	0.017	0.019	0.023

Vehicles					
	One Year Before Entry	Year of Entry[(a)]	One Year Later[(b)]	Two Years Later[(c)]	Three Years Later[(d)]
Treatment Group: $\bar{T}$	0.164	0.151	0.124	0.137	0.125
Control Group: $\bar{C}$	0.129	0.099	0.087	0.092	0.077
ATT	0.034***	**0.052*****	**0.037*****	**0.045*****	**0.048*****
	(0.011)	(0.012)	(0.012)	(0.011)	(0.011)
ATT/$\bar{T}$		**0.344**	**0.298**	**0.328**	**0.384**
No. of matched pairs	1,649	1,518	1,367	1,013	873
Mean difference in propensity score	0.014	0.016	0.019	0.017	0.025

Notes: The first two lines present the outcomes observed in the given time period. The average treatment effect on the treated (ATT) is presented in the third row along with bootstrapped standard errors in parentheses. $***$, $**$, $*$ indicate significance at the 1%, 5%, and 10% levels, respectively.

(a) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+0} - \left(\frac{i}{k}\right)^{control}_{entry\ year+0}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(b) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+1} - \left(\frac{i}{k}\right)^{control}_{entry\ year+1}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(c) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+2} - \left(\frac{i}{k}\right)^{control}_{entry\ year+2}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(d) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+3} - \left(\frac{i}{k}\right)^{control}_{entry\ year+3}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

before and after the Asian crisis and across different types of capital. Likewise, in each case we find that firm-level capital holdings adjust to exporting slowly over time. We conclude that our first two model predictions are strongly supported by the data. Our findings are broadly consistent with the results in Soderbury (2010), Nguyen and Schaur (2011), Ahn and McQuoid (2012) and Vannoorenberghe (2012) who suggest that new exporters are often capital constrained. Our results indicate that new exporters are investing rapidly upon entry to relax these constraints.

To reinforce this finding we nonetheless perform a number of additional checks to verify the robustness of our results. Specifically, we check the impact of sample attrition, the impact of endogenous firm-level exit from export markets and the impact of varying our definition of firm size on our findings. In each case, we find results which are very similar both in magnitude and significance to those already documented in Section 5. Because of this we omit further discussion of these findings from the main text, although the interested reader can find full results and associated discussion in our Appendix.

Instead, we now turn our attention to our second set of questions. That is, we study the role of financial frictions on firm-level investment rates upon entry into export markets. Given the difficulty associated with institutional and financial reform, understanding the degree to which new exporters are constrained by financial frictions is key for evaluating the potential benefits from trade from developing countries.

Credit Constrained Exporters

Although few papers have studied capital accumulation and exporting, a number of recent related papers have emphasized the importance of financial frictions in determining export outcomes across firms, industries and countries. Manova (2010), Aisen et al.

(2011), Ahn and McQuoid (2012), Manova, Wei and Zhang (2011), Kohn, Leibovici and Szkup (2012) and Manova and Yu (2012) all suggest that the presence of firm-level financial frictions affect export decisions and growth. Naturally, financial frictions will also affect investment. We are interested in identifying whether within-firms changes, namely investment behavior, are consistent with evidence that financial frictions have a large impact on export outcomes

A large number of papers argue that multinational corporations (MNCs) are able to relax financial constraints for affiliates located in developing countries. For example, Blalock, Gertler and Levine (2008) use observable differences in ownership structure to demonstrate that foreign owned firms in Indonesia, *certeris paribus*, invested at a higher rate than domestic firms as the domestic credit market tightened during the Asian crisis.[17] They argue that a key reason for the observed difference in the investment rate arises naturally since foreign owned firms are likely to have much better access to foreign credit markets.

We further expect that financial frictions will affect how firms invest over time. In the presence of non-convex investment costs, we would expect that foreign firms, with strong ties to credit markets, will be able to adjust to export markets faster than comparable domestic firms. As noted in Bond, Tybout and Utar (2008), small firms in developing countries are likely to have to finance investment from internal saving. If financial frictions impede export-associated investment we might expect to observe sizable differences in our context across ownership, time and lending regimes in Indonesia.

Of course, financial access is not the only key difference between foreign and do-

[17] Other supporting evidence includes Antràs, Desai and Foley (2009) and Carluccio and Fally (2010) who the activities of US and French MNCs, respectively. Similarly, Bustos (2007) shows that Argentine firms in sectors more reliant on external finance are more likely to be foreign owned and funded. Huang et al. (2008), Héricourt and Poncet (2009) and Girma and Görg (2009) document that FDI helps private domestic firms in China overcome credit constraints and accelerate innovation activities.

mestic firms. Rather, we expect that foreign owned firms also benefit from substantial technological and efficiency advantages relative to their domestic counterparts. Accounting for these differences across firms allows us to disentangle the benefit from better access to credit markets. We begin by repeating our matching and difference-in-difference exercise for foreign and domestically owned firms separately. This will allow us to document systematic differences across foreign and domestic firms. However, it will not identify the degree to which access to foreign credit markets allows foreign owned firms to expand faster into export markets. We then proceed to further investigate the interaction of ownership and investment over time and lending regimes to quantify the impact of credit constraints on firm-level investment decisions upon entry into export markets.

Foreign and Domestic Ownership

Here we reconsider our matching exercise to investigate whether there are systematic differences in the investment behavior of foreign and domestic firms upon entry into export markets. We begin by noting that we need to be careful in our definition of what constitutes a foreign firm. As noted above, we first consider any firm where at least 10 percent of firm equity is owned by foreign investors to be foreign owned. Second, we need to be careful not to misinterpret the causal impact of becoming foreign with that from exporting.[18] To this end, we first define a new foreign exporter as a firm which has been held by foreign investors for at least one year prior to starting to export. We choose this definition of foreign firms so that our findings cannot be attributed to MNCs choosing to purchase Indonesian firms with larger capital holdings, better access to credit markets or superior export potential. Likewise, we capture our domestic sample in a similar fashion;

[18] Arnold and Javorcik (2009) show that firms that receive foreign direct investment tend to experience productivity increases in Indonesia.

Table 45. Investment Rate and Exporting, Foreign vs. Domestic Firms

Foreign Firms					
	One Year Before Entry	Year of Entry[(a)]	One Year Later[(b)]	Two Years Later[(c)]	Three Years Later[(d)]
Treatment Group: $\bar{T}$	0.199	0.161	0.120	0.125	0.131
Control Group: $\bar{C}$	0.271	0.105	0.083	0.076	0.062
ATT	-0.071	**0.055****	**0.037**	**0.048***	**0.069****
	(0.040)	(0.026)	(0.034)	(0.032)	(0.029)
ATT/$\bar{T}$		**0.341**	**0.308**	**0.384**	**0.527**
No. of matched pairs	227	200	171	118	117
Mean difference in propensity score	0.001	0.001	0.001	0.001	0.001

Domestic Firms					
	One Year Before Entry	Year of Entry[(a)]	One Year Later[(b)]	Two Years Later[(c)]	Three Years Later[(d)]
Treatment Group: $\bar{T}$	0.116	0.097	0.074	0.080	0.071
Control Group: $\bar{C}$	0.108	0.069	0.062	0.056	0.051
ATT	0.008	**0.028*****	**0.012***	**0.025*****	**0.020*****
	(0.008)	(0.006)	(0.007)	(0.008)	(0.008)
ATT/$\bar{T}$		**0.289**	**0.162**	**0.313**	**0.282**
No. of matched pairs	2,080	1,829	1,597	1,181	1,088
Mean difference in propensity score	0.0001	0.0001	0.0002	0.0004	0.0004

Notes: The first two lines present the outcomes observed in the given time period. The average treatment effect on the treated (ATT) is presented in the third row along with bootstrapped standard errors in parentheses. $***$, $**$, $*$ indicate significance at the 1%, 5%, and 10% levels, respectively.

(a) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+0} - \left(\frac{i}{k}\right)^{control}_{entry\ year+0}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(b) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+1} - \left(\frac{i}{k}\right)^{control}_{entry\ year+1}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(c) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+2} - \left(\frac{i}{k}\right)^{control}_{entry\ year+2}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(d) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+3} - \left(\frac{i}{k}\right)^{control}_{entry\ year+3}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

we define a new domestic exporter as a firm which has been held by domestic owners for at least one year prior to entry into export markets.

The results from this exercise are presented in Table 45. There are a number of striking among foreign firms. First, the estimated average treatment effects on the treated are strongly significant among foreign firms in the year of entry and three years after entry. During the intervening years the ATTs are insignificantly different from zero when evaluated at the 5 percent level of significance. This pattern suggests a degree of lumpiness in investment consistent with non-convex adjustment costs. Second, we observe a very large ATT among foreign exporters in the year they enter export markets. In this year, the ATT captures a 5.5 percentage point increase in the investment rate among foreign exporters and is strongly significant. Moreover, when we compare the ATT in the year of entry relative to the average investment rate among foreign exporters we find that it explains 31-53% of total firm-level investment.

The results from the sample of domestic firms contrast sharply. First, we note that we begin to observe significant differences between treated and control firms in the year of initial entry and these continue during the years after entry. This result is consistent with the idea that domestic firms may be constrained by financial frictions and, as such, can only adjust capital holdings slowly over time. We find that the investment rate among domestic exporters is 2.8 percentage points higher in the year of entry and 1.2-2.5 percentage points higher in the years following entry. Collectively, these explain approximately 16-31% of overall investment in each year.

The results from Table 45 are suggestive of financial frictions affecting firm-level entry into export markets. In particular, they suggest that foreign firms invest more over a shorter period of time when entering export markets, while domestic exporters increase investment more modestly over a longer time period. However, our results require some caution. In particular, the control firms are likely to differ substantially across subsamples and, as such, it would be incorrect to draw conclusions by comparing the estimated differences between treated and control groups across experiments. Nonetheless, these findings motivate further inquiry into the impact of financial frictions on firm-level export and investment behavior. We study this issue in more detail next.

Identifying Differential Responses Foreign and Domestic Firms

Our matching exercise does not allow for a straightforward comparison of the relative magnitude of impact of exporting across foreign and domestic firms for a number of reasons. First, we also observe large differences in the standard errors on the average treatment effects across experiments in Table 8. This is hardly surprising: our definition of a foreign firm greatly reduces the number of foreign firms in our sample and, consequently, inflates the standard errors of that group of firms. Second, the average investment rate across foreign and domestic firms also varies considerably among control firms.

To address this issue we consider a second experiment in the same spirit as our preceding matching exercise. We first regress the investment rate in year $t + l$ on dummy variables capturing the firm export and ownership status and a large set of control variables where $l = 0, 1, 2, 3$. The idea is to capture differences in firm-level investment rates across foreign and domestic firms in comparison to a given set of control firms.

Specifically, the variable x_{jt}^{d} takes a value of 1 if a domestic firm is a first-time exporter in year t and 0 otherwise. Likewise, the variable x_{jt}^{f} similarly takes a value of 1 if the firm is simultaneously a first time exporter in year t and owned by foreign investors.[19] Finally, we also include a large number of controls for firm-level characteristics in the pre-entry year, on the right-hand side. This leads us to consider the following regression

$$r_{j,t+l} = \alpha_0 + \alpha_d x_{jt}^{d} + \alpha_f x_{jt}^{f} + \beta X_{j,t-1} + u_{jt} \qquad \text{(IV.11)}$$

where $X_{j,t-1}$ includes firm-level measures of productivity, employment, age, capital-intensity, average wages, imported input shares and the investment ratio in the pre-entry year. Importantly, we also include the firm's ownership status as an explanatory variable. This

[19] Our definition of a foreign firm is as before. For a firm to be considered foreign at least 10 percent of equity must be held by foreign investors before entry into export markets

implies that α_f will capture the impact of exporting on investment above and beyond any investment premium that pertains to foreign firms in and of themselves.

This simple regression allows us to test a number of interesting results. First, by testing the difference between α_f and α_d, we can test whether there are significant differences in the impact exporting has on the investment rate across similar foreign and domestically-owned firms. Second, we are able to document evidence of the impact of financial frictions affecting export behavior in Indonesia. Specifically, our previous exercise suggested a number of empirical patterns which would be consistent with the presence of financial frictions. We expect that the domestic export premium α_d will be positive and significant in numerous years after initial entry into export markets. To the extent that domestic firms have to self-finance new investment we expect that they may not be able to fully adjust capital holdings in one year if they face significant financial constraints. Since foreign firms are likely to have better access to foreign credit markets we believe that they will be better able to finance to new investment in a shorter-period of time and grow into export markets quickly. As such, we expect that foreign exporters will have a positive export premium α_f in only one or at most two years around export entry, while domestic firms will have positive export premia in all years after export entry. Further, because we are comparing firms with very similar firm-level characteristics we expect that in the years immediately around entry into export markets we will observe a positive difference between the foreign and domestic export premia, $\alpha_f - \alpha_d > 0$. A positive and significant difference would represent evidence of underinvestment by domestic firms.

As before we only include firms which enter our sample without previous export experience. Table 46 documents the main results from our regression exercise.[20] The

[20]Full results are available in the Appendix.

Table 46. Foreign vs. Domestic Firms Revisted

	Dependent Variable: Investment Rate							
Export Premium	Year of Entry	One Year Later	Two Years Later	Three Years Later	Year of Entry	One Year Later	Two Years Later	Three Years Later
	Full Sample, 1991-2000				Matched Sample, 1991-2000			
α_d (Dom.)	0.035***	0.016***	0.024***	0.018***	0.031***	0.016**	0.027***	0.019**
	(0.003)	(0.003)	(0.004)	(0.004)	(0.007)	(0.007)	(0.008)	(0.009)
α_f (For.)	0.066***	0.030***	0.020**	0.018*	0.087***	0.057***	0.022	0.047**
	(0.009)	(0.009)	(0.010)	(0.010)	(0.015)	(0.016)	(0.020)	(0.022)
$\alpha_f - \alpha_d$	**0.031***	0.014	-0.003	0.000	**0.056***	0.041**	0.005	0.028
Wald Stat	11.28	1.89	0.10	0.00	12.15	5.98	0.06	1.65
p-value	0.001	0.169	0.754	0.984	0.001	0.015	0.812	0.199
Obs.	106,153	85,887	68,091	52,904	4,272	3,118	2,141	1,934

Notes: Standard errors in parentheses. $***$, $**$, $*$ indicate significance at the 1%, 5%, and 10% levels, respectively.

first four columns of the top panel present the results of the regression of (**??**) on our full sample of data. We repeat the exercise 4 times, once for each annual investment rate around the window of entry into export markets. Consistent with our previous results, our estimates suggest that domestic exporters increase their investment rate by 2-3 percent in the years around entry into export markets. As expected, these coefficients are significant at conventional levels from the year of entry all the way through three years after entry.

In contrast, the foreign exporters display significant differences only in the year of entry and in the first year after entry into export markets. The export premium among foreign firms is nearly double that of domestic exporters in the year of entry indicating that firms with better access to foreign credit are able to expand capital holdings nearly twice as fast as those without access to foreign credit markets. This difference is strongly significant in the year of entry. As noted above, the difference between α_f and α_d does not reflect omitted differences if firm-ownership alone or firm-level productivity; both productivity and ownership are individually included as control variables.

After the first year, however, there does not appear to be a statistically significant difference between foreign and domestic firms. To the extent that credit constraints affect investment among domestic firms, our results would suggest that these are most acutely felt in the year of entry into export markets when foreign firms are able to expand capital stock much more rapidly. This evidence is consistent with the hypothesis that domestic exporters face more stringent credit constraints than their foreign counterparts in an environment where investment in physical capital is subject to non-convex adjustment costs.

One potential problem with our analysis is that the control group in equation (IV.11), all non-exporting plants in 1991-2000, may not be the most appropriate. Indeed, one of the assumptions in the regression of equation (IV.11) is that there are no unobserved shocks that affect the treated and control groups differently. In the spirit of our previous matching exercise we repeat all of the same regressions on a sample of matched firms. Our intention is to minimize the impact of unobserved which affect the treated and control groups differently (Meyer, 1995). For each new exporter, foreign or domestic, we use our previous propensity score matching technique to find a similar control firm as a match and present these findings in the right panel of Table 9. Despite a drastic fall in sample size, we find even stronger results in terms magnitude, significance and timing.

Credit Constraints, Foreign Firms and the Asian Crisis

While Table 46 documents substantial evidence for financial frictions among domestic exporters, our data allows us to consider a particularly interesting robustness check to this specific hypothesis. It is well-known that the domestic credit market contracted substantially during the Asian crisis. We expect that firms which do not have access to alternative sources of credit will be particularly affected by the crisis, whereas those with access to alternative sources of credit markets will be less affected. Specifically, we expect that contracting domestic credit markets was more constraining to domestic firms during the Asian crisis who, unlike their foreign counterparts, are unlikely to be able to access foreign

Table 47. Foreign Firms, Domestic Firms and the Asian Crisis

	Dependent Variable: Investment Rate							
Export Premium	Year of Entry	One Year Later	Two Years Later	Three Years Later	Year of Entry	One Year Later	Two Years Later	Three Years Later
	Full Sample				Matched Sample			
	Pre-Asian Crisis: 1991-1995							
α_d (Dom.)	0.035***	0.021***	0.026***	0.031***	0.023***	0.015*	0.028***	0.027**
	(0.004)	(0.005)	(0.005)	(0.006)	(0.008)	(0.008)	(0.009)	(0.010)
α_f (For.)	0.057***	0.033**	-0.001	-0.009	0.058***	0.063***	0.032	0.004
	(0.012)	(0.014)	(0.015)	(0.018)	(0.021)	(0.022)	(0.024)	(0.029)
$\alpha_f - \alpha_d$	**0.022***	0.013	-0.027*	-0.040**	**0.035**	0.048**	0.004	-0.023
Wald Stat	2.91	0.79	2.78	4.62	2.63	4.71	0.02	0.57
p-value	0.088	0.373	0.096	0.032	0.105	0.030	0.875	0.450
Obs.	52,746	37,664	25,259	14,997	3,052	2,383	1,767	1,216
	Asian Crisis and Post-Crisis: 1997-2000							
α_d (Dom.)	0.031***	0.009*	0.021***	0.009*	0.061***	0.016	0.013	0.015
	(0.005)	(0.005)	(0.005)	(0.005)	(0.013)	(0.012)	(0.021)	(0.017)
α_f (For.)	0.068***	0.022*	0.034**	0.030**	0.112***	0.036*	0.006	0.115
	(0.012)	(0.012)	(0.015)	(0.017)	(0.021)	(0.020)	(0.040)	(0.033)
$\alpha_f - \alpha_d$	**0.037*****	0.013	0.012	0.021	**0.051****	0.020	-0.007	0.082***
Wald Stat	7.53	0.97	0.77	2.50	5.16	0.85	0.02	7.96
p-value	0.006	0.324	0.381	0.114	0.023	0.358	0.880	0.005
Obs.	53,407	48,223	42,832	37,907	1,220	735	374	718

Notes: Standard errors in parentheses. $***$, $**$, $*$ indicate significance at the 1%, 5%, and 10% levels, respectively. Investment data is not collected in 1996.

credit markets. As such, the estimated differences across foreign and domestic firms should be stronger during the crisis period than during the pre-crisis years. To test this hypothesis we repeat our experiment on the period before the crisis, 1991-1995, when credit was relatively loose in Indonesia and compare it the period during the crisis and that immediately afterwards, 1997-2000, when credit was relatively restricted.

The top panel of Table 47 documents the estimated regression coefficients in both the full and matched samples before the Asian crisis, while the bottom panel presents the same results for the period afterwards when credit was relatively tight. In the pre-crisis period we observe coefficients of similar magnitude to those in the full-sample. Further, we observe fewer statistically significant differences across foreign and domestic firms. Although the coefficients on the foreign exporter dummy are generally larger than their domestic counterparts, these differences are relatively small and are only strongly different from zero in the year after entry among the matched sample of firms.

We contrast these results with those from the bottom panel. The magnitude of the coefficients on the export dummies increase among both domestic and foreign exporters in the year of entry. This potentially reflects the growing importance of the export market in a period when the domestic market is contracting. Further, the difference between the foreign exporter effect α_f and the domestic exporter effect α_d grows substantially in the year of entry into export markets, but remains largely unaffected in all other years.[21] In the full sample, the investment rate among foreign firms is 3.7 percent higher than that of similar domestic firms, while the foreign investment rate is 5.1 percent higher in the matched sample. For the average Indonesian firm, our results suggest that credit constraints reduce investment of new exporters by as much as 53 percent.

Conclusion

This paper documents that exporting has a large impact on firm-level investment. We find that exporting increases firm-level investment by 40 percent in the initial year of entry into export and that firm-level capital stock continues adjust to exporting for at least 3 years after initial entry. The estimates are strongly significant for both large and small firms, before and after the Asian crisis and across all types of capital holdings, among other robustness checks. Our findings are strongly consistent with the notion that many new exporters are constrained upon initial entry into export markets.

We further show that access to foreign credit markets has a large impact on firm-level investment patterns upon entry into export markets. We document that new domestic exporters, with relatively poor access to credit markets, accumulate capital slowly over time. In contrast, foreign-owned firms tend to make larger changes in a smaller number of

[21] In the matched sample, we also find a significant difference three years after initial entry. This likely reflects differences in the lumpiness of exporting across firms with differential access to credit markets.

years. In fact, in the year of entry new foreign exporters expand capital holdings nearly twice as fast as similar domestic exporters. These results are particularly strong in periods when domestic credit access in Indonesia was relatively restricted. Our results suggest that while new exporters actively increase capital stock upon entry into export markets, poor or costly access to credit markets are likely to dampen firm-level growth into export markets. In particular, financial frictions may be particularly damaging to export promotion, a key objective in many developing country contexts.

Appendix

Additional Robustness Checks

Sample Selection

A potential concern is that our main estimates (Section 5) will be broadly affected by sample attrition. We examine this issue by studying samples of firms which are in our sample for at least T years where $T = 6, 7, 8$. Specifically, the treated sample includes firms which exist for at least one year before entering export markets and $T - 2$ years after entry (not including the year of entry). The group of control firms include firms which exist T years but never export. The results from the matching exercise are presented in Table 48.

Naturally, as we impose stronger requirements on the length of time a firm must be present, our overall sample size falls. Despite the reduction in sample size in all cases we find very similar results to those found in the full sample both in size and significance. Specifically, we find average treatment effects on the treated of 2-4 percentage points, all of which are strongly significant. In the bottom panel of Table A1 we report the results for our strictest time requirement; we required that firms produce for at least 8 consecutive years. We again find nearly identical results during the initial year of entry and our estimates lose little of their statistical significance even six years after initial entry. Our findings suggest that exporting may create long-lived differences across firms.

Table 48. Table A1: Investment Rate and Exporting, Firms which produce for T consecutive years

	Firms which produce for 6 consecutive years							
	One Year Before Entry	Year of Entry	One Year Later	Two Years Later	Three Years Later	Four Years Later		
Treatment Group	0.140	0.118	0.089	0.086	0.078	0.061		
Control Group	0.132	0.088	0.069	0.051	0.050	0.040		
ATT	0.008	**0.029*****	**0.020****	**0.035*****	**0.028****	**0.020****		
	(0.010)	(0.008)	(0.009)	(0.009)	(0.007)	(0.008)		
$ATT/\bar{T}$		**0.246**	**0.225**	**0.407**	**0.359**	**0.328**		
No. of matched pairs	1,389	1,160	1,215	1,205	1,184	1,089		
Mean difference in propensity score	0.010	0.011	0.011	0.011	0.010	0.011		
	Firms which produce for 7 consecutive years							
	One Year Before Entry	Year of Entry	One Year Later	Two Years Later	Three Years Later	Four Years Later	Five Years Later	
Treatment Group	0.149	0.118	0.092	0.085	0.085	0.066	0.059	
Control Group	0.140	0.093	0.065	0.058	0.057	0.040	0.038	
ATT	0.009	**0.025****	**0.027*****	**0.028*****	**0.029*****	**0.026*****	**0.021****	
	(0.011)	(0.010)	(0.008)	(0.009)	(0.009)	(0.010)	(0.010)	
$ATT/\bar{T}$		**0.212**	**0.293**	**0.329**	**0.341**	**0.394**	**0.356**	
No. of matched pairs	1,092	1,092	928	916	899	813	812	
Mean difference in propensity score	0.011	0.011	0.012	0.012	0.011	0.012	0.011	
	Firms which produce for 8 consecutive years							
	One Year Before Entry	Year of Entry	One Year Later	Two Years Later	Three Years Later	Four Years Later	Five Years Later	Six Years Later
Treatment Group	0.160	0.123	0.093	0.091	0.089	0.067	0.60	0.062
Control Group	0.147	0.097	0.070	0.066	0.061	0.044	0.036	0.037
ATT	0.013	**0.027****	**0.023****	**0.025****	**0.027****	**0.023****	**0.024****	**0.025****
	(0.014)	(0.012)	(0.011)	(0.009)	(0.012)	(0.009)	(0.010)	(0.011)
$ATT/\bar{T}$								
No. of matched pairs	877	877	877	707	691	616	617	877
Mean difference in propensity score	0.011	0.011	0.011	0.012	0.010	0.012	0.011	0.011

Notes: The first two lines present the outcomes observed in the given time period. The average treatment effect on the treated (ATT) is presented in the third row along with bootstrapped standard errors in parentheses. $***$, $**$, $*$ indicate significance at the 1%, 5%, and 10% levels, respectively. The ATT is computed analogously to that in other tables (the formulas are suppressed for ease of presentation.)

Table 49. Investment Rate and Exporting, $\geq$ 2 Years of Consecutive Exporting

	One Year Before Entry	Year of Entry$^{(a)}$	One Year Later$^{(b)}$	Two Years Later$^{(c)}$	Three Years Later$^{(d)}$
Treatment Group	0.140	0.111	0.086	0.098	0.087
Control Group	0.141	0.076	0.061	0.060	0.057
ATT	-0.002	**0.035*****	**0.025*****	**0.037*****	**0.030*****
	(0.012)	(0.009)	(0.008)	(0.010)	(0.010)
ATT/$\bar{T}$		**0.315**	**0.291**	**0.378**	**0.345**
No. of matched pairs	1,269	1,171	1,132	787	748
Mean difference in propensity score	0.011	0.011	0.011	0.011	0.012

Notes: The first two lines present the outcomes observed in the given time period. The average treatment effect on the treated (ATT) is presented in the third row along with bootstrapped standard errors in parentheses. $***$, $**$, $*$ indicate significance at the 1%, 5%, and 10% levels, respectively.

(a) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+0} - \left(\frac{i}{k}\right)^{control}_{entry\ year+0}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(b) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+1} - \left(\frac{i}{k}\right)^{control}_{entry\ year+1}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(c) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+2} - \left(\frac{i}{k}\right)^{control}_{entry\ year+2}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(d) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+3} - \left(\frac{i}{k}\right)^{control}_{entry\ year+3}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

Endogenous Exit from Export Markets

A potential concern in our context is that new exporters which exit export markets shortly after initial entry may have a smaller incentive to invest and, as such, bias our main estimates.[22] We examine this issue by repeating our experiment on subsamples of firms which have different export histories. Specifically, we restrict the treated sample to new exporting firms which export for at least 2 consecutive years.

As expected our restriction results in a substantial reduction in sample size. However, we again observe nearly identical results. In Table 49 we consider the set of new exporters which export for at least two years in a row. The average treatment effect on the treated estimates suggest that the investment rate is 2-4 percentage points higher in the years immediately around initial entry. Relative to the full sample we find that the export effect accounts for a slightly smaller percentage of total investment. This is can largely be attributed to the fact that the average investment among our continuing exporters is higher than the average investment rate in the full sample both before and after entry. This is not

[22]See Eaton et al. (2009), Arkolakis (2010) and Rho and Rodrigue (2012) for examples.

surprising given that the continuing exporters are generally among the largest and most productive firms in each industry.

Small vs. Large Firms Revisited

In this section we revisit our investigation of differences across firm size. Here we consider a second, common metric of firm size: employment. We define a large firm in the Indonesian manufacturing sector as one with more than 100 employees in the year before initial entry into export markets.[23] This roughly divides the sample in two equally sized groups in Table 50. We observe that exporting again appears to have an impact on investment among both groups of firms, though the ATT suggests that it may be moderately stronger among smaller firms.

[23] This definition is similar to that in Blalock, Gertler and Levine (2008), who study a similar set of Indonesian manufacturing firms.

Table 50. Investment Rate Across Large and Small Firms (Employment)

Large Firms (Employment $\geq$ 100)					
	One Year Before Entry	Year of Entry[(a)]	One Year Later[(b)]	Two Years Later[(c)]	Three Years Later[(d)]
Treatment Group: $\bar{T}$	0.155	0.127	0.092	0.100	0.088
Control Group: $\bar{C}$	0.145	0.100	0.086	0.068	0.069
ATT	0.010	**0.026****	**0.006**	**0.032****	**0.019***
	(0.011)	(0.011)	(0.010)	(0.013)	(0.010)
ATT/$\bar{T}$		**0.205**	**0.065**	**0.320**	**0.216**
No. of matched pairs	1,222	1,028	974	757	501
Mean difference in propensity score	0.018	0.019	0.017	0.021	0.030

Small Firms (Employment < 100)					
	One Year Before Entry	Year of Entry[(a)]	One Year Later[(b)]	Two Years Later[(c)]	Three Years Later[(d)]
Treatment Group: $\bar{T}$	0.090	0.087	0.064	0.060	0.055
Control Group: $\bar{C}$	0.089	0.045	0.035	0.033	0.047
ATT	0.002	**0.042*****	**0.029*****	**0.027*****	**0.008**
	(0.008)	(0.010)	(0.009)	(0.008)	(0.011)
ATT/$\bar{T}$		**0.483**	**0.453**	**0.450**	**0.145**
No. of matched pairs	1,201	1,098	876	591	518
Mean difference in propensity score	0.010	0.009	0.011	0.011	0.014

Notes: The first two lines present the outcomes observed in the given time period. The average treatment effect on the treated (ATT) is presented in the third row along with bootstrapped standard errors in parentheses. $***$, $**$, $*$ indicate significance at the 1%, 5%, and 10% levels, respectively.

(a) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+0} - \left(\frac{i}{k}\right)^{control}_{entry\ year+0}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(b) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+1} - \left(\frac{i}{k}\right)^{control}_{entry\ year+1}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(c) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+2} - \left(\frac{i}{k}\right)^{control}_{entry\ year+2}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

(d) $ATT = \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year+3} - \left(\frac{i}{k}\right)^{control}_{entry\ year+3}\right] - \frac{1}{n}\sum_1^n \left[\left(\frac{i}{k}\right)^{treated}_{entry\ year-1} - \left(\frac{i}{k}\right)^{control}_{entry\ year-1}\right]$

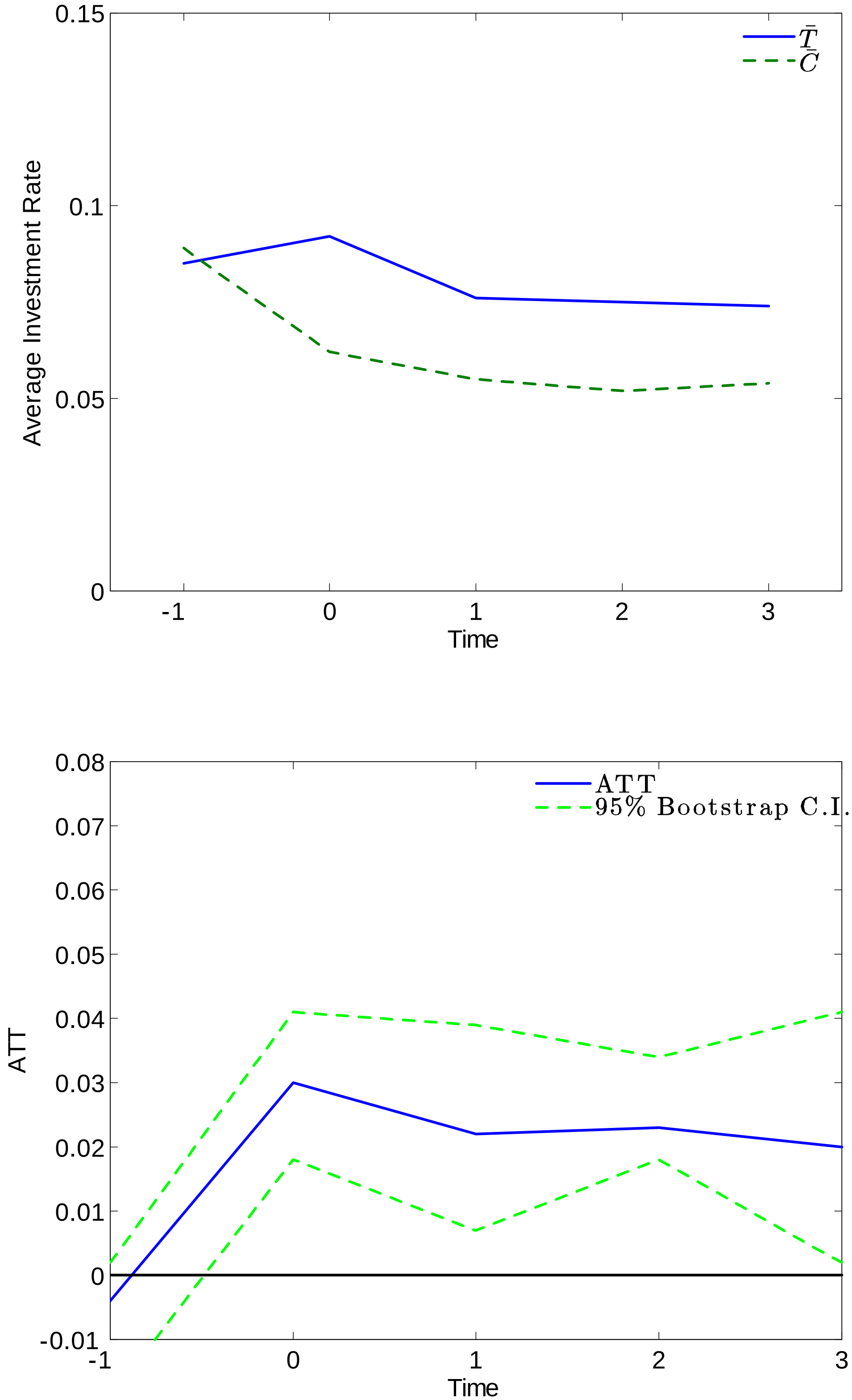


Figure 11. Average Treatment Effect

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