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Heterogeneous Exporters' Responses to Trade Liberalization in a Two-Dimensional Product Space

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Heterogeneous Exporters' Responses to Trade Liberalization in a Two-Dimensional Product Space

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Abstract

Multiproduct firms are responsible for the majority of the global trade network. The majority of studies on multiproduct firms that incorporate the notion of core competency—the idea that a firm is more efficient in some products than others—find success in explaining observed empirical patterns. However, because products in these models are represented on a one dimensional interval, the models are unable to capture the fact that products are inherently hierarchical and multidimensional. This paper proposes a way to extend the concept of core competency into a two-dimensional space with an introduction of industries. This allows for a richer prediction on the exporters' responses to a reduction in trade cost. In particular, the differential responses of large and small firms depend on the convexity of the cost function. Using a novel dataset on Thai exporters' responses to Vietnam's tariff reductions in 2001–2008, I find that while all exporters respond to foreign tariff reduction on the intensive margin, they respond differently on the extensive margin. While large firms tend to introduce products within the industry they already have presence in, small firms tend to start exporting products in new industries. This suggests that the cost curve is concave in the product dimension, but is convex in the industry dimension.

JEL classification: D24, F14, L25

Keywords: multiproduct firms, international trade, trade liberalization

1 Introduction

Multiproduct firms dominate international trade. According to an estimate by Bernard, Jensen, Redding and Schott (2007), approximately 40 percent of US exporting firms export a single product to a single destination, but these firms account for less than one percent of US export value. On the other hand, firms exporting five or more products account for 25 percent of exporting firms but are responsible for a staggering 98 percent of US export value. Given the prevalence of multiproduct firms, learning more about firms' product scope and how they change in response to various trade shocks is crucial to understanding international trade.

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In the growing literature that has taken many approaches in modeling multiproduct firms, one common element is the concept of core competency—a notion that a firm faces different costs in producing different products (Eckel and Neary, 2010). A firm's *core product* is the product that the firm can produce with the least cost.

Despite their success in explaining empirical patterns on how a firm adjusts its product scope (a firm adds products further away from the core when conditions are favorable, or drops products when conditions are adverse), existing multiproduct models are silent about what these products actually are. A t-shirt company's expansion into the jeans business definitely tells a rather different story than a t-shirt company's expansion into, say, the digital camera business; yet these two scenarios are reflected in exactly the same way in existing one-dimensional multiproduct models: an increase in the product scope from one product to two products.

In this paper, I develop a partial equilibrium model based on Eckel and Neary (2010) and Bernard, Redding and Schott (2011) that allows products to be differentiated in two dimensions. The first dimension is the product's industry. Products within each industry can then be represented by the second dimension, similar to that in the existing literature. From our previous example, we might define "clothing" and "consumer electronics" as our two industries. In the first scenario where the firm expands into the jeans business, the firm expands its product scope within the same industry (a product-level extensive margin), while in the second scenario the firm expands into a new industry (an industry-level extensive margin).

Similar to both Eckel and Neary (2010) and Bernard *et al.* (2011) on which the model is based, this model gives rich predictions on the export pattern of firms. More productive firms tend to export more in terms of both value and number of products produced. A unilateral trade liberalization in the foreign country allows existing exporters to export products that are further away from their core products. By incorporating a notion of "industry" into the model, the model also gives predictions on exporters' decisions to expand their scope to new industries as well. Similar to the adjustments on the product level, the model predicts that exporters will enter new industries in response to trade liberalization. However, depending on convexity of the cost function, the responses to trade liberalization might be different for exporters with different levels of productivity.

In order to pin down convexity of the cost function, I turn to a detailed dataset on Thai firms' exports to Vietnam. Focusing on Vietnam's major trade liberalization episode from 2001–2008, I study how Thai exporters of different sizes respond differently to unilateral tariff reduction from

Vietnam, using differences in tariff reductions across industries as the main source of variation.

The main empirical finding is that tariff reduction has a positive effect on both small and large exporters on the intensive margin. This supports the prediction of the Melitz (2003) model that the revenue ratio between exporters of different productivities does not depend on tariffs. On the extensive margins, however, exporters respond differently. Large exporters respond to tariff reductions by expanding their product scope within industries they have presence in, while small exporters respond to tariff reductions by introducing products in a completely new industry. This suggests that the cost curve is convex along the industry dimension, and is concave along the product dimension.

The primary contribution of this paper is twofold. First, the paper suggests a way to incorporate the second dimension—industry—to models of multiproduct firms. This allows for richer predictions not just in terms of the number of products a firm produces, but also if those new products would be within the same industry or a new one. Second, the paper provides an empirical description of how heterogeneous exporters respond differently to a unilateral trade liberalization in the foreign country. This is in contrast to the majority of the empirical literature on the effects of trade liberalization which tends to focus on firms in the liberalizing country.

The rest of the paper is organized as follows. Section 2 discusses related literature. I present the model in Section 3. In Section 4, I look at the model's predictions on the effects of a decrease in trade cost on firms with different productivity levels, as well as how the convexity of the cost function shapes the predictions. Section 5 presents the data, methodology, and empirical findings. Finally, Section 6 concludes.

2 Literature Review

The paper is related to two strands of literature. The first is the literature on multiproduct firms. Existing trade models with multiproduct firms, as alluded to earlier, tend to characterize the product space as a one-dimensional object. Bernard, Redding and Schott (2011), for example, build a general equilibrium multiproduct, multi-country model where firms draw product-specific productivity levels λ_k from some distribution $Z(\lambda)$ and face fixed costs in serving each market. More productive firms are able to cover the fixed cost even for lower product-specific productivity levels, and thus can supply more products compared to less productive firms. A bilateral decrease in trade cost would force firms to become more efficient and drop less productive products from the

mix. Using data from the Canada-US Free Trade Agreement, they also find evidence of product rationalization.

Taking a more structured approach on the firm's cost, Eckel and Neary (2010) propose a model in which firm i faces a cost function $c_i(k)$ to produce product $k \in [0, N]$. This cost function is assumed to be increasing in k, so the variety $k = 0$ is the core product of the firm.[1] Many other studies take a similar approach (Feenstra and Ma, 2008; Mayer, Melitz and Ottaviano, 2014, among others).

The second strand of literature is the empirical study on firms' responses to trade liberalization. Empirical works most closely related to this topic focus only on how reduced tariffs abroad affect the probability of entry or survival of an average domestic firm.[2] Only recently did researchers begin to look at the heterogeneous responses of the exporting firms.

In her study of Argentinian firms' responses to Brazil's tariff reduction, Bustos (2011) finds that a one percentage point reduction in Brazilian tariff leads to a significant increase in the probability of a firm's becoming an exporter for the firms in the third size quartile, while the effect is smaller for firms in other quartiles. The model is based on technology upgrading, where the benefits of upgrading production technology is increasing in the firm's revenue, and a firm incurs fixed cost to upgrade its technology. The largest firms are already using the most advanced production technology and already are exporters, so they do not respond to tariff reduction. Less productive firms in the first and second quartiles, on the other hand, do not find it profitable to pay the fixed cost to upgrade technology. Only firms in the third quartile are non-exporters who are productive enough to pay the upgrade cost and enter the export market.

In another study, Berthou and Fontagné (2013) estimate the effect of the introduction of the euro on French firms, using other European countries that were not part of the Euro Zone as controls. They find that the reduction of trade cost brought about by the introduction of the euro affected only the largest firms in terms of number of products exported and average value exported per product.

[1] The cost structure of the Bernard *et al.* (2011) model is then equivalent to that of the Eckel and Neary (2010) if we rearrange the product such that λ_k is increasing.

[2] For example, Baggs (2005) find that in the context of CUSFTA, the reduction in United States' tariffs reduce the probability of Canadian firms' exiting.

3 Model

3.1 Consumers

Consider a world with two countries, home and foreign. There are M industries in the world. The consumer's preference is given by a Cobb-Douglas utility function

$$U = \sum_{i}^{M} \alpha_i \ln Q_i,$$

where i indexes the industries. There is also an outside good that could be produced with a constant returns to scale. This allows us to normalize wage to one.

Within each industry i, there are N_i products which are indexed by k. The industry-level consumption Q_i is a constant elasticity of substitution aggregate of product-level consumption q_{ik} with elasticity of substitution $\varepsilon > 1$:

$$Q_i = \left(\sum_{k=1}^{N_i} q_{ik}^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}}.$$

Within each product, there is a continuum of firms on the interval Ω. Each firm supplies a differentiated variety indexed by ω. The product-level consumption is also a constant elasticity of substitution aggregate with elasticity of substitution $\sigma > 1$:

$$q_{ik} = \left(\int_{\Omega} q_{ik}(\omega)^{\frac{\sigma-1}{\sigma}} \, \mathrm{d}\omega \right)^{\frac{\sigma}{\sigma-1}}.$$

I also assume that the elasticity of substitution across product varieties is greater than the elasticity of substitution across products: $\sigma > \varepsilon$.

Since the top-level preference is a Cobb-Douglas function, we know that the share of income for products from each industry is $\alpha_i I$, where I is the consumer's income. The demand for each individual variety, then, is given by

$$q_{ik}(\omega) = \left(\frac{P_{ik}}{p_{ik}(\omega)} \right)^{\sigma} \left(\frac{P_i}{P_{ik}} \right)^{\varepsilon} \frac{\alpha_i I}{P_i}, \tag{1}$$

where P_{ik} and P_i are ideal price indices for product ik and industry i, respectively:

$$P_{ik} = \left(\int_{\Omega} p_{ik}(\omega)^{1-\sigma} \, \mathrm{d}\omega \right)^{\frac{1}{1-\sigma}},$$
$$P_i = \left(\sum_k P_{ik}^{1-\varepsilon} \right)^{\frac{1}{1-\varepsilon}}.$$

3.2 Firms

The production function is a two-dimensional extension of the core competency model in Eckel and Neary (2010). The idea is that a firm is competent at producing goods in one core industry. Within each industry, a firm is competent at producing one core product. As a firm gets further away from this core product and industry, the cost of producing that product becomes higher. Because our focus is on within-firm adjustments as opposed to adjustments via firms' exit and entry, I will assume that the number of exporters are exogenously given. In this subsection, I will drop the firm's variety notation ω since the focus is on a single firm.

A firm is characterized by its ability φ, its core industry $\hat{\imath}$, and a vector of core products $\hat{\mathbf{k}} = [\hat{k_1}, \hat{k_2}, \ldots, \hat{k_N}]$. The marginal cost of producing a product k in industry i is a function of its ability, the distance between the industry and the firm's core industry, and the distance between the product and the firm's core product within that industry: $c(\varphi, i, k) = \tilde{c}(\varphi, |i - \hat{\imath}|, |k - \hat{k}_i|)$. This $\tilde{c}$ function is decreasing in the first argument, and is increasing in the second and third arguments. Tariff is modeled as the standard iceberg cost. In order to sell q units of product k in industry i for a product with tariff τ_{ik}, the firm has to pay $q \cdot c(\varphi, i, k) \cdot (1 + \tau_{ik})$.

Given its characteristics, the firm chooses the set of products it wishes to export. Each product the firm exports incurs a fixed cost of f_{ik}, which could include the cost of market research, advertisement, distribution, etc. and could potentially depend on the industry i and product k.

A firm sets a price for each variety it produces to maximize profits and solves the following maximization problem:

$$\max_{p_{ik}} \; p_{ik} q_{ik} - q_{ik} c(\phi, i, k)(1 + \tau_{ik}) - f_{ik}.$$

Plugging in the expression for q_{ik} from (1) gives us constant markup pricing,

$$p_{ik} = \frac{\sigma}{\sigma - 1} c(\varphi, i, k)(1 + \tau_{ik}),$$

and revenue for a particular product is given by

$$r_{ik} = \left(\frac{\sigma - 1}{\sigma} \frac{1}{c(\varphi, i, k) \cdot (1 + \tau_{ik})} \right)^{\sigma - 1} P_{ik}^{\sigma - \varepsilon} P_i^{\varepsilon - 1} \alpha_i I. \tag{2}$$

The profit that a firm gets for each product is given by revenue minus variable and fixed costs:

$$\begin{aligned} \pi_{ik} &= p_{ik} q_{ik} - q_{ik} c(\varphi, i, k)(1 + \tau_{ik}) - f_{ik} \\ &= p_{ik} q_{ik} - \frac{\sigma - 1}{\sigma} p_{ik} q_{ik} - f_{ik} \\ &= \frac{1}{\sigma} r_{ik} - f_{ik}. \end{aligned}$$

The zero profit condition implies that, for each product, there is a cutoff cost c_{ik}^* (including trade cost) which is the solution to the equation $r_{ik} = \sigma f_{ik}$.[3] Substituting the expression for revenue from (2) into the zero profit condition, we can solve for the cutoff cost:

$$c_{ik}^* = \frac{\sigma - 1}{\sigma} \left(\frac{P_{ik}^{\sigma - \varepsilon} P_i^{\varepsilon - 1} \alpha_i I}{\sigma f_{ik}} \right)^{\frac{1}{\sigma - 1}}. \tag{3}$$

Since there is a continuum of producers, a firm cannot influence the price indices and hence the cutoff cost is treated as exogenous by the firms. For a product k in an industry i, firms with final cost $c(\varphi, i, k) \cdot (1 + \tau_{ik})$ higher than the cutoff cost would not export that product, while firms with final cost lower than the cutoff cost would export. Holding everything else constant, a firm with higher ability φ would have the cutoff product (a product farthest from the core) that is farther away from its core product in that industry. Likewise, a more productive firm would participate in industries farther away from its core industry.

4 Effects of reduction in trade cost

In this section, I investigate how a unliateral reduction in trade cost has differential effects on exporters with different levels of productivity.

Consider two exporters, one with high level of productivity φ_H and another with low level of productivity φ_L. On the intensive margin, from (2), we can see that as trade cost decreases, revenue increases. That is, exporters respond on the intensive margin by increasing export volumes when

[3] In addition to the zero profit condition, Melitz (2003) and Bernard *et al.* (2011) also incorporate the free entry condition which allows them to make predictions about the mass of firms entering the export market. Since that is not the focus of this paper (our unit of observation is firm-product), I refrain from describing that element here.

trade cost decreases. Furthermore, the ratio of revenue between two exporters with productivity levels φ_H and φ_L in the same product is constant:

$$\frac{r_H}{r_L} = \left(\frac{c(\varphi_L, i, k)}{c(\varphi_H, i, k)} \right)^{\sigma - 1}.$$

This means that there is no differential response on the intensive margin between exporters with different productivity levels.[4]

On the extensive margin, since the cutoff cost in (3) is exogenous to the firm, a reduction in trade cost would simply shift the firm's cost curve down, allowing exporters to start exporting products that are further away from their core products.

Precisely what the effect on heterogeneous firms would be depends on the convexity of the cost function as well as our assumption on the fixed cost f_{ik}. For simplicity, let us assume that f_{ik} is the same for all values of i and k. Because a product is represented in a two-dimensional space, we need to consider the cost curve's convexity with respect to both dimensions: (i) holding the industry constant, what is the convexity of the cost curve as we move further away from the core product, and (ii) holding the product constant, what is the convexity of the cost curve as we move further away from the core industry. Let us focus only on the product dimension and abstract away from the notion of industries for the moment. The effects of convexity in the industry dimension will be analogous.

While the original model in Eckel and Neary (2010) is agnostic about the shape of the marginal cost function, aside from requiring that it is increasing with the distance from the core product, the authors use an example of a linear marginal cost:

$$c(\varphi, k) = c_0(\varphi) + m \left| k - \hat{k} \right|, \quad [5] \tag{4}$$

where $c_0(\varphi)$ is an increasing function in φ, and $m > 0$. This linear cost assumption, as we shall see, leads to a uniform response from exporters with different productivity levels.

Without loss of generality, let $\hat{k} = 0$. A graphical representation of a typical firm's response to tariff reduction is shown in Figure 1. The firm has ability φ, and tariff is given by τ. The solid

[4] Even if we allow wage to be determined endogenously as in Melitz (2003) and Bernard *et al.* (2011), this result still holds because wage enters as a multiplier in the firm's cost as well as in the firm's price.

[5] In their model, there is no notion of "productivity." Including ability in the intercept term is the only way to guarantee, for a linear function, that an exporter with higher ability would always have lower marginal cost than an exporter with lower ability.

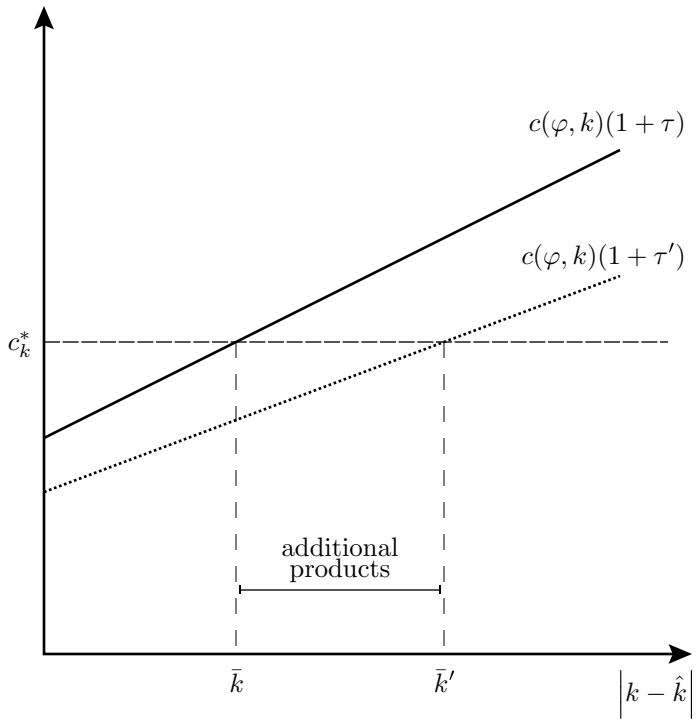


FIGURE 1: Optimal product scope for a typical exporter before and after tariff reduction.

line shows the firm's marginal cost curve as a function of the distance from the firm's core product. As we move away from the core product, the firm faces higher marginal cost. The firm's optimal product scope is the range $[0, \bar{k}]$, where $\bar{k}$ is k that solves $c(\varphi, k)(1+\tau) = c_k^*$. After tariff reduction, the firm faces a lower marginal cost curve (dotted line), and can expand its product scope to $[0, \bar{k}']$.

Suppose we have two firms, one with high productivity φ_H and the other with low productivity $\varphi_L < \varphi_H$. We want to see the effect that a tariff reduction from τ to τ' has on these firms' product scopes. This is given by $\bar{k}' - \bar{k}$. We can solve the zero profit condition and get

$$\bar{k} = \frac{1}{m}\left(\frac{c_k^*}{1+\tau} - c_0(\varphi)\right).$$

The expression for $\bar{k}'$ is analogous, with τ replaced by τ'. As a result, the number of additional products introduced by a typical firm with ability φ is given by

$$\bar{k}' - \bar{k} = \frac{1}{m}\left(\frac{c_k^*}{1+\tau'} - \frac{c_k^*}{1+\tau}\right).$$

Note that the size of the increased product scope does not depend on firm's ability φ, and so firms

with different ability levels would respond in a similar way to tariff reduction under the assumption of a linear cost curve.

Next, let us assume a more general form of the cost function:

$$c(\varphi, k) = c_0(\varphi) + g(k - \hat{k}),$$

where $g(\cdot)$ is a strictly increasing and twice differentiable function that could be either convex or concave. Assume also that $\hat{k} = 0$. In this case, the cutoff product $\bar{k}$ is given by k that solves $c_k^* = [c_0(\varphi) + g(k)](1+\tau)$. We have that

$$\bar{k} = g^{-1}\left(\frac{c_k^*}{1+\tau} - c_0(\varphi)\right).$$

The number of additional products as a result of a reduction in trade cost from τ to τ' is then

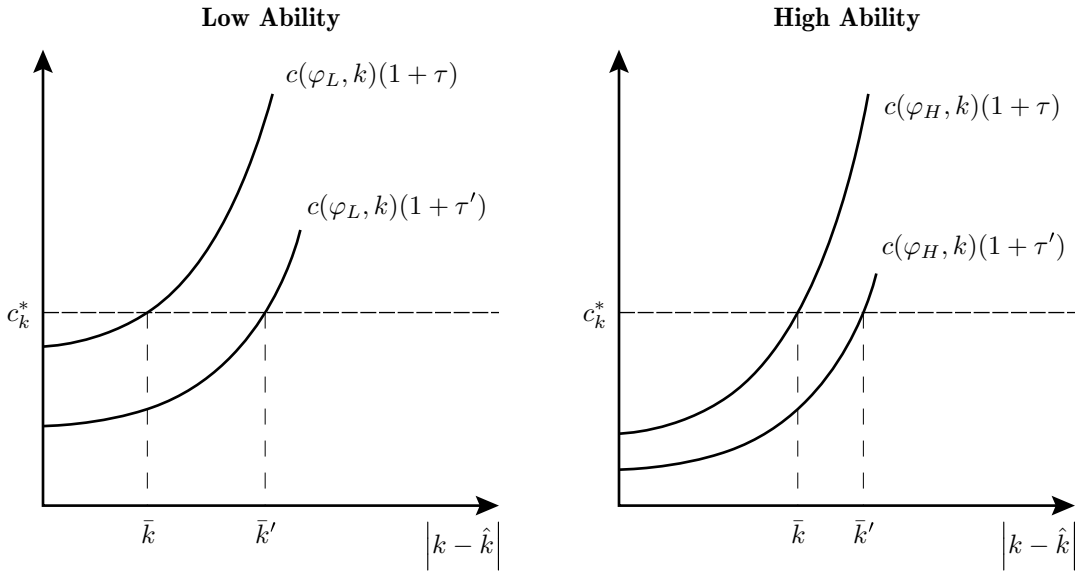
$$\begin{aligned}\bar{k}' - \bar{k} &= g^{-1}\left(\frac{c_k^*}{1+\tau'} - c_0(\varphi)\right) - g^{-1}\left(\frac{c_k^*}{1+\tau} - c_0(\varphi)\right) \\ &= \frac{g^{-1}\left(\frac{c_k^*}{1+\tau'} - c_0(\varphi)\right) - g^{-1}\left(\frac{c_k^*}{1+\tau} - c_0(\varphi)\right)}{\frac{c_k^*}{1+\tau'} - \frac{c_k^*}{1+\tau}} \cdot \left(\frac{c_k^*}{1+\tau'} - \frac{c_k^*}{1+\tau}\right).\end{aligned}$$

It can be shown using the mean value theorem that the number of additional products is an increasing (decreasing) function of the firm's productivity level φ if the $g(\cdot)$ function is concave (convex).[6]

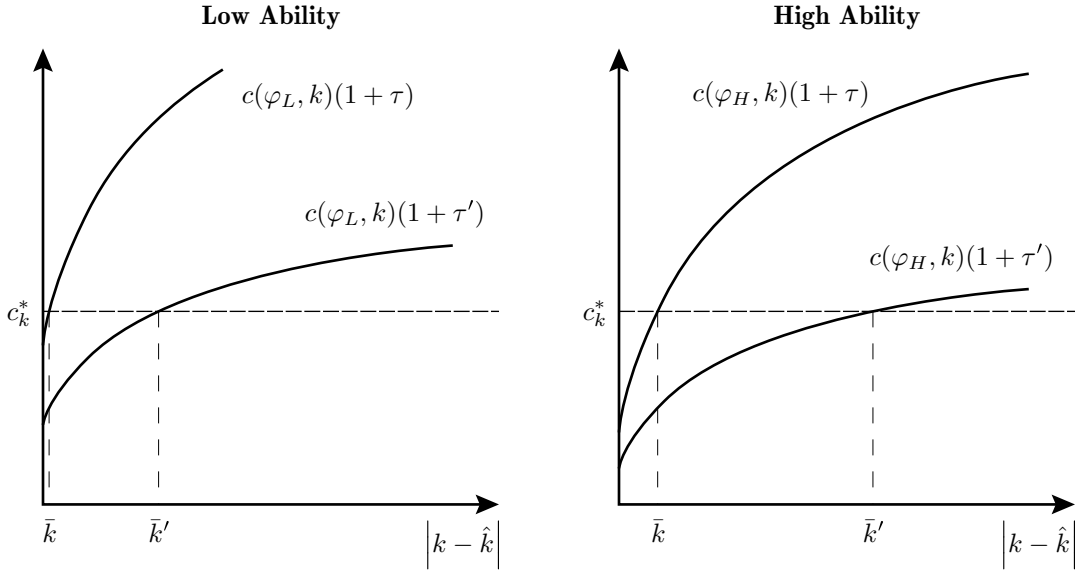
Figure 2 shows the optimal product scope for both convex and concave functions. In all cases, ability affects the intercept term (the marginal cost where $k = \hat{k}$.) Similar results still hold if ability affects, for example, the curvature of the function. The result is that if the cost function is convex (Figure 2a), then firms with lower ability will respond more to tariff reductions. On the other hand, if the cost function is concave (Figure 2b), then firms with higher ability will respond more to tariff reductions.[7]

[6] A sketch of the proof: the first term could be rewritten as $\frac{h(x')-h(x)}{x'-x}$, where $h(\cdot) = g^{-1}(\cdot)$. By the mean value theorem, this has to be equal to $h'(y)$ for some $y \in [x, x']$. If $h(\cdot)$ is convex, then $h'(\cdot)$ is increasing in y, and therefore $\bar{k}' - \bar{k}$ is increasing in x as well. Since x is increasing in φ, it must be that $\bar{k}' - \bar{k}$ is increasing in φ. Finally, h is convex if and only if g is concave.

[7] It is worth noting that the Melitz model is convenient in that the cutoff cost c_k^* does not change with trade cost, as seen in (3). If we were to allow the cutoff cost to vary with trade cost (for example, Melitz and Ottaviano, 2008), then this result would hold as long as the cost cutoff falls slower than a firm's cost function.



(a) Convex cost function



(b) Concave cost function

FIGURE 2: Optimal product scopes for a firm with low productivity (left) and a firm with high productivity (right).

5 Empirical Patterns

In order to determine the convexity of the cost curve in both dimensions, as well as understand more about firms' responses to tariff reductions in the foreign country, I now turn to the empirics.

I use a major trade liberalization period in Vietnam as an exogenous shock to trade cost. To control for time-specific shocks, I take industries with no change in tariff as controls and look at how firms adjust exports in other industries.

5.1 Background

The trade agreement between Thailand and Vietnam was done under the broader ASEAN Free Trade Area (AFTA). In 1996, Vietnam joined Thailand and five other Southeast Asian nations in AFTA, which was formed three years prior. In exchange for lower tariffs that Vietnam would receive from member countries, Vietnam agreed to lower the majority of its tariff to below 5 percent by the year 2006. This is in contrast to the other six founding members who had to do so by the year 2002. This resulted in a unique setting of unilateral liberalization on Vietnam's part. Figure 3 shows Vietnam's rapid tariff decrease from 2001 to 2008.[8] Through this period, Thai exports to Vietnam increased five-fold, from 900 million USD to 5 billion USD. This translates to a doubling in Vietnam's share of Thailand's total exports, from 1.22 percent in 2001 to 2.64 percent in 2008.

5.2 Data

In this subsection I describe the data used in my empirical analysis and outline some of the limitations of the data, as well as the ways I address them.

5.2.1 Tariff data

I collect Vietnamese tariff data from the ASEAN Free Trade Area (AFTA) website. This data is available at the Vietnamese tariff line level beginning in the year 2001. Since the definitions of a product at this tariff line level are different across countries, I first aggregate the tariff lines into the Harmonized System (HS) 6-digit level. There are more than 5,000 products at this level of aggregation. For each HS 6-digit product with all tariff lines' being ad valorem tariffs, the

[8] It is possible that Vietnam could have been reducing its tariff since it joined AFTA in 1996. While tariff data from AFTA is not available for years earlier than 2001, the WTO has data on Vietnamese tariff in 1999, which is at 19.1 percent, only slightly higher than that in 2001.

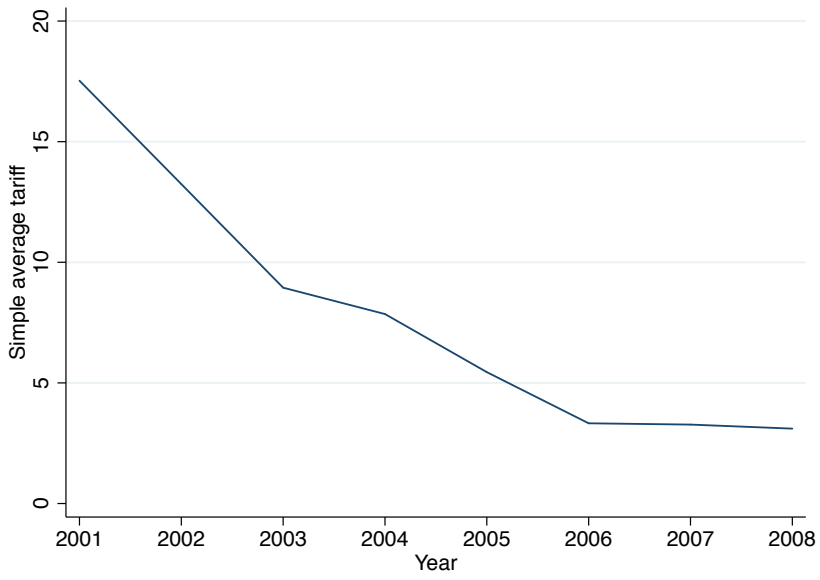


FIGURE 3: Average tariff of Vietnam on Thai exports over the years 2001–2008.

tariff for that HS 6-digit product is a simple average of the tariff lines.[9] For products with one or more specific or mixed tariff lines, I use ad valorem equivalent (AVE) tariff provided by the Trade Analysis and Information System (TRAINS) database.

One potential problem with using the product definition at this level is that the Harmonized System is updated every five years. With each update, there are numerous HS 6-digit codes that are discontinued or introduced. In addition, countries tend to adopt the new HS definitions at different times, sometimes with a lag of a few years. This presents a difficulty in linking products across time.[10] To address this, I aggregate the products up to the International Standard Industrial Classification (ISIC) 4-digit level. Unlike its counterpart, the ISIC is updated much less frequently than the HS and is therefore less problematic in linking products across time. Aggregating products to the ISIC 4-digit industry level brings the number of industries down to 145 industries. Similar to prior works (Trefler, 2004; Bustos, 2011), I focus my analyses at this industry level.

I further remove non-manufacturing industries (industries whose ISIC sector falls outside the manufacturing sectors). These consist mostly of wastes and by-products. After removing non-

[9]Since trade data is available only at the HS 6-digit level, it is not possible to calculate the weighted average tariff based on trade value of each tariff line.

[10]Other studies that define products at this level usually cover a relatively shorter time span of 2–3 years, during which time the HS codes remain unchanged. The United Nations does provide a conversion table as a mean for researchers to convert from a newer HS classification to an older classification. This, however, is a function that is neither one-to-one nor onto, so there will be some discontinued codes that do not show up in the new trade data and we would mistaken that product for not being exported.

manufacturing industries, the number of industries falls to 119 industries. The tariff for each ISIC 4-digit industry is the average tariff weighted by Thailand's export value to Vietnam.

In 2001, the simple average tariff was 17.53 percent, with a standard deviation of 18.41 percent. There are two outliers (industry codes 1551 and 1552: ethanol spirits and wine) whose tariffs are more than 3 standard deviations away from the mean. This is possibly because of the error in calculating the ad valorem equivalent from specific tariffs.

The simple average tariff fell to 3.10 percent in 2008, with a standard deviation of 5.04 percent. Tariff for tobacco (industry code 1600) increased from 31 percent to 42 percent, an increase of 8 percent. This again is an artifact from converting specific tariff to its ad valorem equivalent.

In my main regression, I exclude these three outliers. Nonetheless, all results are robust to including these industries (see Appendix B). Excluding the outliers, there are 116 industries in our sample. The simple average tariff fell from 16.10 percent in 2001 down to 2.73 percent in 2008.

Tariff reduction is spread out across industries. Figure 4 shows the histogram of tariff reduction. The average tariff reduction is 11.45 percent, with a standard deviation of 10.99 percent.

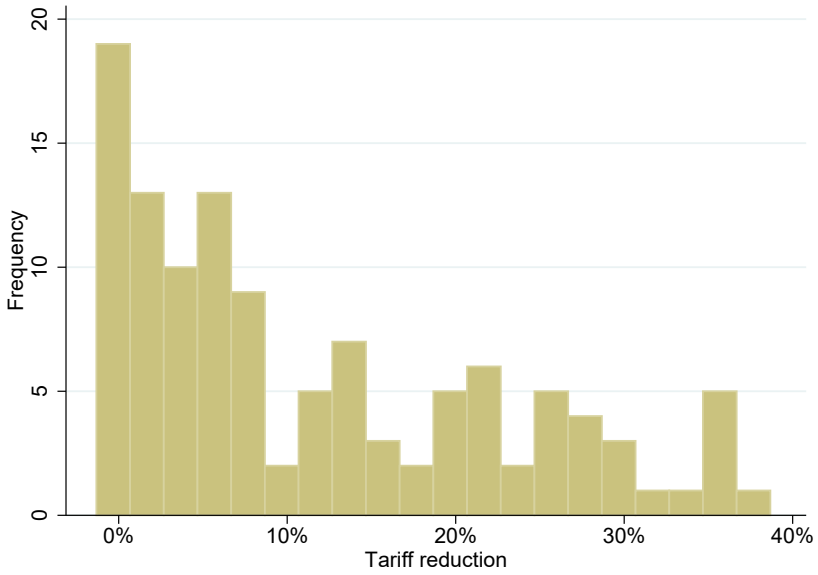


FIGURE 4: Histogram of tariff reductions between 2001–2008.

5.2.2 Export data

Export data is provided by the Thai Customs Department. This annual panel contains information on exporters, products (at Thai tariff line level), and export value (in Thai baht) and includes all

goods exported by firms or individuals. I exclude exports by private individuals (those who use their personal identification number or passport number in the export declaration form), as well as academic institutions and exporters who are not registered with the Department of Business Development from the sample. These non-business exports account for less than 5 percent of the export value from Thailand to Vietnam.

For the export data, I first deflate the export value using the Thai consumer price index. I then aggregate the products at the Thai tariff line level into ISIC 4-digit level.

I depart from the approaches used in related literature in one important way. Whereas other researchers (Trefler, 2004; Bustos, 2011) treat a firm as being an exporter in a single industry (so that a firm in a textile industry responds only to tariffs on textile products), I argue that it is important to look into what products firms actually export.

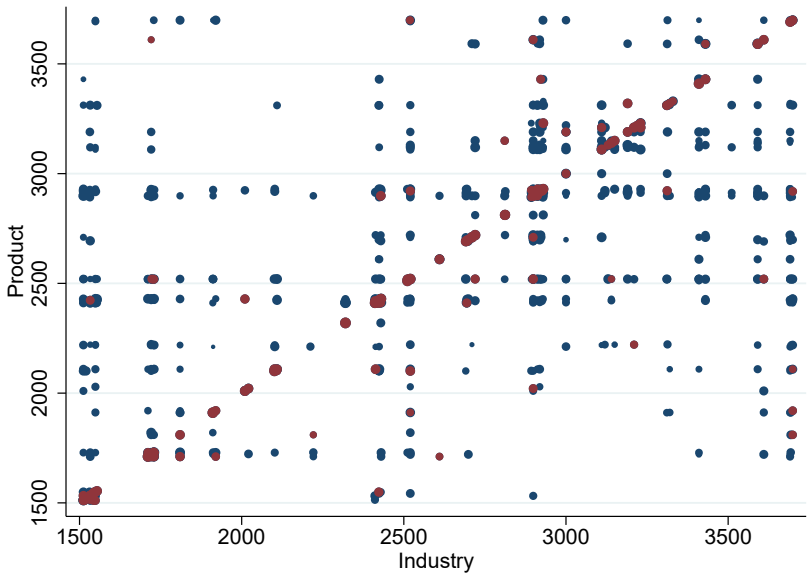
Figure 5 shows scatter plots of Thai exports to Vietnam according to the firm's primary industry and the industries it actually exports in 2001 and 2008. We expect to see a large number of diagonal entries—firms' exporting products within its primary industry—and this is indeed the case: roughly 65 percent of Thai export value to Vietnam falls on the diagonal line. However, the remaining 35 percent are off-diagonal, and the change in export values of these diagonal entries would have been misattributed to the change in the tariff of the firm's primary industry.

5.2.3 Firm-level data

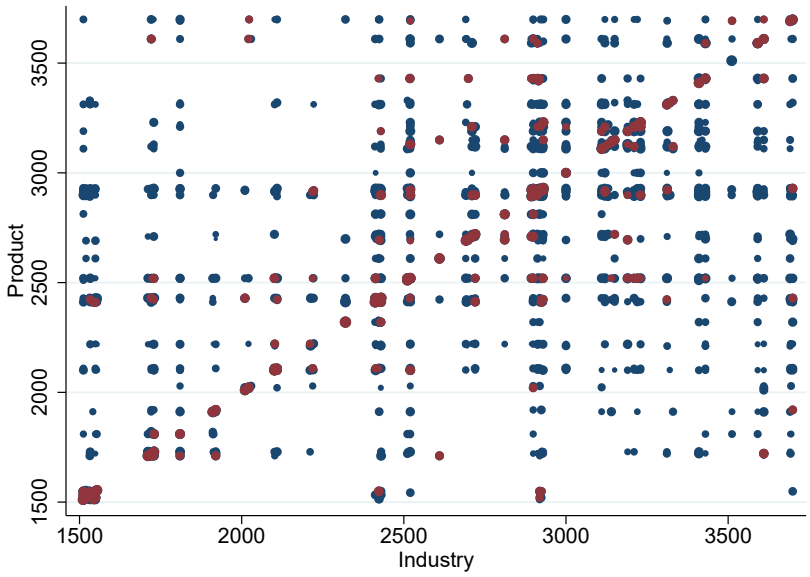
Firm-level data comes from the Revenue Department and the Department of Business Development. The purpose of this data is twofold.

First, this data provides the firm's industry. It allows me to include in my analysis only firms whose main activity is manufacturing (ISIC divisions 15 through 37) and exclude wholesalers and shipping companies. I exclude wholesalers because there is no easy way to control for products exported by wholesalers (so rice wholesalers and electronics wholesalers are grouped under the same sector). Shipping companies are excluded because the export decision is made by the manufacturing firms and not related to the characteristics of the shipping companies. We have no way to trace back to the actual manufacturers of the products exported by these shipping companies.[11] Recent literature suggests that firms that are more credit constrained are more likely to export through intermediaries. If we assume that smaller firms are more credit constrained, then my analysis would

[11] Manufacturing firms account for 55.8 percent of total Thai exports to Vietnam in 2001. This ratio rises to 72.7 percent in 2008.



(a) Industry vs. product in 2001



(b) Industry vs. product in 2008

FIGURE 5: A plot of a firm's primary industry against the products it exports. The size of the dots corresponds to the export value of that industry-product exports. Red markers denote industry-products on the diagonal.

understate the export value of smaller firms.

The second purpose of the firm-level data is to provide a measure for firm size. As noted by Calof (1994), both employment and sales revenue are frequently used to measure firm size in the international trade literature. The measure of firm size used in this project is the sales revenue to all countries, excluding sales revenue in Vietnam. This is different from other recent papers such as Trefler (2004) and Bustos (2011) where the authors use employment to measure firm size. Ideally, I would use both measures for robustness checks. However, due to data availability I am limited to measuring firm size by sales revenue alone.

Similar to the export data, I first deflate the firm's sale revenue with the CPI. While the firm's balance sheet data is available for the years 2001–2008, recent digitization efforts ensure that the data is accurate only from 2005 onwards. Because of this as well as missing data, I use the median of the log of sales revenue across the years as the main measure of firm size. This measure correlates highly with other sales revenue measures of firm size (correlation coefficient of 0.908 with sales revenue in 2001 and 0.983 with sales revenue in 2005), and results are robust to these alternative measures (see Appendix B).

Following Bustos (2011), I demean firm size by their respective industry means. I then divide the firms into two groups, small and large. Small firms are firms whose demeaned sizes are less than the median firm size, and large firms are firms whose demeaned sizes are greater than the median firm size.

Table 1 shows summary statistics. Overall, small firms export less than large firms, and are less likely to export. Nonetheless, after tariff reduction, the probability of exporting (average of export dummy) increases to be roughly the same as that of large firms. Both groups of firms face roughly the same average tariffs. I also show additional summary statistics in Appendix A.

5.3 Methodology

Similar to other works quantifying the effect of tariff changes, I use the variation in tariff reductions across industries as my main source of identification. Let Z_{fit} be the outcome of interest for exports of products in industry i of firm f at time t. The main regression specification is

$$Z_{fit} = \beta\tau_{it} + \theta L_f \tau_{it} + \gamma \mathbf{x}_{fit} + \varepsilon_{fit}. \tag{5}$$

TABLE 1: Summary statistics, with sample restricted to firm-industries that have at least one year of positive exports to one of Thailand's top eleven trading partners.

Variable	Small firms				Large firms			
Year 2001	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
Export value (million THB)	0.066	1.384	0.000	130.444	0.397	8.686	0.000	886.958
Export dummy	0.038	0.192	0	1	0.051	0.221	0	1
Number of HS 6-digit products	0.347	0.837	0	8	1.220	3.086	0	30
Median sales revenue	17.676	1.241	11.067	21.264	20.514	1.441	16.524	27.234
Tariff	16.396	13.691	0.000	59.542	15.359	13.707	0.000	59.542
Observations				11774				24109
Year 2008	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
Export value (million THB)	0.299	4.574	0.000	315.004	1.889	52.587	0.000	6756.859
Export dummy	0.128	0.334	0	1	0.111	0.315	0	1
Number of HS 6-digit products	1.279	1.973	0	16	2.600	3.922	0	29
Median sales revenue	17.676	1.241	11.067	21.264	20.514	1.441	16.524	27.234
Tariff	2.620	2.466	0.000	31.916	2.477	2.488	0.000	31.916
Observations				11774				24109

Variable τ_{it} is the measure of Vietnamese tariff for industry i at time t. Variable L_f is a dummy variable which takes a value of one if the firm is large (defined in the previous subsection) and zero otherwise. From this, we have that the coefficient β is the effect tariff has on small firms' outcome, while the estimated coefficient θ measures the difference in response of tariff for large firms compared to small firms. I also control for various combinations of product sector (ISIC 2-digit level to which the product belongs) and firm sector (ISIC 2-digit level to which the firm belongs) time trends with $\mathbf{x}_{fit}$.[12]

There is empirical evidence that it takes time for exporters to adjust to changes. This includes the time needed to study a new market, search for new customers, and adjust production bundle. Hence the regression equation in (5), which is based on year-to-year change, is likely to understate the effect of tariff changes in the longer run. One way to address this is to regress the outcome on the lagged tariff levels. However, this means that I will have to take a stance on how quickly the exporters adjust to tariff changes.

A widely adopted alternative to using lagged tariff levels looks at the change in outcome between pre- and post-FTA periods. This is the approach I take, as it captures the long-run effect of trade liberalization and takes no stance on the dynamics of the firms. I use 2001 as the first period, and 2008 as the second period, as 2001 is the year the data is first available, and 2008 is the last year before the financial crisis hits. From (5), we can take the first difference in time to eliminate

[12]To control for firm's sector fixed effect, I define the firm's industry to be the industry in which the firm has the highest total export value instead of using the firm's self-reported industry from the dataset.

firm-industry fixed effect:

$$\Delta Z_{fi} = \beta \Delta \tau_i + \theta L_f \Delta \tau_i + \gamma \Delta \mathbf{x}_{fi} + \Delta \varepsilon_{fi}. \tag{6}$$

There may be a concern that tariff changes are endogenous. For example, large firms with political influence might be able to convince the government to prioritize tariff reduction for certain industries. Figure 6 shows that there is no systematic correlation between firm size and tariff reduction for the industries in which the firm exports. To check for robustness, I have also in-

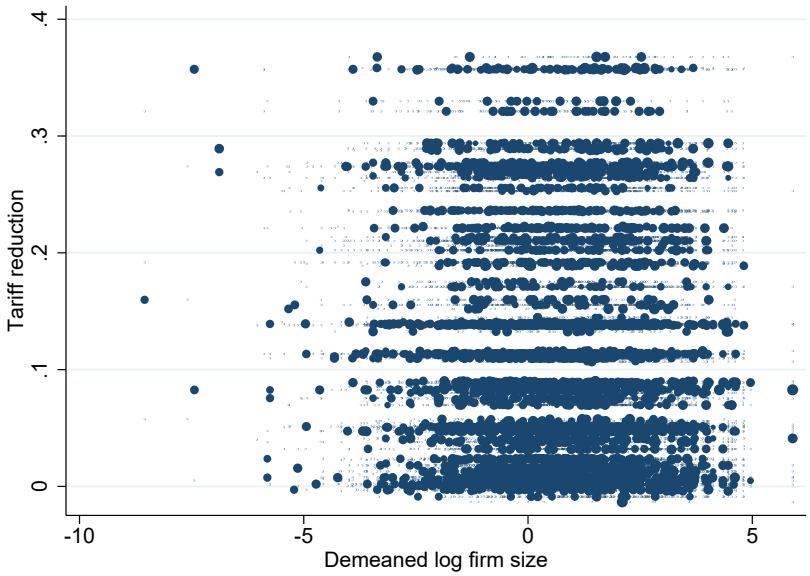


FIGURE 6: A scatter plot of firms' demeaned size against tariff reduction, showing that there is no systematic relationship between the two.

cluded results from instrument variable regressions using the tariff level in 2001 as an instrument in Appendix B. The results remain the same.

In line with the model, I separate the effects of Vietnamese trade liberalization on Thai exports into the intensive and extensive margins. I define an intensive margin at the firm-industry level. A firm adjusts on the intensive margin when its export value of an ISIC 4-digit industry changes. On the extensive margin, there are two margins we need to consider. The first is the industry-level extensive margin, which refers to the adjustment a firm undertakes when it starts or stops exporting products in an industry. The second is the product-level extensive margin. Because the data is aggregated up to the industry level, I take this to be the change in the number of unique HS-6

products exported within an ISIC 4-digit industry.[13]

5.4 Results

In this section, I discuss the empirical patterns I find for each of the three margins of adjustment using (6) as the main estimating equation. I invert the sign of change in log tariff so that the coefficient estimates are responses to tariff reduction, rather than responses to a tariff increase.

5.4.1 Intensive margin

Table 2 shows the estimation result for (6) with the change in log export value as the dependent variable. The sample is restricted to 888 firm-industries with positive exports in both 2001 and 2008.

TABLE 2: Change in product's log export value for small and large firms.

Δ log export value	(1)	(2)	(3)
Tariff reduction	3.861**	3.208**	3.243*
	(1.179)	(1.098)	(1.287)
Tariff reduction × large firms	0.298	0.299	0.782
	(1.391)	(1.340)	(1.395)
Product's sector FE	Yes	–	Yes
Firm's sector FE	–	Yes	Yes
R^2	0.026	0.038	0.065
Observations	888	888	888

Note: Standard errors are clustered at the product's sector level and are shown in the parentheses. Δ denotes a change in a variable during the period 2001–2008. Markers *, **, and *** denote statistical significance at 5, 1, and 0.1 percent confidence levels respectively.

I find that both small and large firms respond positively to tariff reduction. For a given one percent decrease in tariff of a particular industry, a firm would, on average, increase its export in that industry by 3.24–3.86 percent. This estimate is in line with those of current literature for developing countries. This implies that the average reduction of Vietnamese tariffs of approximately 11 percent would lead to an increase in export value of around 35–40 percent.

There is no evidence that there are significant differential responses to tariff reduction for small and large firms. The coefficient on the interaction term is positive but not statistically significant. This is in line with the Melitz (2003) model where the ratio of the sales revenue does not depend on trade cost, but only on the relative productivity of the firms.

[13]While there is no standard way to measure product varieties (some authors use HS-8 and some use UPC code, for example), data for products at HS-6 level is the most disaggregated reliable information I have.

5.4.2 Industry-level extensive margin

To study the firms' responses on the extensive margin, I follow Bustos (2011) and use the change in the firm-industry's export status as the dependent variable. This variable takes a value of zero if the firm-industry does not change its export status, a value of −1 if the firm exported products in a particular 4-digit ISIC industry in 2001 but not in 2008, and a value of 1 if the firm did not export products in a particular industry in 2001 but had positive exports in 2008. With fixed effects, estimation with a probit model is inconsistent. Therefore I estimate this equation using a linear probability model.

Using all possible firm-industry combinations would yield approximately 420,000 observations (3,620 firms multiplied by 116 industries), most of which would have no export activities. This implicitly assumes that a firm could export goods in every industry, which is certainly not the case. Therefore, I use the notion of potential export relationship (Besedeš and Prusa, 2011) to refine the sample. I restrict my sample to firm-industries with at least one year of positive exports in 2001–2008 to one of Thailand's top eleven trading partners.[14] With this, I can rule out the majority of firm-industries that have no potential for trading (for example, a car company's exporting food for children) and ensure that the firm at least has a capability to manufacture such products. There are approximately 36,000 potential export relationships in my sample.

TABLE 3: Change in a firm's export status in an industry for small and large firms, restricting sample to firm-industries with positive exports to one of Thailand's top eleven trading partners in at least one year.

Δ export dummy	(1)	(2)	(3)
Tariff reduction	0.138**	0.148**	0.145***
	(0.041)	(0.047)	(0.038)
Tariff reduction × large firms	−0.142***	−0.154***	−0.147***
	(0.017)	(0.021)	(0.020)
Product's sector FE	Yes	–	Yes
Firm's sector FE	–	Yes	Yes
R^2	0.006	0.004	0.008
Observations	35883	35883	35883

Note: Standard errors are clustered at the product's sector level and are shown in the parentheses. Δ denotes a change in a variable during the period 2001–2008. Markers *, **, and *** denote statistical significance at 5, 1, and 0.1 percent confidence levels respectively.

Table 3 reports the estimates for the extensive margin of adjustment with the change in export

[14] Strictly speaking, this should have been firm-industries with at least one year of positive exports to *any* country. However, I do not have the export data for all countries. Thailand's top eleven trading partners are: Australia, China, Germany, Hong Kong, Indonesia, Japan, South Korea, Malaysia, Singapore, the United States, and Vietnam. These countries account for more than 65 percent of Thailand's total exports.

status as the dependent variable. I find that only small firms respond to tariff reduction on the product-level extensive margin. The estimated coefficient on large firms is negative and statistically significant. The test of whether the sum of the coefficients (the overall response for large firms) is indistinguishable from zero cannot be rejected.

To test the robustness of this result, I explore a possible explanation that perhaps the set of potential export relationships is country-specific. Even when I restrict the sample to firm-industries with potential export relationships, there are still numerous industries in which a particular firm exports to other countries but not to Vietnam. For example, tropical fruits could grow in both Thailand and Vietnam. A firm that exports tropical fruits could have potential export relationship with countries in colder regions but might not have one with Vietnam. Figure 7 compares the number of firm-industries that are exported to Vietnam in at least one year (this could be thought of as the number of potential relationships for Vietnam) against the overall number of potential export relationships. The number of firm-industries that actually gets exported to Vietnam as a fraction of total potential firm-industry relationships is around 35 percent for small firms, and 25 percent for large firms.

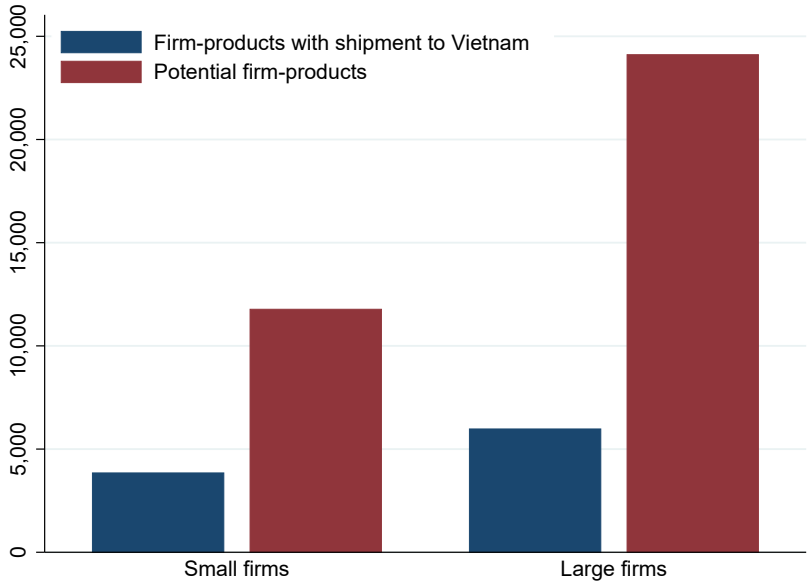


FIGURE 7: The number of firm-industries that are exported to Vietnam in at least one year and the number of total potential firm-industries.

This means that for a given industry, it is more likely that a large firm would not be actually exporting anything into Vietnam but was coded as having a potential export relationship, and therefore the effect of tariff reduction is reduced for large firms. Just to investigate this idea further,

it is possible to restrict the sample to only firm-industries with positive exports to Vietnam in at least one year during the period 2001–2008. The result is presented in Table 4.

TABLE 4: Change in product's export status for small and large firms, restricting sample to firm-industries with positive exports to Vietnam in at least one year.

Δ export dummy	(1)	(2)	(3)
Tariff reduction	0.303**	0.396***	0.305**
	(0.101)	(0.087)	(0.103)
Tariff reduction × large firms	−0.225***	−0.252***	−0.225***
	(0.047)	(0.047)	(0.043)
Product's sector FE	Yes	–	Yes
Firm's sector FE	–	Yes	Yes
R^2	0.009	0.012	0.018
Observations	9818	9818	9818

Note: Standard errors are clustered at the product's sector level and are shown in the parentheses. Δ denotes a change in a variable during the period 2001–2008. Markers *, **, and *** denote statistical significance at 5, 1, and 0.1 percent confidence levels respectively.

When we restrict the sample this way, the effect of tariff reduction becomes larger and more positive as expected. However, the test of whether the sum of the coefficients is indistinguishable from zero still cannot be rejected.

5.4.3 Product-level extensive margin

In addition to the intensive and extensive margins at the firm-industry level, I also look at the firm's response to tariff changes through the change in the number of products it exports within each industry. That is, given that the firm has presence in a particular industry, how do tariff reductions affect its decision to introduce new products within that industry?

Table 5 reports the estimates for the product-level extensive margin of adjustment, with the number of distinct HS 6-digit products within the ISIC 4-digit industry as the dependent variable. The sample is the same as the one used for the intensive margin.

We can see that tariff reduction does not have a statistically significant effect on the product-level extensive margin for small firms. Large firms, in contrast, are extremely responsive to tariff reductions on this margin. A one percent decrease in tariff would lead large firms to add 2.26–2.79 more HS 6-digit products.

To sum up the empirical findings, I find that all firms respond positively on the intensive margin and there are no differential responses between large and small firms. Firms do, however, respond differently on the two extensive margins. Large firms respond to a reduction in trade cost by

TABLE 5: Change in number of unique products for small and large firms.

Δ number of unique products	(1)	(2)	(3)
Tariff reduction	0.537	0.229	0.543
	(0.702)	(0.689)	(0.705)
Tariff reduction × large firms	2.151*	2.032*	2.251*
	(0.849)	(0.859)	(0.870)
Product's sector FE	Yes	–	Yes
Firm's sector FE	–	Yes	Yes
R^2	0.038	0.045	0.063
Observations	888	888	888

Note: Standard errors are clustered at the product's sector level and are shown in the parentheses. Δ denotes a change in a variable during the period 2001–2008. Markers *, **, and *** denote statistical significance at 5, 1, and 0.1 percent confidence levels respectively.

introducing new products within the industries they already have presence in. Small firms, on the other hand, respond by an expansion into new industries.

6 Discussion

In this paper, I develop a three-tier model of multiproduct firms based on Bernard *et al.* (2011) and Eckel and Neary (2010). The model yields standard predictions that, with lower trade cost, firms export more on both the intensive and the extensive margins. The differential response for firms on the product- and industry-level extensive margins, however, depends on the convexity of the cost function.

To learn about the shape of the cost function, I turn to a unique dataset on Thai firms' exports to Vietnam during a major trade liberalization episode from 2001–2008. On the intensive margin, both small and large firms respond positively to tariff reduction. In addition, I find that there is no differential responses between firms with different levels of productivity. This is one of the first empirical supports for the differential responses of heterogeneous firms predicted by the Melitz (2003) model.

On the extensive margin, I find that firms do respond differently. A reduction in tariff leads large firms to export more products within the same industry, whereas small firms respond by exporting products in industries it has never exported before. This pattern suggests that in the two-dimensional product model developed earlier, the cost function is convex in the industry dimension and is concave in the product dimension.

The findings relate to the previous work in the international organization literature by Leonard-

Barton (1992). In her work, the author calls to attention the seemingly paradoxical decision by a manager whether to continue improving the existing technology or upgrade to a completely new technology. If we take the term technology to loosely refer to an industry, this is akin to the choice that a firm has to make about whether the new product it introduces will be within the same industry or in a completely new one. She finds that there is a tendency for firms with high industry-specific capabilities keep innovating in those industries.

In our case, larger, more productive firms have already invested a lot in infrastructure and manufacturing technology to the extent that it would be more efficient to stay within those industries. Smaller firms, on the other hand, have less industry-specific skills. Due to the convexity of the cost function, expanding the product scope within the industry might cost as high as expanding into new industries. As a result, they are more flexible and therefore more willing to "try out" other industries. One possible explanation for the concavity of the cost function in the product dimension is that larger firms tend to have higher brand capital, and this allows them to expand more easily into products that are related to the current product line.

In addition to these aforementioned contributions, I also find that firms do not only export in their primary industry. As a result, using the tariff of a firm's primary industry to measure treatment intensity in order to study the effect of trade liberalization could be problematic, as the firm's exports in other industries could be mistakenly attributed to the primary industry's tariff change.

There are several possibilities for future works. First, in thinking about the product space, requiring the space to be two-dimensional and labeling them as industries and products might be somewhat restrictive. For example, products in different industries as defined by the ISIC might turn out to be quite similar. To this end, a more general way of thinking about the product space would be an interesting extension. Second, and related to the first, is an empirical study of how products that a firm offers are related in that product space. In addition, it would be interesting to see an empirical evidence on how cost curves differ among different industries. Finally, there are still very few studies focusing on the effects of trade liberalization on heterogeneous exporters. More evidence from other countries would be extremely valuable.

References

Baggs, J. (2005). Firm survival and exit in response to trade liberalization. *The Canadian Journal of Economics / Revue canadienne d'Economique*, **38** (4), pp. 1364–1383.

Bernard, A. B., Jensen, J. B., Redding, S. J. and Schott, P. K. (2007). Firms in international trade. *Journal of Economic Perspectives*, **21** (3), 105–130.

—, Redding, S. J. and Schott, P. K. (2011). Multiproduct firms and trade liberalization. *Quarterly Journal of Economics*, **126** (3), 1271 – 1318.

Berthou, A. and Fontagné, L. (2013). How do multiproduct exporters react to a change in trade costs? *The Scandinavian Journal of Economics*, **115** (2), 326–353.

Besedeš, T. and Prusa, T. J. (2011). The role of extensive and intensive margins and export growth. *Journal of Development Economics*, **96** (2), 371 – 379.

Bustos, P. (2011). Trade liberalization, exports, and technology upgrading: Evidence on the impact of mercosur on argentinian firms. *American Economic Review*, **101** (1), 304–40.

Calof, J. L. (1994). The relationship between firm size and export behavior revisited. *Journal of International Business Studies*, **25** (2), pp. 367–387.

Eckel, C. and Neary, J. P. (2010). Multi-product firms and flexible manufacturing in the global economy. *The Review of Economic Studies*, **77** (1), 188–217.

Feenstra, R. and Ma, H. (2008). Optimal choice of product scope for multiproduct firms under monopolistic competition. In E. Helpman, D. Marin and T. Verdier (eds.), *The Organization of Firms in a Global Economy*, Harvard University Press, pp. 173–99.

Leonard-Barton, D. (1992). Core capabilities and core rigidities: A paradox in managing new product development. *Strategic Management Journal*, **13** (S1), 111–125.

Mayer, T., Melitz, M. J. and Ottaviano, G. I. P. (2014). Market size, competition, and the product mix of exporters. *American Economic Review*, **104** (2), 495–536.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, **71** (6), 1695–1725.

— and Ottaviano, G. I. P. (2008). Market size, trade, and productivity. *The Review of Economic Studies*, **75** (1), 295–316.

Trefler, D. (2004). The long and short of the canada-u. s. free trade agreement. *American Economic Review*, **94** (4), 870–895.

A Additional Summary Statistics

Tables 6 and 7 show summary statistics when the sample is restricted further as is used in the regressions. The concern might be that as we restrict our sample to firm-industries with at least one year of positive exports to Vietnam, then to firms with positive exports to Vietnam in both 2001 and 2008, small firms and large firms might become more similar. The tables below indicate that this is indeed not the case, as the average firm size for each group does not vary much from sample to sample.

TABLE 6: Summary statistics, with sample restricted to firm-industries with at least one year of positive exports to Vietnam.

Variable	Small firms				Large firms			
Year 2001	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
Export value (million THB)	0.203	2.417	0.000	130.444	1.603	17.394	0.000	886.958
Export dummy	0.117	0.322	0	1	0.207	0.405	0	1
Number of HS 6-digit products	0.494	1.090	0	8	2.535	5.066	0	30
Median sales revenue	17.492	1.258	11.067	21.264	20.341	1.468	16.524	27.234
Tariff	15.933	13.606	0.000	59.542	15.770	13.655	0.000	59.542
Observations				3844				5974
Year 2008	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
Export value (million THB)	0.916	7.970	0.000	315.004	7.624	105.442	0.000	6756.859
Export dummy	0.392	0.488	0	1	0.450	0.498	0	1
Number of HS 6-digit products	1.827	2.644	0	16	4.587	5.703	0	29
Median sales revenue	17.492	1.258	11.067	21.264	20.341	1.468	16.524	27.234
Tariff	2.669	2.707	0.000	31.916	2.668	2.794	0.000	31.916
Observations				3844				5974

TABLE 7: Summary statistics, with sample restricted to firm-industries with positive exports to Vietnam in both 2001 and 2008.

Variable	Small firms				Large firms			
Year 2001	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
Export value (million THB)	2.099	4.014	0.000	26.370	11.622	47.758	0.000	886.958
Export dummy	1.000	0.000	1	1	1.000	0.000	1	1
Number of HS 6-digit products	1.940	1.508	1	8	5.670	7.309	1	30
Median sales revenue	17.902	1.163	11.067	19.967	20.574	1.477	17.629	27.234
Tariff	15.214	13.026	0.015	49.969	16.244	14.170	0.033	59.542
Observations				149				739
Year 2008	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
Export value (million THB)	4.623	9.615	0.000	66.756	40.547	286.511	0.000	6756.859
Export dummy	1.000	0.000	1	1	1.000	0.000	1	1
Number of HS 6-digit products	2.819	3.100	1	16	6.855	7.791	1	29
Median sales revenue	17.902	1.163	11.067	19.967	20.574	1.477	17.629	27.234
Tariff	2.553	1.681	0.000	5.000	3.026	3.932	0.000	31.916
Observations				149				739

B Robustness

To check for robustness of the regression results, I vary the specification in three dimensions. The results are presented for each of the regressions in the empirical results section. This includes results of tariff reduction on the intensive margin (Table 8), industry-level extensive margin (Table 9), industry-level extensive margin restricting sample to firm-industries with positive exports to Vietnam (Table 10), and the product-level extensive margin (Table 11).

First, I use three different measures of firm size. Recall that firm size is measured by sales revenue. I have firm-level data from 2001 through 2008. Recent digitization efforts help ensure that the data is accurate from 2005 onwards. Because of this as well as missing data for some firms in some years, I use the median (deflated) sales revenue of each firm to measure the firm's size. I show the results if I were to measure the size of the firms by their median sales revenue (columns 1 through 3), sales revenue in 2001 (columns 4 through 6) and sales revenue in 2005 (columns 7 through 9). Using median sales revenue gives results that match more closely to using sales revenue in 2005 than in 2001. Nevertheless, the signs and statistical significances of coefficient estimates remain unchanged.

In addition to using different measures of firm sizes, I also report results from two-stage least squares in the case that tariff reduction is endogenous. The results of two-stage least squares are presented in Panel B of each table. The point estimates are different in some cases, but the signs and statistical significances remain the same.

Finally, I include outlier industries (ISIC industry codes 1551, 1552, and 1600). These are outliers because of the drastic change in tariffs, which results from converting specific tariffs into their ad valorem equivalents. Including the outliers does not have any effect on the sample for intensive margin or the product-level extensive margin, since there is no firm that exports products in these industries in both 2001 and 2008, but adds approximately 100 observations to the regression for the industry-level extensive margin (Table 9) and about 10 observations to the regression for the industry-level extensive margin with restricted sample (Table 10). The results with outliers included are presented in Panels C and D.

TABLE 8: Change in product's log export value for small and large firms.

Measures of firm size	Median sales revenue			Sales revenue in 2001			Sales revenue in 2005		
Δ log export value	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Ordinary least squares									
Tariff reduction	3.861**	3.208**	3.243*	4.716***	3.884***	4.147**	4.306**	3.668**	3.775*
	(1.179)	(1.098)	(1.287)	(1.084)	(0.965)	(1.220)	(1.388)	(1.268)	(1.541)
Tariff reduction × large firms	0.298	0.299	0.782	−0.775	−0.564	−0.342	−0.169	−0.350	0.145
	(1.391)	(1.340)	(1.395)	(1.394)	(1.353)	(1.523)	(1.276)	(1.350)	(1.439)
Product's sector FE	Yes	–	Yes	Yes	–	Yes	Yes	–	Yes
Firm's sector FE	–	Yes	Yes	–	Yes	Yes	–	Yes	Yes
Observations	888	888	888	858	858	858	849	849	849
Panel B: Two-stage least squares									
Tariff reduction	4.270***	3.204**	3.588**	5.173***	3.902***	4.532***	4.828**	3.751**	4.279**
	(1.139)	(1.012)	(1.224)	(1.222)	(0.916)	(1.310)	(1.490)	(1.210)	(1.621)
Tariff reduction × large firms	0.383	0.293	0.881	−0.651	−0.558	−0.196	−0.219	−0.469	0.071
	(1.348)	(1.296)	(1.339)	(1.290)	(1.277)	(1.402)	(1.242)	(1.329)	(1.397)
Product's sector FE	Yes	–	Yes	Yes	–	Yes	Yes	–	Yes
Firm's sector FE	–	Yes	Yes	–	Yes	Yes	–	Yes	Yes
Observations	888	888	888	858	858	858	849	849	849

Note: Standard errors are clustered at the product's sector level and are shown in the parentheses. Δ denotes a change in a variable during the period 2001–2008. Markers *, **, and *** denote statistical significance at 5, 1, and 0.1 percent confidence levels respectively.

TABLE 9: Change in a firm's export status in an industry for small and large firms, restricting sample to firm-industries with positive exports to one of Thailand's top eleven trading partners in at least one year.

Measures of firm size	Median sales revenue			Sales revenue in 2001			Sales revenue in 2005		
Δ export dummy	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Ordinary least squares									
Tariff reduction	0.138**	0.148**	0.145***	0.157**	0.153**	0.157**	0.139**	0.144**	0.144**
	(0.041)	(0.047)	(0.038)	(0.042)	(0.041)	(0.042)	(0.041)	(0.046)	(0.038)
Tariff reduction × large firms	−0.142***	−0.154***	−0.147***	−0.164***	−0.172***	−0.164***	−0.128***	−0.141***	−0.133***
	(0.017)	(0.021)	(0.020)	(0.023)	(0.027)	(0.024)	(0.019)	(0.023)	(0.023)
Product's sector FE	Yes	–	Yes	Yes	–	Yes	Yes	–	Yes
Firm's sector FE	–	Yes	Yes	–	Yes	Yes	–	Yes	Yes
Observations	35883	35883	35883	30882	30882	30882	33405	33405	33405
Panel B: Two-stage least squares									
Tariff reduction	0.160***	0.166***	0.167***	0.182***	0.173***	0.181***	0.160***	0.160***	0.166***
	(0.042)	(0.048)	(0.038)	(0.043)	(0.043)	(0.044)	(0.041)	(0.047)	(0.038)
Tariff reduction × large firms	−0.144***	−0.156***	−0.149***	−0.168***	−0.177***	−0.169***	−0.128***	−0.141***	−0.132***
	(0.017)	(0.021)	(0.020)	(0.024)	(0.028)	(0.026)	(0.019)	(0.023)	(0.023)
Product's sector FE	Yes	–	Yes	Yes	–	Yes	Yes	–	Yes
Firm's sector FE	–	Yes	Yes	–	Yes	Yes	–	Yes	Yes
Observations	35883	35883	35883	30882	30882	30882	33405	33405	33405
Panel C: Ordinary least squares, including outlier industries									
Tariff reduction	0.139**	0.151**	0.146***	0.155**	0.154**	0.154**	0.136**	0.144**	0.142***
	(0.040)	(0.046)	(0.037)	(0.041)	(0.041)	(0.041)	(0.040)	(0.046)	(0.037)
Tariff reduction × large firms	−0.148***	−0.160***	−0.153***	−0.167***	−0.176***	−0.167***	−0.129***	−0.142***	−0.133***
	(0.017)	(0.021)	(0.020)	(0.023)	(0.027)	(0.025)	(0.019)	(0.023)	(0.023)
Product's sector FE	Yes	–	Yes	Yes	–	Yes	Yes	–	Yes
Firm's sector FE	–	Yes	Yes	–	Yes	Yes	–	Yes	Yes
Observations	35938	35938	35938	30932	30932	30932	33459	33459	33459
Panel D: Two-stage least squares, including outlier industries									
Tariff reduction	0.160***	0.169***	0.168***	0.179***	0.173***	0.179***	0.156***	0.159***	0.163***
	(0.041)	(0.047)	(0.038)	(0.042)	(0.043)	(0.043)	(0.040)	(0.046)	(0.037)
Tariff reduction × large firms	−0.149***	−0.162***	−0.155***	−0.171***	−0.180***	−0.172***	−0.128***	−0.142***	−0.133***
	(0.017)	(0.021)	(0.020)	(0.024)	(0.029)	(0.026)	(0.020)	(0.024)	(0.023)
Product's sector FE	Yes	–	Yes	Yes	–	Yes	Yes	–	Yes
Firm's sector FE	–	Yes	Yes	–	Yes	Yes	–	Yes	Yes
Observations	35938	35938	35938	30932	30932	30932	33459	33459	33459

Note: Standard errors are clustered at the product's sector level and are shown in the parentheses. Δ denotes a change in a variable during the period 2001–2008. Markers *, **, and *** denote statistical significance at 5, 1, and 0.1 percent confidence levels respectively.

TABLE 10: Change in product's export status for small and large firms, restricting sample to firm-industries with positive exports to Vietnam in at least one year.

Measures of firm size	Median sales revenue			Sales revenue in 2001			Sales revenue in 2005		
Δ export dummy	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Ordinary least squares									
Tariff reduction	0.303**	0.396***	0.305**	0.384*	0.459***	0.376*	0.306*	0.391***	0.309*
	(0.101)	(0.087)	(0.103)	(0.136)	(0.101)	(0.135)	(0.117)	(0.089)	(0.119)
Tariff reduction × large firms	−0.225***	−0.252***	−0.225***	−0.363***	−0.394***	−0.363***	−0.193***	−0.232***	−0.206***
	(0.047)	(0.047)	(0.043)	(0.076)	(0.078)	(0.073)	(0.037)	(0.037)	(0.034)
Product's sector FE	Yes	–	Yes	Yes	–	Yes	Yes	–	Yes
Firm's sector FE	–	Yes	Yes	–	Yes	Yes	–	Yes	Yes
Observations	9818	9818	9818	8479	8479	8479	9086	9086	9086
Panel B: Two-stage least squares									
Tariff reduction	0.339***	0.427***	0.340***	0.430**	0.498***	0.420**	0.341**	0.416***	0.343**
	(0.099)	(0.089)	(0.100)	(0.135)	(0.103)	(0.134)	(0.113)	(0.090)	(0.114)
Tariff reduction × large firms	−0.218***	−0.246***	−0.219***	−0.369***	−0.401***	−0.370***	−0.183***	−0.223***	−0.196***
	(0.048)	(0.047)	(0.043)	(0.078)	(0.079)	(0.074)	(0.041)	(0.040)	(0.038)
Product's sector FE	Yes	–	Yes	Yes	–	Yes	Yes	–	Yes
Firm's sector FE	–	Yes	Yes	–	Yes	Yes	–	Yes	Yes
Observations	9818	9818	9818	8479	8479	8479	9086	9086	9086
Panel C: Ordinary least squares, including outlier industries									
Tariff reduction	0.287**	0.393***	0.290**	0.359**	0.449***	0.352*	0.280*	0.378***	0.284*
	(0.095)	(0.085)	(0.098)	(0.126)	(0.097)	(0.126)	(0.105)	(0.085)	(0.108)
Tariff reduction × large firms	−0.238***	−0.265***	−0.240***	−0.368***	−0.399***	−0.369***	−0.193***	−0.232***	−0.207***
	(0.046)	(0.047)	(0.042)	(0.075)	(0.077)	(0.072)	(0.037)	(0.037)	(0.034)
Product's sector FE	Yes	–	Yes	Yes	–	Yes	Yes	–	Yes
Firm's sector FE	–	Yes	Yes	–	Yes	Yes	–	Yes	Yes
Observations	9832	9832	9832	8490	8490	8490	9100	9100	9100
Panel D: Two-stage least squares, including outlier industries									
Tariff reduction	0.323***	0.424***	0.326***	0.405**	0.488***	0.396**	0.316**	0.403***	0.319**
	(0.093)	(0.087)	(0.096)	(0.126)	(0.099)	(0.125)	(0.102)	(0.086)	(0.104)
Tariff reduction × large firms	−0.231***	−0.260***	−0.234***	−0.373***	−0.406***	−0.375***	−0.182***	−0.222***	−0.197***
	(0.047)	(0.047)	(0.042)	(0.077)	(0.078)	(0.073)	(0.042)	(0.040)	(0.038)
Product's sector FE	Yes	–	Yes	Yes	–	Yes	Yes	–	Yes
Firm's sector FE	–	Yes	Yes	–	Yes	Yes	–	Yes	Yes
Observations	9832	9832	9832	8490	8490	8490	9100	9100	9100

Note: Standard errors are clustered at the product's sector level and are shown in the parentheses. Δ denotes a change in a variable during the period 2001–2008. Markers *, **, and *** denote statistical significance at 5, 1, and 0.1 percent confidence levels respectively.

TABLE 11: Change in number of unique products for small and large firms.

Measures of firm size	Median sales revenue			Sales revenue in 2001			Sales revenue in 2005		
Δ number of unique products	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Ordinary least squares									
Tariff reduction	0.537	0.229	0.543	0.772	0.409	0.803	0.728	0.293	0.709
	(0.702)	(0.689)	(0.705)	(0.676)	(0.654)	(0.715)	(0.736)	(0.699)	(0.674)
Tariff reduction × large firms	2.151*	2.032*	2.251*	2.025*	1.941*	2.101*	2.001*	1.924*	2.123*
	(0.849)	(0.859)	(0.870)	(0.807)	(0.848)	(0.870)	(0.901)	(0.883)	(0.899)
Product's sector FE	Yes	–	Yes	Yes	–	Yes	Yes	–	Yes
Firm's sector FE	–	Yes	Yes	–	Yes	Yes	–	Yes	Yes
Observations	888	888	888	858	858	858	849	849	849
Panel B: Two-stage least squares									
Tariff reduction	0.561	0.093	0.547	0.751	0.262	0.755	0.755	0.119	0.704
	(0.726)	(0.716)	(0.693)	(0.703)	(0.671)	(0.683)	(0.790)	(0.768)	(0.689)
Tariff reduction × large firms	2.069**	1.901*	2.164**	1.957**	1.815*	2.034*	1.910*	1.841*	2.057*
	(0.784)	(0.790)	(0.792)	(0.745)	(0.780)	(0.802)	(0.842)	(0.813)	(0.821)
Product's sector FE	Yes	–	Yes	Yes	–	Yes	Yes	–	Yes
Firm's sector FE	–	Yes	Yes	–	Yes	Yes	–	Yes	Yes
Observations	888	888	888	858	858	858	849	849	849

Note: Standard errors are clustered at the product's sector level and are shown in the parentheses. Δ denotes a change in a variable during the period 2001–2008. Markers *, **, and *** denote statistical significance at 5, 1, and 0.1 percent confidence levels respectively.