Rules of Origin and Firm Heterogeneity*

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Abstract

This paper develops a heterogeneous firm model to study the effects of trade policy, trade preferences and the rules of origin needed to obtain them (ROOs) and applies it to Bangladeshi garment exports to the US and EU. There are differences across products and export destinations that make for an interesting natural experiment. These differences are shown to generate differences in the composition of exporters and productivities. Data on Bangladeshi garment exporters is used to construct firm level total factor productivity estimates. Predictions of the model on the relation between the distributions of TFP of various groups of firms are tested non parametrically. We show that the facts match the predictions of the model.

Keywords: Rules of origin, firm heterogeneity, export performance and productivity.
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1 Introduction

This paper studies the effect of trade policy, trade preferences and the rules of origin ($ROOs$) needed to obtain them, on the pattern of firm exports and performance when firms have heterogenous productivity. The predictions of the model are tested using a new data set on Bangladeshi garment exporters to the US and EU. To date, the entire literature in this area assumes that firms are homogeneous ex ante: see, for example, Krueger (1999), Krishna and Krueger (1995), Ju and Krishna (2005). When firms are homogeneous, they will not make different choices unless they are indifferent between the alternatives and even then, their choices will be random. If firms do make systematically different choices, then homogenous firm models, while useful, miss an essential part of the story and as a result, their predictions and policy prescriptions could be quite misleading.[1] That firms in an industry do behave very differently is acknowledged. Eaton, Kortum and Kramarz (2004, 2005), for example, model and document the major differences among French firms in terms of market participation and size.

Why look at Bangladesh? First, Bangladesh is among the major garment suppliers to both the EU and US markets.[2] Second, we have a unique firm level data set (with information on costs as well as export destinations) for a sample of 350 garment exporters in Bangladesh that was collected under the auspices of the World Bank and the Government of Bangladesh.[3] We also have complete customs data on all exporting garment firms in Bangladesh. This data was provided by the Bangladesh export authority. It has information on sales and volume of exports for the whole population of exporting firms in 2004 by major destination markets. Third, there are differences across products (garments made from woven cloth and non woven ones, sweaters and knitwear) and export destinations (the EU and the US) that make for an interesting natural experiment. This is described in detail in the next section.

In the data, firms exporting garments made from woven cloth seem to behave very differently from firms exporting non woven garments both in terms of their sales to the US and to the EU and in terms of firm productivity. Although the EU is the favored export destination for Bangladeshi

[1] For example, Bernard, Redding and Schott (2005) argue that trade liberalization forces firms to focus on their core competencies, which provides an additional source of gains from liberalization.

[2] According to data obtained from Comtrade, in 2003, Bangladesh supplied \$3.7 and \$1.8 billion worth of apparel products to the EU and US, and ranked the 7th and 8th in the two markets, respectively.

[3] The same data set is used in Kee (2005) to study the possible horizontal spillover effects on the productivity of domestic firms due to productivity growth in FDI firms.

firms as a whole, it is less so for firms making woven garments. While the EU bias can easily be explained in a standard homogeneous firm setting by the less harsh trade policy of the EU overall, homogenous firm models cannot explain another fact that is clear in the data: namely, firms that export to the US are larger, more productive, and tend to export to more markets than those who export to the EU. This is especially so in the non woven sector. Thus, a heterogeneous firm setup is clearly called for.

In order to see how firms with different productivity behave as a results of the differences in the *ROOs* of the EU and US, we build on the work of Melitz (2003). We allow for *ROOs* to affect both the fixed costs and marginal costs of exporting and model the differences across markets and products. We show that the model makes a number of predictions about the mean productivities of various groups of firms as well as the distributions of their productivities in terms of the first order stochastic dominance partial order.

We estimate firm productivity using Olley and Pakes (1996), while allowing for firm and year specific effects in the estimation. The estimated firm productivity is then related to export performance of the firms. We consider both the within and between variation of the data set. We estimate the effects of the trade policy differences on mean firm productivity[4], using as controls the differences between export destination markets as well as the differences between sectors. In addition, we employ a nonparametric test of stochastic dominance developed in Anderson (1996) to compare the productivity distributions of firms exporting to different markets in different industries. Our predictions are shown to be consistent with the data.

Thus, the contribution of this paper is as follows. First, our heterogenous firm model shows how differences in trade policy of the EU and US and in the preferences granted by them to Bangladesh, in combination with the *ROOs* needed to access them, act as a sorting mechanism for firms. This results in productivity differences between firms that differ in their product lines and markets. We are able to capture both how firm productivity differs according to the toughness of the exporting market, and how the toughness of the market depends on *ROOs* and trade policy. The former channel is missing in homogenous firm models. Our model makes simple predictions about differences in the market equilibrium in a heterogenous firm setting as a result of such trade policy differences.[5] (This is important because the effects of policy in such models can differ significantly

[4] The mean productivity is increasing in the cutoff level and so can be seen as a proxy for it.

[5] Although there are a number of papers now dealing with heterogeneous firm models in general equilibrium (see,

from that in a homogeneous firm setting. For example, if liberal preferences given by the EU to Bangladesh reduce the average productivity of firms exporting to it from Bangladesh, then such preferences may not spur very much of an increase in imports.) Second, we take the model to the data and show that the empirical evidence supports the model's predictions. Thus, our paper adds to this growing literature: see, for example, Russ (2004), and Eaton, Kortum and Kramarz (2004, 2005).[6]

The paper is organized as follows. Section 2 contains a brief discussion of the trade environment in which the industry operates. Section 3 describes the data. Section 4 lays out the theoretical model. The estimation of firm productivity and tests of the model's predictions are presented in Section 5. Section 6 concludes.

2 The Trade Environment

There are three main components of the trade environment in the Apparel sector as far as trade with the US and EU goes: namely, the trade policy of the US and the EU, the trade preferences granted to Bangladesh, and rules of origin upon which preferences are conditional.

2.1 Trade Policy of the US and EU

Both the US and EU had trade restrictions in the Apparel industry in 2004-2005. The EU had an MFN tariff rate of 12-15% on the various categories of apparel. There were no quotas presented. The US, on the other hand, had tariffs of about 20% as well as country and product specific quotas in place in selected apparel categories.[7] Thus, countries with less of a comparative advantage in apparel are at less of an disadvantage in the US than they would be in the absence of the quota as the quota in effect guarantees them a niche as long as they are not too inefficient. Their inefficiency reduces the price of their quota licenses, while the quota licenses of a very competitive country

for example, Melitz (2003), Bernard, Eaton, Jensen, and Kortum (2003), Bernard, Redding, and Schott (2004)), this paper is the first to our knowledge that focuses of the results of differential trade policies.

[6] They model and document the major differences among French firms in terms of market participation, size, and export intensity. Our work complements theirs as we can construct TFP indices at a firm level while they have to use differences in value added across firms.

[7] Of the 924 HS 10 digit garment products Bangladesh exported to the US each year (1998-2004), half were subjected to quota restrictions. In terms of value, 74% of garment import from Bangladesh was in the woven industry (HS62), and the remaining 26% was in the knitwear industry (HS61), which also included sweaters. Roughly 75% of exports was under quota.

would be highly priced. Note also that as the quotas are country specific, exporting is contingent on obtaining origin: that is, unless the good is shown to originate from Bangladesh, it cannot enter under its quota.

2.2 Trade Preferences Granted to Bangladesh

As a least developed country, Bangladesh obtains zero tariffs on its EU exports of apparel (as long as origin requirements are met) under the "Everything But Arms" (EBA) initiative. This gives it a substantial advantage in the EU over other developing countries, like India, who merely get GSP preferences. GSP preferences would reduce an MFN tariff of 12% in the EU, by 20%, or about 2.4% in absolute terms. So India would pay 9.6% while Bangladesh would pay zero on their apparel exports to the EU.

2.3 Rules of Origin

ROOs specify constraints that must be met in order to obtain origin and thereby qualify for country specific quotas or trade preferences.[8] They can take a variety of forms. The important thing to note is that, whatever the form, if *ROOs* are binding then the choice of inputs used in production differs from the unconstrained ones. Hence, costs are higher if the *ROOs* are met. Since more restrictive *ROOs* constrain choices more than do less restrictive ones, an increase in restrictiveness raises the minimized level of costs. Thus, from an analytical viewpoint, *ROOs* raise the production costs of the product when they are binding. On the other hand, they may provide access to the market at a lower tariff and this benefit has to be traded off against the cost.

US *ROOs* regarding apparel products are governed by Section 334 of the Uruguay Round Agreements Act.[9] Particularly, for the purpose of tariffs and quotas, an apparel product is considered as originating from a country if it is wholly assembled in the country. No local fabric requirement is necessary. Thus, the products of a firm are not penalized if the firm chooses to use imported fabrics. All apparel products are subjected to non-preferential tariffs of about 20%, and prior to January 2005, selected apparel categories were subjected to quota restrictions that were country specific.

[8] For a relatively comprehensive and up to date survey see Krishna (2005).

[9] For details, please, refer to the following website:
http://www.washingtonwatchdog.org/documents/usc/ttl19/ch22/subchIII/ptB/sec3592.html

On the other hand, EU *ROOs* on apparel products are considerably more restrictive. According to Annex II of the GSP (Generalized System of Preferences) guidebook which details the *ROOs* of all products, for an apparel product to be considered originated from a country, it must start its local manufacturing process from yarn.[10] In other words, the use of imported fabrics in apparel products would result in the product failing to meet the *ROOs* for the purpose of tariff and quota preferences under GSP or EBA for the case of LDCs. It would thus be subject to MFN tariffs of about 12% to 15%.

Within the garment industry, there are two major sub-industries, namely, non-woven (knitwear and sweaters) and woven garments. Due to current production techniques, non-woven firms are able to manufacture garments from yarn. Thus, they can easily satisfy the *ROOs* of EU and can obtain tariff preferences at low cost. However, firms making garments from woven material (woven firms) mostly assemble cut fabrics into garments. Given the limited domestic supply of woven cloth[11], it commands a premium price, so that woven garment makers can meet *ROOs* only by paying a roughly 20% higher price for cloth which translates into a significantly higher cost of production as cloth is a lions share of the input cost. The cost of cloth to FOB price is roughly is $70 - 75\%$ for shirts, dresses, and trousers[12], so that this directly translates into a 15% cost disadvantage.[13] In contrast, US *ROOs* do not discriminate against the origin of fabrics: assembly is all that is required. Nor does the US give tariff preferences to Bangladeshi garments, and the presence of country specific quotas in most categories make meeting *ROOs* mandatory for exports.

Thus, an item exported to the US may be considered as a product of Bangladesh and imported under the quota allocation of Bangladesh. However, the same item may fail to meet the *ROOs* of the EU and would not qualify for the 12-15% tariff preference under the EBA initiative.

[10] For the details, please, refer to the following websites:
1. EBA user guide:
http://europa.eu.int/comm/trade/issues/global/gsp/eba/ug.htm
2. Annex II on GSP:
http://europa.eu.int/comm/taxation_customs/common/publications/info_docs/customs/index_en.htm

[11] Of 1320 million meters of total demand in 2001, only 190 was locally supplied in the woven sector while 660 of the total of 940 million meters of knit fabric was locally supplied according to a study by the company, Development Initiative, in 2005.

[12] See Table 33 in Development Initiative (2005).

[13] In contrast, India has the ability to meet its woven cloth needs domestically at competitive prices so that its firms can avail themselves of GSP preferences in the EU. As a result, Bangladeshi firms find themselves at a disadvantage in woven garments.

3 The Data

We use two data sets. The first a limited data set on the complete set of exporters and their markets. The second is a more complete data set on a smaller subset of exporters from a firm level survey. The firms in our survey data are also matched with the firms in the exporters data set. This allows us to perform a number of cross checks on the results based on the firm level survey data.

3.1 Firm Level Export Data

The customs data set contains data on exports for *all* firms that applied for Country of Origin Certificates in 2004. This certificate is requested by the importing countries to verify the origin of the good and is a needed to export and apply for trade preferences. Thus, this data set consists of the whole population of exporting firms in the garment industry of Bangladesh. This data set has information on the 2387 garment firms exporting in 2004. The total value of exports is US$11.6 billion, with more than 400 million dozens of garment exported. Overall, in terms of value, nearly 79% of garments are exported to the EU, 10% to the US, and the remaining 11% go to the other countries such as Canada and Australia. In terms of the distribution of firms across different markets in 2004, there are 1967 (82.4%) firms exporting under GSP, mainly to the European market, 1039 (43.5%) firms exporting to the US, of which 709 (29.7%) export under quota allocations, and 1231 (51.6%) firms exporting to other countries.[14]

If we consider the distribution of firms by number of export destinations, we find that of all exporting firms, 47% only supply to one market, 34% supply to two markets, 14% to three markets, and 5% to all four markets.

Figure 1 presents the choice of export markets of Bangladesh garment exporters according to the number of export markets the firms supply. It is very clear that the EU is the most popular destination, especially among firms that have only one export market. Among the 1109 firms that only supply one market, nearly 850 firms (76%) concentrate on the EU. The US market appears to be the toughest to break into: among this group of firms, less than 8% only export to the US with and without quota.

[14]The composition of US imports is biased towards knitwear, which are cheaper than sweaters so that the value share of the US is less than its share in terms of firms or output.

Eaton, Kortum and Kramarz (2004) study the export performance of French firms. Their work suggests that the number of markets a firm supplies reflects the productivity and competitiveness of the firm in the world market. This is consistent with the evidence in our data. If we plot the unit value of garment exports against the total export value or the number of export destinations, we find a monotonic relationship exists. Firms that export to more destinations have higher average unit values and are larger in size. The former is likely to be correlated with better quality and the latter with greater scale economies. Both are likely to be positively correlated with firms productivity.[15] Therefore, our data is consistent with their conjectures.

Thus, there seem to be significant differences in firms exporting to the EU and the US. Firms exporting to the US tend to export to many markets, while those that sell to the EU tend to sell only to the EU. Consequently, firms exporting to the US should have higher unit values and be larger than those exporting to the EU: we will see that this is true in the woven sector but not in the non woven sector.

These differences seem to be product based as well. Given that this customs data set consists of the whole population of firms exporting to the EU and US in different sub-industries, we can compare unit values of exports to the EU and US in different product categories. On average, the unit value per dozen within the woven industry is $58 for firms exporting to the US under quota, whereas that for the EU exporters is only $34. On the other hand, within the non-woven industry, unit values per dozen for the US and EU are $30 and $35, respectively, with the unit value of sweaters being $38 and $46 respectively, and the unit value of knitwear being about $28 for both countries. In other words, there seem to be significant price differences in the woven industry between the two export destinations, whereas the price differences in the non-woven industry seem to be much smaller.

3.2 Firm Level Survey Data

The firm level survey was conducted from the period of November 2004 to April 2005. It covers a stratified random sample of 350 firms, which is about 10% of the total population of the garment firms currently operating in Bangladesh. After cleaning up the data to exclude outliers and firms with incomplete information, there are a total of 232 firms in the unbalanced final panel of 1027,

[15] The differences in unit values and total size among firms with different number of markets are statistically significant.

from 1999 to 2003. In this unbalanced panel, the composition of sub-industries of knitwear, sweaters, and woven is 24%, 8%, and 68%, respectively.

Table 1 presents the sample means of the key variables by the sub-industries of non-woven and woven, and export destinations (EU vs US). In the woven sector, firms exporting to the US are in general larger in sales, in exports, they purchase more material inputs, including imported materials, have more investment and hire more employees. They have a slightly smaller capital stock. In the non woven sector, the opposite occurs: EU variables are larger, except for slightly lower employee numbers. Particularly striking is the more than tenfold higher investment level of firms exporting to the EU in the non woven sector, a clear indication of expectations regarding future profitability. Thus, there are significant differences across firms in the different industries and export destinations.[16]

Before we move on to our theoretical model and the empirical tests, are there any signs in the two data sets we have that indicate that trade policy, preferences, and *ROOs* in the EU and US play a role in sorting firms? The answer is yes. Overall, non-woven firms seem to behave very differently both in terms of their sales to the US and to the EU. Although the EU is the favored export destination for Bangladeshi firms as a whole, it is less so for firms making woven garments. While only 24% of the sampled firms exported more than 50% of their output to the US, i.e., were majority US exporters, 90% of the these made woven garments. On the other hand, while 51% of the sampled firms were majority EU exporters, only 58% of these made woven garments. Despite this, only 34% of all firms exporting woven garments were majority US exporters, while 46% were majority EU exporters confirming a EU bias even among woven firms.

This differential EU bias can be explained by the differences in trade policy and *ROOs* in the two destinations. Overall, trade policy was harsher in the US. Though *ROOs* were stricter in the EU than in the US, especially in the woven sector, the EU gave significant preferences to Bangladeshi exporters counteracting the stricter *ROOs*, and tariffs were lower in the EU, which, unlike the US, had no quotas. This helps to explain why the EU is by far the most preferred first market for Bangladeshi firms, especially for non-woven firms.

However, the differences between firms that export to the US and EU in woven and non woven

[16] How does this firm survey data compare to the custom data set? For the five year sample period, our firm level survey slightly over-samples the US firms, which tend to be larger, and under-samples the smaller firms that only export to the EU.

garments as documented above, cannot be explained except by appealing to firm heterogeneity. Moreover, firms who export to the US have higher unit values which could signal higher productivity than those who export to the EU in non-woven garments, but are similar in woven garments. All of this points to a heterogeneous firm setup being called for. Recall that if firms were homogeneous, then all firms would behave in the same manner and any differences in behavior between them would be random. This is clearly not the case here.

4 The Model

There has been an explosion of interest in heterogeneous firm models in trade in the last few years. It has been well understood for some time that there are significant differences empirically between firms who produce solely for the domestic market and exporters. For one, exporters tend to be more productive as documented in work by Roberts and Tybout (1997) and Bernard and Jensen (1999). Also see Tybout (2002) for a very nice survey of much of this work. However, till recently, there were few theoretical models, at least general equilibrium ones, in trade where firm heterogeneity played a major role. Quite recently, Melitz (2003) and Bernard, Eaton, Jensen and Kortum (2003) provided two quite different approaches to incorporating firm heterogeneity in a reasonably simple and meaningful way into such models.[17]

The assumptions made in the model below are based on the differential *ROOs* and trade policies in the US and EU described earlier. We will use a simple partial equilibrium setting based on the setup in Melitz (2003). This will serve as the basis for the intuition behind the results.[18] We first set up the demand side. Then we explain how firms behave in the presence of *ROOs* and provide the intuition behind our results on the equilibrium effects of *ROOs*. The complete model is in the Appendix.

4.1 Utility

Utility is given by

$$U = (N)^{1-\beta} (Q)^{\beta},$$

[17] See Bernard, Redding, and Schott (2004) for an extension of Melitz (2003) to a Heckscher Ohlin setting.

[18] The complete general equilibrium model is laid out and solved in the appendix.

where Q can be thought of as the services produced by consuming $q(\omega)$ of each of a continuum of varieties indexed by ω. N is a numeraire good, which is freely traded and takes a unit of effective labor to produce. Let the production function take the constant elasticity of substitution form so that

$$Q = \left[\int_{\omega} q(\omega)^{\rho} d\omega \right]^{\frac{1}{\rho}}, \tag{1}$$

where

$$\sigma = \frac{1}{1-\rho} > 0 \tag{2}$$

is the elasticity of substitution. The cost of a util defines the price index

$$P = \left[\int_{\omega} p(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}, \tag{3}$$

which is the price of the a service given the varieties produced.

The derived demand for each variety is then the unit input requirement of the variety (which is the partial derivative of P with respect to $p(\omega)$, which equals $\left[\frac{p(\omega)}{P}\right]^{-\sigma}$) times the number of utils Q :

$$q(\omega) = \left[\frac{p(\omega)}{P} \right]^{-\sigma} Q. \tag{4}$$

4.2 Pricing and Equilibrium

Q and P are taken as given by each firm since there is a continuum of firms. Firms differ according to their productivity level ϕ, and a firm with productivity ϕ has a unit labor requirement (ULR) of $\frac{1}{\phi}$. With wages set at unity, such a firm has a cost of $\frac{1}{\phi}$. Firms draw ϕ independently from the density function $g(\phi)$. To make such a draw, the firm must pay an entry fee of f_e, and to produce in any given period, it must pay a fixed cost f. Once ϕ is realized, it stays with the firm forever as long as it does not die. Profits are zero if a firm exits. We assume that all varieties are symmetric. Each firm first pays the entry fee, gets a draw of productivity, then decides whether to stay in or not, and if it stays in, decides which markets to serve and how.

As each variety is symmetric, and a firm is a monopolist over its variety, price depends only on the productivity draw, not the variety per se, so profit maximization results in

$$p(\phi) = \frac{1}{\rho\phi}. \tag{5}$$

Revenue is

$$\begin{aligned} r(\phi, .) &= p(\phi)q(\phi) \\ &= p(\phi)^{1-\sigma} P^{\sigma} Q \\ &= \left(\frac{p(\phi)}{P}\right)^{1-\sigma} PQ, \end{aligned} \tag{6}$$

where $PQ \equiv E$ ($= \beta I$, where I is total income) is aggregate expenditure on all differentiated goods. Since $\sigma > 1$, firms with ϕ close to zero whose price goes to infinity get close to zero in variable profits. Note that output share and revenue share depend inversely on price relative to average price of goods produced. Using (5) and (6), it follows that per period profits are

$$\pi(\phi, .) = \frac{r(\phi, .)}{\sigma} - f. \tag{7}$$

As profits rise with ϕ due to the envelope theorem, and since firms pay f to produce, as well as a marginal cost, low productivity firms will exit so that only firms with $\phi > \phi^*$ stay in. As a result, ex-post, ϕ is distributed as $M\mu(\phi)$ if a mass of M firms is in the market and get realizations according to $g(\phi)$, where $\mu(\phi) = \frac{g(\phi)}{1-G(\phi^*)}$.

Firms are assumed to die at a constant rate δ, independent of age. A mass M_e of firms enters in each period and entering firms draw their ϕ from the same distribution, $g(.)$. Because of this assumption, in steady state, the mass of successfully entering firms is exactly equal to the mass of firms that die, or

$$\left(1 - G\left(\phi^*\right)\right) M_e = \delta M. \tag{8}$$

Thus, if we know M and ϕ^*, we know M_e, and, as will become apparent, all the endogenous variables in the model.

Using equation (3) and (5), the fact that the cutoff level is ϕ^*, and that a mass of M firms is in the market gives

$$P = \left[M \int_{\phi^*} \left(\frac{1}{\rho\phi} \right)^{1-\sigma} \frac{g(\phi)}{1 - G(\phi^*)} d\phi \right]^{\frac{1}{1-\sigma}} \tag{9}$$

$$= p(\tilde{\phi}(\phi^*)) M^{\frac{1}{1-\sigma}}. \tag{10}$$

The price index, P, depends on the cutoff level, ϕ^*, which defines the representative firm $\tilde{\phi}(\phi^*)$, and the mass of firms, M. It is easy to verify that $P(\phi^*, M)$ is decreasing in ϕ^*, since an increase in ϕ^* makes firms more productive on average so that the average price charged falls. Similarly, an increase in M reduces $P(\phi^*, M)$ as consumers like variety.

Basically, ϕ^* will be determined by ex post profits of the marginal firm, $\pi(\phi^*, .) = 0$. M will be determined from the ex ante condition that entry will occur till expected profits from entering are zero. This defines the closed economy equilibrium.

4.3 Trade and Trade Policy

Next we turn to how trade and trade policy of the kind we want to model can be incorporated. Trade makes the choices open to a Bangladeshi firm more complex as firms have additional choices: to export or not, to invoke preferences or not if these are available, and which markets to export to? Fortunately, since marginal costs are constant, decisions in each market are independent.

Assume a firm must pay f_x each period to export to any given market. There are transport costs τ of the iceberg form so that if $\tau > 1$ units leave, one unit arrives.[19] As a result, the profits of a Bangladeshi firm with productivity ϕ from exporting F without invoking preferences market, which has an aggregate price P^F, are the same as that of a domestic firm in F with a productivity $\frac{\phi}{\tau}$.

Since there are fixed costs which can be more easily covered by more productive firms with larger sales, all firms with productivity above a threshold ϕ_x^* will find it worth exporting and all firms with productivity above ϕ^* will produce for the domestic market. If fixed costs of exporting are large relative to those of producing domestically, then the cutoff for exports will exceed that

[19] Ad-valorem tariffs would affect the firms behavior in the same way, but would also result affect net government revenue and hence the general equilibrium. Quotas can be handled by converting the license price of a quota into its ad valorem equivalent.

for domestic production and only the more productive firms will be exporters.

4.3.1 Incorporating Preferences and Quotas

How can *ROOs* be incorporated? Let the superscript $j = B, U, E$ denote the level of the variable in Bangladesh, the US, and the EU, respectively. Let a dual superscript ij, where $i, j = B, U, E$ and $i \neq j$, denote the policy set by i on j. Thus, τ^U is the tariff set by the US and as this is an MFN tariff, it has no second index. λ^{EB} is the preference the EU gives Bangladesh and as it is country specific, it has a dual index. However, as Bangladesh is the only country we are considering, we can simplify our notation and denote λ^{EB} by λ^E.

If the firm meets *ROOs*, its cost of production for the export market is $\left(\frac{\theta}{\phi}\right)$ per unit, where $\theta > 1$ to reflect the cost of meeting *ROOs*. But it faces lower tariffs so its trade costs are $\lambda\tau$, where $\lambda < 1$ is the fraction of trade costs they are exempt from. Thus, the revenue of a firm in Bangladesh with draw ϕ, that chooses to meet *ROOs*, from exporting to the US, is that of a firm situated in the US with draw $\frac{\phi}{\tau\lambda\theta}$. Moreover, there are fixed documentation costs of d. The revenues earned by a Bangladeshi firm exporting to the EU and meeting *ROOs* are, thus, given by $r(\frac{\phi}{\tau^E\lambda^E\theta^E}, P^E, E^E)$.[20] For any firm to choose to meet *ROOs*, $\lambda\theta$ must be less than unity.

4.3.2 Bangladeshi Firms Choices

Bangladeshi firms have several options to choose from in terms of serving each of their three potential markets in our model. When it comes to their domestic market, they can not produce and get 0, or produce. Thus, from this market they get $\max\left(0, \frac{r(\phi, P^B, E^B)}{\sigma} - f\right)$.

When it comes to exporting to the EU, they can choose not to do so, export under EBA and meet *ROOs*, or not invoke preferences and pay the MFN tariff. Thus, from this market they get $\max\left(0, \frac{r(\frac{\phi}{\tau^E}, P^E, E^E)}{\sigma} - f_x, \frac{r(\frac{\phi}{\tau^E\lambda^E\theta^E}, P^E, E^E)}{\sigma} - f_x - d\right)$.

When it comes to serving the US market, firms have no choice but to meet *ROOs* there as there are quotas. They also need to pay for a quota license. Thus, from the US market they get $\max\left(0, \frac{r(\frac{\phi}{\tau^U(\lambda^U\theta^U + t^U)}, P^U, E^U)}{\sigma} - f_x - d\right)$.

[20] Note that the revenue and profit functions take the same *form* at home or abroad, as for an exporter or as for a domestic firm. All that needs to change to pin down the context is the level of the arguments.

Hence, the overall profits of a Bangladeshi firm are the sum of its profits from the three markets.

$$\begin{aligned} \Pi^B(\phi) &= \max\left(0, \frac{r(\phi, P^B, E^B)}{\sigma} - f\right) \\ &+ \max\left(0, \frac{r(\frac{\phi}{\tau^E}, P^E, E^E)}{\sigma} - f_x, \frac{r(\frac{\phi}{\tau^E \lambda^E \theta^E}, P^E, E^E)}{\sigma} - f_x - d\right) \\ &+ \max\left(0, \frac{r_d(\frac{\phi}{\tau^U(\lambda^U \theta^U + t^U)}, P^U, E^U)}{\sigma} - f_x - d\right), \end{aligned} \tag{11}$$

where $\tau^U t^U = s^{UB}$ is the equilibrium price of a quota license for exporting to the US from Bangladesh.

A firm serves a market if its profit from doing so is positive. Hence, there are three kinds of cutoffs: the domestic cutoff, ϕ^{*i}, below which firms do not serve the domestic market i, the export cutoff to market i, ϕ_x^{*i}, below which firms choose not to export to country i, and ϕ_{xr}^{*i}, above which exporters choose to invoke preferences offered by country i. Let $\pi_d^B(\phi)$ be the abbreviated notation for total profits from serving the Bangladeshi domestic market alone or the first line of equation (11). Let $\pi_x^i(\phi)$ and $\pi_{xr}^i(\phi)$ denote the profits from also exporting to country i ($i = E, U$) without invoking preferences and with invoking preferences, respectively. Thus, the second and third lines of equation (11) are $\max\left(0, \pi_x^E(\phi), \pi_{xr}^E(\phi)\right)$ and $\max\left(0, \pi_{xr}^U(\phi)\right)$.[21]

Now, $\pi_d^B(\phi)$ must be flatter than $\pi_d^B(\phi) + \pi_x^i(\phi)$, and have a higher intercept. Thus, assuming that f_x is large enough relative to f, as we do, ensures that $\phi_x^{*i} > \phi^{*B}$. Similarly, as long as $\lambda\theta < 1$, assuming that d is large enough will ensure that $\phi_{xr}^{*i} > \phi_x^{*i}$. This explains the relative positions of these variables in Figures 2 and 3.

Note that an increase in the aggregate price index in a country or an increase in its size, given the price index, makes the profit function steeper as it raises firm profits. As the US and EU are similar in size, we will neglect size differences. Moreover, to the extent that Bangladesh is a relatively small exporter and other countries are also exporting to both of them, we can take their aggregate price indices as fixed. Moreover, aggregate price differences between them are not likely to be very large though the US quotas and higher tariffs are likely to raise the price index in the US above that in the EU.

[21] Note that r stands for rules of origin and x for exports. Exporting to the US without meeting *ROOs* is not an option as there are quotas.

Now, an increase in tariffs, a reduction in preferences, or stricter *ROOs* does the opposite (i.e., makes the profit function flatter). The two industries, woven and non woven apparel, differ in terms of the trade polices they face. Figures 2 and 3 depict the situation in the woven and non woven garment industries. In both industries, the only way to export to the US is assumed to be under quota so that *ROOs* have to be met. Thus, the Bangladeshi firm compares zero, $\pi_d^B(\phi)$, and $\pi_d^B(\phi)+\pi_{xr}^U(\phi)$. Firms with productivity below ϕ^{*B} exit. Firms with productivity above ϕ_{xr}^{*U} export under quota. In both industries, Bangladeshi firms can export to the EU by invoking preferences or not. Thus, the Bangladeshi firm considering the EU market compares zero, $\pi_d^B(\phi)$, $\pi_d^B(\phi)+\pi_x^E(\phi)$, and $\pi_d^B(\phi)+\pi_{xr}^E(\phi)$. Firms with productivity below ϕ^{*B} exit. Firms with productivity productivity above ϕ_{xr}^{*E} invoke preferences and export while those in between ϕ^{*B} and ϕ_{xr}^{*E} pay MFN tariffs..

In the woven industry, there are fewer advantages of selling in the EU compared to selling in the US. Thus, unless the price index in the EU is much higher than that in the US, the profit line for exporting to the EU without meeting *ROOs* is not very steep. Nor does meeting *ROOs* give as much of a benefit because they are costly to meet in wovens. Hence, the line for exporting and obtaining preferences to the *EU* starts out below that for exporting without meeting *ROOs*, but is not much steeper. As a result, exporting firms end up having roughly the same productivity whether they export to the US or EU in the woven garments sector (ϕ_x^{*E} is close to ϕ_{xr}^{*U}).

Figure 3 depicts the situation for the non-woven garments case. We assume here that $\theta^E = \theta^U \approx 1$ as *ROOs* are easy to be met in both the EU and the US. We also set $\lambda^E < \lambda^U = 1$ as there are no tariff preferences for Bangladesh in the US. $\tau^U > \tau^E$ reflects the slightly higher tariffs levied in the US and $\tau^U t = s^U$ reflects the presence of a binding quota. As the US market is tougher, with higher tariffs, a quota, and no preferences, unless the price index in the EU is very much lower than that in the US (the unit value of knitwear seems to be the same while the unit value of sweaters is higher for the EU), we would expect ϕ_x^{*E} to be considerably lower than ϕ_{xr}^{*U}.

Thus, the model has the following predictions:

Result 1. The TFP distributions of groups of firms can be ordered in terms of first order stochastic dominance.

1.(a) Firms that invoke *ROOs* should be more productive than those that do not. More precisely, the productivity distribution of Bangladeshi exporters to the EU who invoke *ROOs* must first order stochastically dominate (FOSD) that of all exporters to the EU or exporters who do not invoke *ROOs*.

1.(b) As trade policy in the US is more restrictive overall, firms that export to the US will tend to be more productive. More precisely, the productivity distribution of Bangladeshi exporters to the US is overall likely to FOSD that of exporters to the EU.

1.(c) As EU preferences are costly to obtain in wovens, firms that export to the US and EU in wovens will be relatively similar. More precisely, we cannot reject the null hypothesis that both their distributions are the same.

1.(d) As EU preferences are easy to obtain in non wovens, firms that export to the US in non wovens will be more productive. More precisely, the productivity distribution of Bangladeshi exporters to the US in non wovens FOSD that of exporters to the EU.

Result 2. Differences in firm concentration across various markets and activities are predicted.

2. (a) The share of firms that export to the US should be smaller than the share of firms who export to the EU in both woven and non-woven industries.

2. (b) A larger fraction of Bangladeshi firms should sell to the EU in the non woven sector than in the woven sector.

2. (c) The fraction of firms who sell to the EU and invoke *ROOs* should be higher in the non woven sector.

Result 3. Firms who export to both markets are more productive than those who do not. More broadly, there should be a positive correlation between the number of markets a firm exports to and its TFP.

Of course, a full analysis of equilibrium involves solving for the basic endogenous variables, ϕ^*, ϕ_x^*, and M, in each country as in Melitz (2003). It is well understood that his model is easily solvable only under extreme symmetry assumptions: he assumes that there are $n+1$ identical countries trading with each other. However, if we want to consider the effect of *ROOs* and differential trade policy in this setting, where some countries (the developed ones) are offering preferences to others (the less developed ones), the model becomes inherently asymmetric and Melitz (2003) needs to be extended to deal with this. We provide a simple way of doing so (in a reasonably realistic setting) in the appendix. Our results there show that the predictions on the cutoffs above hold in the complete general equilibrium setup as well.

We now turn to the data to see if our results are borne out.

5 Productivity Estimates and Results

To obtain the productivity of firms, we need to estimate the firm's production function, taking into account total factor usage per unit of output. In the firm survey we asked firms to provide the annual increase in the main product price and the main material input price. This firm level price information allows us to construct firm level price indexes of output and material, which we use to deflate sales and material costs to obtain real output and material levels. We estimate the following Cobb Douglas production function,

$$\begin{aligned} Y_{it} &= \phi_{it} L_{it}^{\alpha_L} M_{it}^{\alpha_M} K_{it}^{\alpha_K}, \\ \ln Y_{it} &= \ln \phi_{it} + \alpha_L \ln L_{it} + \alpha_M \ln M_{it} + \alpha_K \ln K_{it}, \end{aligned} \tag{12}$$

where i and t are the indexes for firm and year, respectively. In logs, output, Y_{it}, is linearly related to labor, L_{it}, materials, M_{it}, and capital stock, K_{it}. Firm capital stock, K_{it}, is constructed by summing real investment, I_{it}, over the years using perpetual inventory method with an annual depreciation rate, δ, of 10%:

$$\begin{aligned} K_{it} &= K_{it-1}(1-\delta) + I_{it}, \\ K_{i0} &= \frac{1}{2}\left(F_{i1} + \frac{I_{i1}}{\delta}\right), \end{aligned}$$

with initial capital stock, K_{i0}, being constructed using an average of the firm's first year fixed asset, F_{i1}, and the infinite sum series of investment prior to the first year, assuming a zero growth rate of investment and a depreciation rate of 10%. Firms' real investment, I_{it}, is obtained by deflating nominal investment from the firm survey by the GDP deflator of domestic fixed capital formation of Bangladesh in the respective years.

According to (12), any part of Y_{it} that is not explained by the three factors of production is attributed to productivity, ϕ_{it}, which varies by firm and year. In other words, if we regress $\ln Y_{it}$ on $\ln L_{it}$, $\ln M_{it}$, and $\ln K_{it}$ using ordinary least squares (OLS) estimation, the regression errors are the firms productivity, $\ln \phi_{it}$.

However, firm's input choices are endogenous – they depend on the productivity of the firm which is known to the firm but not the researcher. Such input endogeneity will bias OLS coefficients of labor and materials upward since more productive firms will also have higher levels of output.

By omitting the firm productivity when we regress $\ln Y_{it}$ on $\ln L_{it}$, $\ln M_{it}$, and $\ln K_{it}$ using OLS estimation, the error terms are positively correlated with $\ln L_{it}$, $\ln M_{it}$, and $\ln K_{it}$, which leads to upward bias in the coefficients.

In addition, if larger, older firms tend to stay in business despite low productivity, while younger, smaller firms tend to quit more easily, such endogenous exit decisions of the firm will bias OLS estimates of the coefficient on capital downwards. In other words, by omitting firm productivity when we regress $\ln Y_{it}$ on $\ln L_{it}$, $\ln M_{it}$, and $\ln K_{it}$ using OLS estimation, the error terms may also be negatively correlated with $\ln K_{it}$ due to the endogenous exit decision, which will bias the coefficient on $\ln K_{it}$ downward.

To address this input endogeneity bias and selectivity bias, we follow a 3-step nonlinear estimation methodology developed by Olley and Pakes (1996) which yields consistent estimates. In their model, the unobserved productivity, $\ln \phi_{it}$, is the only state variable in each year t that follows a common exogenous Markov process, which, jointly with fixed input, $\ln K_{it}$, and its age, determines the exit decision and investment demand, $\ln I_{it}$, of the firms. Consider only the Markov perfect Nash equilibrium, so firm's expectations match the realization of future productivity. Then we can use a polynomial function of $\ln I_{it}$, $\ln K_{it}$, and age to control for the unobserved productivity, $\ln \phi_{it}$.[22] The polynomial function is assumed to be common across all firms in all years. Furthermore, to control for the exit decision, they estimate a Probit regression to obtain the surviving probability and use that to control for the part of unobserved productivity that is negatively correlated with $\ln K_{it}$.

For the Olley and Pakes procedure to perform well, it is crucial that there will be no systematic measurement errors in output and inputs which may be correlated with the productivity of the firms. However, in our current data set, this is likely to be the case. First, there are by all accounts firm specific fraudulent accounting practices prevailing in Bangladesh. Firms with higher productivity are more profitable, and have the most incentives to overstate material costs and understate sales in order to reduce corporate tax liability. Such accounting practices will bias the coefficient on materials downward as the artificially high material cost is negatively correlated with the artificially low output. Without knowledge of how each firm manipulates its books, this firm specific accounting practice can only be controlled for by using firm specific effects.

[22] This is possible because, given $\ln K_{it}$, $\ln I_{it}$ is an increasing function of $\ln \phi_{it}$, which makes the function invertible.

Second, since we use headcounts of employees to measure labor input, labor is less prone to such accounting fraud. However, the number of employees may systematically underestimate the actual labor input for the more productive firms, if the more productive firms offer more overtime opportunities and attracts better quality workers. This type of measurement error in labor input (one that is positively correlated with firm productivity) will bias the Olley-Pakes estimates on labor upwards.

Finally, for the case of Bangladesh, we need to address the loss in output due to labor strikes called for by the opposition party (hartals) which affect all firms within a year. Such labor strikes decrease the output of all firms, but given that it is the constitutional right of workers, do not affect employment. This introduces an upward bias in the measurement of labor and downward bias in its coefficient. We control for this type of common measurement error in labor by incorporating year specific effects.

We, therefore, modify the three stage nonlinear estimation technique of Olley and Pakes (1996) to include firm and year fixed effects, and only rely on the within variation to estimate α_L and α_M in the first stage.

Results of the regressions are reported in Table 2. Column (1) of Table 2 shows the OLS estimation with no correction for endogeneity, selectivity, or measurement errors that are specific to firms and years. These estimates are likely to be biased as argued.

Column (2) reports the first stage results of the usual OP procedure, where a 3rd order polynomial function of investment, capital, and age is included as a control for the unobserved firm productivity. Note that using the usual OP correction does not change the coefficient on labor and materials by much relative to OLS – while the coefficient on material is marginally lower, the coefficient on labor is marginally higher. We believe this is because of the measurement problems discussed above. Our belief is supported by the estimates moving as explained below.

Column (3) includes firm fixed effects in the OP procedure to address measurement errors that are specific to the firms. The within estimate of the coefficient of materials is significantly higher, which is consistent with our argument that more productive firms systematically overstate material costs and understate sales. On the other hand, the within estimate of the coefficient of labor is significantly lower, which is consistent with our argument that head counts are hard to fudge but that more productive firms tend to attract better workers. This leads to the upward bias in Column (2).

Column (4) presents the within OP estimates controlling for both firm and year fixed effects. As suspected, controlling for year effects further reduces the upward measurement errors in labor due "hartals" that negatively affect the output of all firms in a given year. This leads the estimates in column (4) to be higher than those in Column (3). Thus, correcting for input endogeneity and measurement errors, our estimates of the coefficients of materials and labor are 0.715 and 0.255, respectively.

Given the estimates presented in Column (4), Column (5) presents the within OP estimates with correction for selectivity bias to obtain the estimates for the coefficients of capital and age. This is obtained by first estimating the exit decision of the firms using a Probit regression on a 3rd order polynomial function of investment, capital, and age, controlling for year, region, and industry fixed effects. This regression yields the propensity for a firm to stay in business. We then regress $\ln Y_{it} - \hat{\alpha}_L \ln L_{it} - \hat{\alpha}_M \ln M_{it}$, constructed using the consistent estimates of α_L and α_M from Column (4), on age, capital, a 3rd order polynomial function of propensity of survival, and $E(\ln Y_{it}) - \hat{\alpha}_L \ln L_{it} - \hat{\alpha}_M \ln M_{it}$. The 3rd order polynomial function of propensity of survival, and $E(\ln Y_{it}) - \hat{\alpha}_L \ln L_{it} - \hat{\alpha}_M \ln M_{it}$ is used as a control for the unobserved productivity that is related to capital and age, such that the remaining regression error is not related to capital and age, which is necessary for us to obtain consistent estimates on the coefficients of capital and age. This last-stage nonlinear regression gives us our estimated coefficient on capital, $\hat{\alpha}_K$ and age, and is presented in Column (5).

Relative to Column (1), the estimated coefficient on capital is reduced from 0.025 to 0.021, suggests that the endogeneity of capital dominates the selection bias due to firms' exit decision, which leads to an overall upward bias in the OLS estimate of α_K. In addition, while older firms seem to be more productive, the coefficient is not statistically significant. Based on results presented in Column (5), firm productivity is constructed as the following:

$$\ln \phi_{it} = \ln Y_{it} - 0.715 \ln M_{it} - 0.255 \ln L_{it} - 0.021 \ln K_{it}, \text{ or} \tag{13}$$

$$\phi_{it} = \exp\left(\ln Y_{it} - 0.715 \ln M_{it} - 0.255 \ln L_{it} - 0.021 \ln K_{it}\right), \tag{14}$$

which forms the basis of our empirical exercise.

5.1 Testing for Stochastic Dominance

We use a nonparametric test of stochastic dominance, developed in Anderson (1996) to test whether the productivity distributions of firms serving different markets in different industries are indeed statistically different as predicted by our model. Given that this is a relatively new technique, we will briefly describe the methodology, which is an extension of the Pearson goodness of fit test.

Let Φ be the rangespace of two productivity distributions A and B, with cumulative density functions $F_A(\phi)$ and $F_B(\phi)$. Productivity distribution A first order stochastically dominates (FOSD) B if and only if

$$F_A(\phi) \leq F_B(\phi), \; F_A(\phi_i) \neq F_B(\phi_i), \text{ for some } i, \; \forall \phi \in \Phi. \tag{15}$$

That is, that the CDF of A does not exceed that of B.

To test the hypothesis, first, the range of the two distributions is partitioned into J mutually exclusive and exhaustive intervals with respective relative frequency vectors p_A and p_B, where

$$p_i^j = F_i\left(\phi^j\right) - F_i\left(\phi^{j-1}\right) = \frac{x_i^j}{n^i}, \; i = A, B, \text{ and } j = 1, ..., J \tag{16}$$

and x_i^j is the frequency of observations in sample i in interval j and n^i is the size of sample i. p_i^j is the discrete empirical analogue of the probability density function, namely, the relative frequency in each interval. We choose the partition so that a tenth of the mass of the data in A and B together lies in each interval, i.e., we partition the joint range into deciles.[23] We calculate the discrete empirical analogue of the probability density function, namely, the relative frequency in each interval.

[23] This helps to prevent too small a number of observations from occurring in any interval.

Define I_f as the J by J cumulative sum[24] matrix:

$$I_f = \begin{bmatrix} 1 & 0 & 0 & \dots & \dots & 0 \\ 1 & 1 & 0 & \dots & \dots & 0 \\ 1 & 1 & 1 & 0 & \dots & 0 \\ \vdots & \vdots & \vdots & & & \vdots \\ \vdots & \vdots & \vdots & & & 0 \\ 1 & 1 & 1 & \dots & \dots & 1 \end{bmatrix}_{J\times J} . \tag{17}$$

The test that distribution A FOSD B boils down to:

$$H_0 : I_f \left(p^A - p^B\right) = 0 \text{ vs. } H_1 : I_f \left(p^A - p^B\right) < 0, \tag{18}$$

where under H_0, distributions A and B are statistically the same, whereas under H_1, distribution A statistically FOSD B. It is possible that the test does not support either H_0 or H_1, in which case, while distribution A is not the same as B, we could not say one distribution FOSD the other, which leads to the conclusion of indeterminacy in stochastic dominance.

Let $\upsilon = \left(p^A - p^B\right)$ and $\upsilon_f = I_f \upsilon$. Under H_0, the distributions A and B are the same as the pooled distribution. Anderson (1996) shows that under H_0, υ and υ_f have well defined asymptotically normal distributions, and dividing each element of υ_f by its standard deviation permits multiple comparisons using the studentized maximum modulus distribution (Stoline and Ury, 1979).

$$\upsilon \sim N\left(0, m\Omega\right), \text{ and } \upsilon_f \sim N\left(0, I_f m\Omega I_f'\right), \tag{19}$$

[24]Since post multiplying I_f by the discrete empirical analogue of the probability density function gives the discrete empirical analogue of the cumulative density function.

where $m = n^{-1}\left(n^A + n^B\right)/n^A n^B$, and

$$n^{-1}\Omega = \begin{bmatrix} p_1(1-p_1) & -p_2p_1 & \dots & -p_Jp_1 \\ -p_2p_1 & p_2(1-p_2) & \dots & -p_Jp_2 \\ \vdots & & & \vdots \\ -p_Jp_1 & -p_Jp_2 & \dots & p_J(1-p_J) \end{bmatrix}, \quad (20)$$

$$\text{with } p_j = \frac{x_A^j + x_B^j}{n^A + n^B}, \quad (21)$$

and $PAT = \upsilon_f' \left(I_f m \Omega I_f'\right)^{-1} \upsilon_f$ is asymptotically distributed as $\chi^2_{(J-1)}$.

To implement the test, we separate the pooled sample into 10 intervals according to the deciles of the pooled distribution. The hypothesis that distribution A FOSD distribution B requires that no element of υ_f is statistically greater than 0 and at least one element of υ_f is statistically less than 0. Since the test is perfectly symmetric, if no element of υ_f is statistically less than 0 and at least one element of υ_f is statistically greater than 0, then we can conclude that distribution B FOSD distribution A. In both cases, PAT needs to be statistically different from zero to reject H_0 that distributions A and B are the same. If at least one element of υ_f is statistically greater than 0, while at least one element of υ_f is statistically less than 0, then we conclude that stochastic dominance of distributions A and B is undetermined. We will use this multiple comparison test coupled with the $\chi^2_{(J-1)}$ statistic to check the prediction of our model with data.

5.2 EU vs. US

Based on the productivity estimates, we relate firm productivity to the export destinations of the firms. Table 3 presents the empirical results of the regressions. Column (1) shows the differences in firm productivity when comparing majority EU exporters to non-majority EU exporters, using within firm variations. The slope coefficient is identified by those firms that switch from minority to majority EU exporter status, or vice-versa. On average, when a firm switches from a non-majority EU exporter status to a majority EU exporter status, there is a drop in productivity of 7.0%

which is statistically significant.[25] This is controlling for firm and year fixed effects, and therefore, is independent of the industry in which the firm is operating. The regression estimates reveal a mean difference in such firms. However, the model prediction is that the entire distribution should move due to the implied truncation. For this reason, we also present the estimated cumulative distribution function of these firms in Figure 4. As expected, we see that the CDF for majority EU exporters lies above that of the non-majority EU exporters.[26] This, of course, implies that the mean of the former is less than that of the latter.[27] As a result, the productivity distribution of majority EU exporters lies to the left of that of the non-majority EU exporters.

Column (2) presents the differences in firm productivity when firms switch from being a non-majority US exporter to a majority US exporter. On average, there is an 8.9% increase in productivity to be a majority US exporter, controlling for firm and year fixed effects. We also see in Figure 5 that the CDF for majority US exporters lies below that of the remaining firms with similar consequences. Thus, there are some clear differences in terms of the productivity of firms depending on the market they mostly export to.

Table 4 presents the nonparametric tests. This is a multiple comparison test based on the 10 decile intervals of the pooled distribution. The 1, 5, and 10 percent significant levels are denoted by ***, **, and *, respectively. Column (1) compares the productivity distribution of majority EU exporters (distribution A) to that of the rest of the firms (distribution B). Positive numbers imply that the cumulative distribution of A lies above that of B, and vice-versa. Given that none of the elements is statistically negative, while five are statistically positive, the null hypothesis of a common distribution is rejected in favor of the hypothesis that distribution B FOSD distribution A. In other words, the multiple comparison test suggests that the productivity distribution of majority EU exporters is dominated by the productivity distribution of the other firms. The $\chi^2_{(J-1)}$ statistic listed at the bottom of the table also rejects the null hypothesis that productivity distribution of these two sets of firms are the same, which further supports our findings.

[25] Given that the export status variable is a discrete dummy variable, the percentage effect of switching status is

$$\begin{aligned} \ln TFP_1 - \ln TFP_0 &= \beta, \\ \frac{TFP_1 - TFP_0}{TFP_0} &= e^{\beta} - 1. \end{aligned}$$

[26] In other words, the productivity distribution of the non-majority EU exporters FOSD that of the others.

[27] Note that the converse is not true so that the CDF comparison is much stronger.

Column (2) compares the productivity distribution of majority US exporters (distribution A) to that of the rest of the firms (distribution B). Most of the elements listed in Column (2) are statistically negative and none is statistically positive which indicates that the productivity distribution of firms that mainly export to the US FOSD that of the remaining firms. The $\chi^2_{(J-1)}$ statistic also rejects the null hypothesis that productivity distributions of these two sets of firms are the same. Overall, the results of these nonparametric tests of stochastic dominance support our regression results, which is that firms sort themselves into markets of different toughness according to their productivity.

5.3 Woven vs. Non-Woven Industries

The theoretical model also explains how firms sort themselves out in terms of their productivity as a function of differences in trade policy across industries. Relying on between firm variations, Column (3) of Table 3 shows that, controlling for industry and year fixed effects, firms that supply a majority of their products to the EU market are, on average, 24% less productive than firms that do not supply a majority of their products to the EU market. However, for woven firms, the productivity difference between majority EU exporters and the other firms is statistically insignificant. This is illustrated by interacting the woven industry dummy with the majority EU exporter dummy, and the estimated effect is -0.268+0.233=-0.035, which is not statistically different from zero.

Similarly, Column (4) shows the between firm productivity differences between majority US exporters and minority US exporters, controlling for industry and year fixed effects. On average, firms that supply a majority of their products to the US market are 42% more productive than firms that supply a minority of their products to the US markets. However, the productivity gap is not statistically significant in the woven industry, where the estimate effect is 0.047 and is not significantly different from zero.

Columns (5) and (6) relate firm productivity to the actual shares of the EU and US in firm exports, allowing for firms in the woven industry to have different effects and controlling for year and industry fixed effects. Both these columns are using the between firm variations. Column (5) shows that for the non-woven firms, every 1 percentage point increase in export share to the EU is associated with a productivity decreases of 0.32%. On the other hand, for the woven firms, increases in export share to the EU do not correlate with the productivity of firms. Similarly, Column (6) shows that for the non-woven firms, for every 1 percentage point increase in export share to the

US, firm productivity increases by 0.44%, but that there is no such significant productivity change for the woven firms.

Columns (1) to (3) of Table 5 presents three tests for the non-woven firms. The first compares non-woven firms that supply only to the EU market (distribution A) with all other exporters. Not only are these firms in distribution A the single market firms, they are operating in a market where *ROOs* are not binding. Thus, our model predicts that these firms should have a productivity distribution that is first order stochastically dominated by that of exporters that do not solely export to the EU. Column (1) presents the test statistics. Six out of the 10 elements in v_f are statistically greater than 0, one is negative but far from significant. The $\chi^2_{(J-1)}$ statistic rejects the null hypothesis that the productivity distribution of these two sets of firms are the same. Similar results are obtained when we split the sample according to majority versus minority EU exporters.

Column (2) compares the productivity distributions of firms solely exporting to non-EU market in the non-woven industry to the rest of the firms in the non-woven industry. Given that Bangladeshi firms have tariff preference exporting to the EU, our model predicts that only the more productive firms will be able to compete with exporters from other countries such as China and India in the non-EU market. Column (2) presents the multiple comparison test statistics. None of the elements is statistically positive, while two out of ten are statistically less than zero indicating that the productivity distribution of firms exporting to non-EU market first order stochastic dominates that of firms who do not export to the non-EU market. The $\chi^2_{(J-1)}$ statistic also rejects the null hypothesis that the productivity distribution of these two sets of firms are the same.

Column (3) compares the productivity distributions of firms exporting to the US market in the non-woven industry, to firms that do not export to the US market. Given that Bangladeshi firms have to face the MFA tariff exporting to the US, our model predicts that only the most productive firms will be successful in the US market. None of the elements in Column (3) is statistically positive, while four out of 10 are statistically negative suggests that firms that export to the US market in the non-woven industry are indeed more productive. The $\chi^2_{(J-1)}$ statistic also rejects the null hypothesis that productivity distribution of these two sets of firms are the same, which further supports the hypothesis.

Columns (4) to (6) of Table 5 relate to the woven industry. Given that *ROOs* of the EU in the woven industry are binding, we do not expect to see similar productivity distributions as in the non-woven industry. In the woven industry, the EU cutoff is not much different from the export cutoff so that firms that solely supply to the EU market do not look different from other firms. Similarly, firms that do not supply to the EU market, or firms that export to the US market are not statistically different in terms of productivity from other firms. Note that there are both positive and negative numbers in these three columns with only one being significant. The chi square test does not reject the null hypothesis that the distributions are the same.

Overall the results support the theoretical model that *ROOs* of the EU and US have significant effects in sorting different firms into different markets, depending on whether such rules are binding. For the non-woven industries, given that *ROOs* of the EU and US are not binding, the existence of tariff preference in the EU market allows the less productive firms to access the EU market, while for the woven industries, *ROOs* of the EU are binding, which makes the EU less attractive, and we do not observe significant productivity differentials among woven firms supplying these two markets.

5.4 Do More Productive Firms Invoke Binding ROOs?

To perform some robustness checks, we further merge the custom data set with our firm survey by manually comparing firm names. In 2003, which is the latest year we have for the firm survey data set, there are 119 firms in common in the two data sets, of which 78 are in the woven industry. Assuming that from 2003 to 2004 there are not many changes in terms of export share to the EU we can use this information to further study the effects of *ROOs* by comparing the productivity of these matched firms to the other firms.

To study the effect of binding *ROOs* on firm productivity, we interact the majority EU exporter variable and the EU export shares with a dummy variable which equals one if the firms export to the EU under GSP, and therefore satisfy *ROOs*. Table 6 presents the cross section OLS regression results. In Column (1), we relate firm TFP to the majority EU exporter variable and its interaction term with GSP status in the sub-sample of 64 non-woven firms. As in Table 3, firms that export majority of their products to the EU are significantly less productive, and those firms that satisfy *ROOs* are no different. In Column (2), we restrict the sample to the 132 woven firms. Similarly to the previous finding in Table 3, within the non-woven industry where *ROOs* are not binding, firms that export majority of their products to the EU are no different from firms that do not export majority of their products to the EU. However, in the woven industry, those firms that satisfy *ROOs* and export to EU under GSP are statistically more productive in line with the predictions of the model.

Columns (3) and (4) repeat the same exercises but instead of using majority EU exporter dummy, we use the actual export share of the EU of these firms in 2003. Firms that satisfy *ROOs* and who can therefore export under GSP preference do seem to be, on average, more productive than other firms.

Table 7 presents the nonparametric test for first order stochastic dominance of productivity distributions comparing firms that satisfying *ROOs* to those that do not satisfy *ROOs* in both non-woven and woven industries. Given that the sample size is quite a bit smaller in this subsample, we only split it into 6 intervals according to the sextiles of the pooled sample. Column (1) compares the productivity distribution of the majority EU exporters that satisfy *ROOs* in the non-woven industry to the majority EU exporters that do not satisfy *ROOs*. While the CDF of the *ROOs* firms lies below that of the non-*ROOs* firms given that all elements of Column (1) are negative, none of the elements is statistically negative, which suggests that productivity distribution of *ROOs* firms is not statistically different from the other firms, in the non-woven industry. Column (2) repeats the exercise for the woven firms. Here the multiple comparison test concludes that *ROOs* satisfying firms are indeed more productive. These results are supported by the $\chi^2_{(J-1)}$ statistics.

In summary, in the matched sample of 119 firms, we find statistical evidence supporting our theoretical model: when *ROOs* are not binding, the associated tariff preference allows the less productive firms to export; when *ROOs* are binding, only the more productive firms can satisfy *ROOs* and export.

5.5 Effects of Quota

In this matched data set, we can further test the effects of US quota on firm productivity. In theory, by restricting quantity imported, quota raises aggregate prices and should, therefore, lower the productivity cutoff. On the other hand, in Bangladesh firms may be able to informally trade quota rights among themselves through open bid auctions and such license price would raise the productivity cutoff so that only the more productive firms find it worthwhile to pay for the quota. The net effect on productivity depends on these two opposing forces and is, therefore, ambiguous in theory.

Figure 6 presents the CDF of the US exporters with or without quota restrictions. This seems to suggest that firms exporting under quota tend to be more productive. This is not a consequence of the formal model as there are opposing forces at work. The evidence, thus, suggests that the price effect does not dominate as would be likely if there were non quota constrained exporters. We would need to rely on the nonparametric multiple comparison test to formally test the differences in these CDF.

Column (3) of Table 7 compares the productivity distribution of firms export to US under quota restriction to those without quota restrictions. While all elements are negative which suggests that the CDF of the quota firms are lower than that of the non-quota firms, none of the elements are statistically significant, which suggests that the productivity distributions are similar.

5.6 The Number of Export Destinations

Finally, we look at the number of export destinations using the custom data set. Bangladeshi exporters to the US tend to be of higher productivity and, therefore, of the multi market type. Again, this is consistent with the evidence in Figure 1. In contrast, as the EU gives preferences at little cost, firms in this group tend to have lower productivity and a lower cutoff. As a result, there are more firms of the one market type (low productivity type) in this group.

6 Conclusion

Our findings are important for at least two reasons. First, they renew ones faith in economics: to conclude that the predictions of a rather abstract model (Melitz 2003) for an essentially unobservable variable (TFP) find support in the data is quite something! Second, our results provide insights into the political economy behind recent policy issues of some importance in the Indian subcontinent as a whole. Since the availability of domestic fabric is a binding constraint for Bangladesh to access EBA preferences in its exports to the EU of woven apparel, the EU had granted regional cumulation to SAARC (South Asian Association Regional Cooperation) countries. So far, the Bangladeshi textile industry has successfully opposed regional cumulation.

According to the rules of cumulation, textiles made in other SAARC countries could be used by Bangladeshi exporters of woven apparel without compromising Bangladeshi origin if the value added in Bangladesh exceeds 50%.[28] In fact, even products made outside Bangladesh would be eligible for duty free access to the EU if the value added by Bangladeshi inputs exceeded 50%

[28] See Development Initiative (2005), pg. 5.

(reverse origin). Thus, not only could Bangladesh use low quality cheap Indian textiles and export to the EU, but India could use high quality Bangladeshi textiles (so value added in Bangladesh is more than 50%) and export under the EBA to the EU! Thus, high end textile producers in Bangladesh and low end textile producers in India may gain from such cumulation, but high end apparel producers in Bangladesh would likely lose.

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7 Appendix

The general equilibrium model described below extends the discussion in the text. There are three countries, two of which, the US (U) and the EU (E), are of the same size and with the same technology[29], Bangladesh (B) is smaller in that it has fewer units of effective labor but has a better technology in the differentiated good sector (apparel). To achieve factor price equalization in the presence of asymmetries, we introduce a homogenous good, which can be freely traded and is made using one unit of effective labor. There are L consumers in the US and EU, and L^Bconsumers in Bangladesh. A consumer in country i, $i = E, U, B$, supplies one unit of labor.

7.1 Production and Firm Behavior

We assume that there is no specialization in the equilibrium. Hence, we can normalize the wage rate and the price of the homogenous good to unity.[30] The expenditure and revenue earned from the differentiated good are denoted by E^i and R^i, respectively, for $i = E, U, B$. The trade policy environment is summarized in Figure 7. The per unit trade costs of the US and EU of exporting to Bangladesh are assumed to be the same and equal to τ^B reflecting similar transport costs and the MFN tariffs set by Bangladesh. The per unit trade costs of the US and EU of exporting to each other are assumed to be equal τ reflecting identical transport costs and similar MFN tariffs set by two countries. There are no quotas on their trade. As tariffs are MFN tariffs, we also assume that τ is the direct trade cost for Bangladeshi firms to export to the US and EU. Of course, the US has quotas, which impose an additional cost both as US *ROOs* have to be met and because of the non zero license price, while the EU has preferences, which reduce these costs if EU *ROOs* are met.

Given our assumptions, the export price set by the US and EU firms exporting to Bangladesh

[29] Later we will add a difference between countries in terms of the productivity distributions.

[30] Even if unit labor requirements differ, factor price equalization in efficiency units is achieved.

with productivity level ϕ is $\tau^B p(\phi)$, while the export price set by the US and the EU firms productivity level ϕ exporting to each other is $\tau p(\phi)$. Exporters from Bangladesh with productivity level ϕ set the following prices:

$$p_x(\phi) = \begin{cases} \tau^E p(\phi), \text{ if the firm exports to the EU without meeting } ROOs; \\ \lambda^E \theta^E \tau^E p(\phi), \text{ if the firm meets } ROOs \text{ while exporting into the EU;} \\ \left(\theta^U + t\right) \tau^U p(\phi), \text{ if the firm exports into the US.} \end{cases} \tag{22}$$

Since $r(\phi) = E(\rho\phi P)^{\sigma-1}$, where E is the expenditure on the aggregate differentiated good, we can write the revenues earned by a firm from country k from serving its own market, $r_d^k(\phi)$, and from exporting to country j, $r_x^{kj}(\phi)$ as

$$r_d^k(\phi) = E^k \left(P^k \rho\phi\right)^{\sigma-1}, \; k = E, U, B \tag{23}$$

$$r_x^{EU}(\phi) = E^U \left(P^U \rho\tau^{-1}\phi\right)^{\sigma-1}, \tag{24}$$

$$r_x^{UE}(\phi) = E^E \left(P^E \rho\tau^{-1}\phi\right)^{\sigma-1}, \tag{25}$$

$$r_x^{kB}(\phi) = E^B \left(P^B \rho \left(\tau^B\right)^{-1} \phi\right)^{\sigma-1}, \; k = E, U. \tag{26}$$

A firm from Bangladesh gets:

$$r_x^{BE}(\phi) = E^E \left(P^E \rho \left(\tau^E\right)^{-1} \phi\right)^{\sigma-1}, \tag{27}$$

$$r_{xr}^{BE}(\phi) = E^E \left(P^E \rho \left(\lambda^E \theta^E \tau^E\right)^{-1} \phi\right)^{\sigma-1}, \tag{28}$$

$$r_{xr}^{BU}(\phi) = E^U \left(P^U \rho \left(\left(\theta^U + t\right) \tau^U\right)^{-1} \phi\right)^{\sigma-1}, \tag{29}$$

where $r_{xr}^{Bk}(\phi)$ and $r_x^{Bk}(\phi)$ are the revenues earned by this firm from exporting to country k while meeting $ROOs$ and not meeting $ROOs$ there, respectively. To simplify our analysis, we rewrite $r_{xr}^{BE}(\phi)$ as $r_{x}^{BE}(\phi) + r_{R}^{BE}(\phi)$, where

$$r_{R}^{BE}(\phi) = E^{E}\left(P^{E}\rho\phi\right)^{\sigma-1}\left(\tau^{E}\right)^{1-\sigma}\left(\left(\lambda^{E}\theta^{E}\right)^{1-\sigma} - 1\right).$$

In other words, $r_{R}^{BE}(\phi)$ reflects the additional gains of firms in Bangladesh from meeting $ROOs$ in the EU. As a result, firms in Bangladesh use $ROOs$ only if $r_{R}^{BE}(\phi)$ exceeds the fixed cost of meeting $ROOs$, d^{E}.

Note that in each country under trade, the aggregate revenue earned by domestic firms in the differentiated good sector, R^{k}, can differ from the aggregate expenditure on the differentiated goods, E^{k}. (Since the value of final goods and services equals the value of factor payments, in an open economy, $R^{k} = \gamma^{i}L$, where γ^{i} is the fraction of labor employed in the differentiated good sector in country i[31], and $E^{k} = \beta I^{k}$, where I^{k} is income in country k. $I^{k} = L^{k} + NTR^{k}$, where NTR^{k} is the net tariff revenues received by country k.). Since consumers in each country spend a share β of their incomes on the differentiated goods, and as the world expenditure on the differentiated goods equals the revenues earned in this sector, $\gamma^{E}L^{E} + \gamma^{U}L^{U} + \gamma^{B}L^{B} = \beta(L^{B} + L^{U} + L^{E})$.

Let us define by ϕ^{*i} and ϕ_{x}^{*ij} the productivity cutoffs for the firms in country i, which decide, respectively, to produce for the domestic market ($r_{d}\left(\phi^{*i}\right) = f$) or to export into country j without meeting $ROOs$ ($r_{x}^{ij}\left(\phi_{x}^{*ij}\right) = f_{x}$). In addition, ϕ_{xr}^{*BE} and ϕ_{xr}^{*BU} denote the productivity cutoffs for firms from Bangladesh, which decide to export, respectively, into the EU and US meeting ROOs there, i.e., $r_{R}^{BE}\left(\phi_{xr}^{*BE}\right) = d$ and $r_{xr}^{BU}\left(\phi_{xr}^{*BU}\right) = f_{x} + d$. Now, there are a number of relations between these cutoffs. For example, the export cutoff for a Bangladeshi firm exporting to the EU without

[31] The aggregate revenue R_{i}^{C} in the differentiated good sector equals the total payment to the labor, i.e., $R_{i}^{C} = L_{i}^{C} = \gamma_{i}L$. The total revenue is $R_{i} = R_{i}^{N} + R_{i}^{C} = L$, $i = B, E, U$.

meeting *ROOs* must be related to the entry cutoff for a EU firm. Since

$$r\left(\phi^{*E}, P^E, E^E\right) = f, r\left(\frac{\phi_x^{*BE}}{\tau^E}, P^E, E^E\right) = f_x,$$

using the explicit functional form for revenue, we get

$$\phi_x^{*BE} = \tau^E \left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}} \phi^{*E} = A^{BE}\phi^{*E}.$$

In a similar manner, the following relationships among the productivity cutoffs in all three countries can be obtained:

$$\phi_x^{*EU} = A\phi^{*U}, \quad \phi_x^{*UE} = A\phi^{*^E}, \tag{30}$$

$$\phi_x^{*EB} = \phi_x^{*UB} = A^B\phi^{*B}, \quad \phi_x^{*BE} = A^{BE}\phi^{*E} \tag{31}$$

$$\phi_{xr}^{*BE} = A_{ROO}^{BE}\phi_x^{*BE} = A_{ROO}^{BE}A^{BE}\phi^{*E} \tag{32}$$

$$\phi_{xr}^{*BU} = A_{ROO}^{BU}\phi^{*U}, \tag{33}$$

where

$$A = \tau\left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}} > 1, \; A^B = \tau^B\left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}} > 1, \tag{34}$$

$$A^{BE} = \tau^E\left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}} > 1, \tag{35}$$

$$A_{ROO}^{BE} = \left(\frac{d^E}{f_x}\frac{1}{\left(\lambda^E\theta^E\right)^{1-\sigma} - 1}\right)^{\frac{1}{\sigma-1}}, \tag{36}$$

$$A_{ROO}^{BU} = \tau^U\left(\theta^U + t\right)\left(\frac{f_x + d^U}{f}\right)^{\frac{1}{\sigma-1}} > 1. \tag{37}$$

Note that $ROOs$ in the EU are stricter than those in the US. Therefore, the documentation costs of firms, who export to the EU meeting $ROOs$, are higher compared to those of firms who export to the US, $d^E > d^U$. We assume that d^E is high enough so that $A_{ROO}^{BE} > 1$.

The free entry (FE) condition in country i leads to the following equation:

$$\frac{\bar{\pi}_i}{\delta}\left(1 - G\left(\phi_i^*\right)\right) = f_e, \;\; i = E, U, B, \tag{38}$$

where $\bar{\pi}_i$ represents the average level of profits earned by firms in country i. In other words, in each country the present discounted value of the expected profits upon entering should be equal to the costs of entering. Let's define $\tilde{\phi}\left(\phi^*\right)$ as

$$\tilde{\phi}\left(\phi^*\right) \equiv \left[\int_0^\infty \phi^{\sigma-1}\mu\left(\phi\right)d\phi\right]^{\frac{1}{\sigma-1}} = \left[\frac{1}{1-G\left(\phi^*\right)}\int_{\phi^*}^\infty \phi^{\sigma-1}g\left(\phi\right)d\phi\right]^{\frac{1}{\sigma-1}}. \tag{39}$$

Denote $\tilde{\phi}\left(\phi^{*i}\right)$ by $\tilde{\phi}^i$, $\tilde{\phi}\left(\phi_x^{*ij}\right)$ by $\tilde{\phi}_x^{ij}$, and $\tilde{\phi}\left(\phi_{xr}^{*ij}\right)$ by $\tilde{\phi}_{xr}^{ij}$. Then the average profits earned in the EU, the US, and Bangladesh are, respectively:

$$\bar{\pi}^E = \pi_d^E\left(\tilde{\phi}^E\right) + p_x^{EU}\pi_x^{EU}\left(\tilde{\phi}_x^{EU}\right) + p_x^{EB}\pi_x^{EB}\left(\tilde{\phi}_x^{EB}\right), \tag{40}$$

$$\bar{\pi}^U = \pi_d^U\left(\tilde{\phi}^U\right) + p_x^{UE}\pi_x^{UE}\left(\tilde{\phi}_x^{UE}\right) + p_x^{UB}\pi_x^{UB}\left(\tilde{\phi}_x^{UB}\right), \tag{41}$$

$$\begin{aligned}\bar{\pi}_B \;\; = \;\; & \pi_d^B\left(\tilde{\phi}^B\right) + p_x^{BE}\pi_x^{BE}\left(\tilde{\phi}_x^{BE}\right) \\ & + p_{xr}^{BE}\pi_R^{BE}\left(\tilde{\phi}_{xr}^{BE}\right) + p_{xr}^{BU}\pi_{xr}^{BU}\left(\tilde{\phi}_{xr}^{BU}\right),\end{aligned} \tag{42}$$

where p_x^{ij} is the probability of becoming an exporter from country i to country j conditional on successful entry,

$$p_x^{ij} = \left(1 - G\left(\phi_x^{*ij}\right)\right) / \left(1 - G\left(\phi_i^*\right)\right).$$

Similarly, p_{xr}^{BE} is the probability of becoming an exporter from Bangladesh to the EU who meets $ROOs$, conditional on the probability of becoming an exporter,

$$p_{xr}^{BE} = \left(1 - G\left(\phi_{xr}^{*BE}\right)\right) / \left(1 - G\left(\phi_x^{*BE}\right)\right),$$

and p_{xr}^{BU} is the probability of becoming an exporter from Bangladesh to the US,

$$p_{xr}^{BU} = \left(1 - G\left(\phi_{xr}^{*BU}\right)\right) / \left(1 - G\left(\phi^{*B}\right)\right).$$

Note that

$$\pi_d^i\left(\tilde{\phi}^i\right) = \frac{r_d^i\left(\tilde{\phi}^i\right)}{\sigma} - f \quad \text{and } r_d^i\left(\tilde{\phi}^i\right) = r_d^i\left(\phi^{*i}\right)\left(\frac{\tilde{\phi}^i}{\phi^{*i}}\right)^{\sigma-1} = \sigma f\left(\frac{\tilde{\phi}^i}{\phi^{*i}}\right)^{\sigma-1}. \tag{43}$$

Thus,

$$\pi_d^i\left(\tilde{\phi}^i\right) = fk\left(\phi^{*i}\right), \quad \text{where } k\left(\phi\right) = \left(\frac{\tilde{\phi}\left(\phi\right)}{\phi}\right)^{\sigma-1} - 1. \tag{44}$$

Similarly,

$$\pi_x^{ij}\left(\tilde{\phi}_x^{ij}\right) = f_x k\left(\phi_x^{*ij}\right), \tag{45}$$

$$\pi_{xr}^{BE}\left(\tilde{\phi}_x^{BE}\right) = d^E k\left(\phi_{xr}^{*BE}\right), \tag{46}$$

$$\pi_{xr}^{BU}\left(\tilde{\phi}_{xr}^{BU}\right) = \left(f_x + d^U\right) k\left(\phi_{xr}^{*BU}\right). \tag{47}$$

Let us denote $\left(1 - G\left(\phi\right)\right) k\left(\phi\right)$ by $J\left(\phi\right)$. By substituting the expressions above into (38) and using relationships (30)-(33), we receive three equations for the productivity cutoffs corresponding to, respectively, the EU, the US, and Bangladesh:

$$fJ(\phi^{*E}) + f_x J(A\phi^{*U}) + f_x J\left(A^B\phi^{*B}\right) = \delta f_e, \tag{48}$$

$$fJ(\phi^{*U}) + f_x J(A\phi^{*E}) + f_x J\left(A^B\phi^{*B}\right) = \delta f_e, \tag{49}$$

$$\begin{aligned} fJ(\phi^{*B}) + f_x J(A^{BE}\phi^{*E}) + d^E J\left(A^{BE}_{ROO}A^{BE}\phi^{*E}\right) \\ + \left(f_x + d^U\right) J\left(A^{BU}_{ROO}\phi^{*U}\right) = \delta f_e. \end{aligned} \tag{50}$$

Solving the system above gives ϕ^{*E}, ϕ^{*U}, and ϕ^{*B}, which, in turn, allows to solve for all the other variables in the economy.[32]

Note that from (48) and (49)

$$fJ(\phi^{*E}) - f_x J(A\phi^{*E}) = \delta f_e - f_x J\left(A^B\phi^{*B}\right) \tag{51}$$

$$fJ(\phi^{*U}) - f_x J(A\phi^{*U}) = \delta f_e - f_x J\left(A^B\phi^{*B}\right). \tag{52}$$

As the RHS of the above two equations are the same and the LHS is symmetric, we can show that in equilibrium, they intersect along the 45 degree line. This makes sense: as both US and EU firms sell to Bangladesh, and their trade costs are the same, they must have the same export cutoffs.

Lemma 1 $\phi^{*E} = \phi^{*U}$.

Proof. Denote $fJ(\phi^*) - f_x J(A\phi^*)$ by $\psi(\phi^*)$. We want to show that $\psi(\phi^*)$ is strictly decreasing

[32] All variables in the economy can be expressed through the productivity cutoffs, ϕ^{*E}, ϕ^{*U}, and ϕ^{*B}, and the masses of variety in each country, M^E, M^U, and M^B. To derive M^i, $i = E, U, B$, trade balance equations can be used.

in ϕ^*, therefore, from (51) and (52) $\phi^{*E} = \phi^{*U}$.

$$\psi'(\phi^*) = fJ'(\phi^*) - f_x A J'(A\phi^*). \tag{53}$$

Recall that $J(\phi^*) = (1 - G(\phi^*)) k(\phi^*) = (\phi^*)^{1-\sigma} \int_{\phi^*}^{\infty} \phi^{\sigma-1} g(\phi)\, d\phi - [1 - G(\phi^*)]$.

Thus,

$$J'(\phi^*) = -(\sigma - 1)(\phi^*)^{-\sigma} \int_{\phi^*}^{\infty} \phi^{\sigma-1} g(\phi)\, d\phi < 0. \tag{54}$$

As a result,

$$\frac{f\,|J'(\phi^*)|}{f_x A\,|J'(A\phi^*)|} = \frac{f \int_{\phi^*}^{\infty} \phi^{\sigma-1} g(\phi)\, d\phi}{f_x A^{1-\sigma} \int_{A\phi^*}^{\infty} \phi^{\sigma-1} g(\phi)\, \phi} = \tau^{\sigma-1} \frac{\int_{\phi^*}^{\infty} \phi^{\sigma-1} g(\phi)\, d\phi}{\int_{A\phi^*}^{\infty} \phi^{\sigma-1} g(\phi)\, \phi} > 1. \tag{55}$$

Therefore, $\psi'(\phi^*) = -f\,|J'(\phi^*)| + f_x A\,|J'(A\phi^*)| < 0$. ■

Lemma 1 allows to rewrite system (48)-(50) in terms of ϕ^{*E} and ϕ^{*B} :

$$fJ(\phi^{*E}) + f_x J(A\phi^{*E}) + f_x J\left(A^B \phi^{*B}\right) = \delta f_e, \tag{56}$$

$$fJ(\phi^{*B}) + f_x J(A^{BE}\phi^{*E}) + d^E J\left(A^{BE}_{ROO} A^{BE} \phi^{*E}\right)$$

$$+ \left(f_x + d^U\right) J\left(A^{BU}_{ROO} \phi^{*E}\right) = \delta f_e. \tag{57}$$

To compare ϕ^{*E} and ϕ^{*B}, we note that $A > A^{BE}$ as $\tau^E > \tau^B$. Moreover, we will assume that $A^B > A^{BU}_{ROO}$. This is motivated by Bangladeshi tariffs on imports being high. We assume that they are higher than the implicit effect of US *ROOs* and quotas. We first discuss the solution of the following system of equations

$$fJ(\phi^{*E}) + f_x J(A\phi^{*E}) + f_x J\left(A^B\phi^{*B}\right) = \delta f_e, \tag{58}$$

$$fJ(\phi^{*B}) + f_x J(A\phi^{*E}) + f_x J\left(A^B\phi^{*E}\right) = \delta f_e, \tag{59}$$

where equation (58) corresponds to the EU and equation (59) corresponds to Bangladesh.

Then, we analyze the effect of the following three changes on the solution of the system:

(a) In equation (59), A falls to A^{BE} and A^B falls to A^{BU}_{ROO}.

(b) We add $d^E J\left(A^{BE}_{ROO}A^{BE}\phi^{*E}\right) + d^U J\left(A^{BU}_{ROO}\phi^{*E}\right)$ to equation (59). Thus, we now have

$$fJ(\phi^*_B) + f_x J(A\phi^{*E}) + f_x J\left(A^B\phi^{*E}\right) + d^E J\left(A^{BE}_{ROO}A^{BE}\phi^{*E}\right) + d^U J\left(A^{BU}_{ROO}\phi^{*E}\right) = \delta f_e; \tag{60}$$

(c) The productivity distribution in Bangladesh improves in terms of hazard rate stochastic dominance (HRSD).

Finally, we show that the difference between Bangladesh and the EU and US means having all three changes all together in our model, which leads to $\phi^{*E} < \phi^{*B}$, and as a result, $\phi^{*U} < \phi^{*B}$.

Lemma 2 $\phi^{*U} = \phi^{*E} < \phi^{*B}$.[33]

Proof. We can express ϕ^B as a function of ϕ^E from each equation (58) and (59). Then, we can plot both functions in the $\left(\phi^E, \phi^B\right)$ space and find the equilibrium pair $\left(\phi^{*E}, \phi^{*B}\right)$ as an intersection of two curves. Using a similar technique as in Demidova (2005), it can be shown that both curves are decreasing in ϕ^E. Moreover, at any intersection of two curves, the curve corresponding to equation (59) is flatter than the curve corresponding to equation (58). This property implies the uniqueness

[33] *An appendix with a detailed proof is available upon request.*

of the intersection point, since both curves are decreasing in ϕ^E. (If there is another intersection, at this point, the curve corresponding to equation (59) should be steeper than the curve corresponding to equation (58), which violates the property proved above.) Note that this result does not depend on the relationship between the productivity distributions in two countries.

In addition, since both equations are symmetric, the intersection of two curves lies on the 45^0 line as shown in Figure $8(a)$.

(a) A fall in A and A^{BE} in equation (59) means that the curve corresponding to equation (59) shifts up and to the right as shown in Figure $8(b)$. The logic is that for any fixed ϕ^{*E}, $fJ(\phi_B) = \delta f_e - \left[f_x J(A\phi^{*E}) + f_x J\left(A^B \phi^{*E}\right)\right]$ decreases, since $J(\cdot)$ is a decreasing function. Thus, ϕ^B increases. Note that it can be shown that at the intersection of two curves, the curve corresponding to equation (59) is again flatter than the curve corresponding to equation (58).

(b) By adding these terms get back the original system, we get (60). Again, this change means that for any fixed ϕ^{*E}, $fJ(\phi^B)$ decreases. Thus, the effect is the same as shown in Figure $8(b)$. Moreover, the property of the slopes of two curves at the intersection point remains the same. Hence, this also has the same effect.

(c) If the productivity distribution in Bangladesh improves in terms of hazard rate stochastic dominance (HRSD), then, as shown in Demidova (2005), this change means that in equation (59), which corresponds to Bangladesh, function $J(\phi)$ becomes higher than it was before for any ϕ. As a result, the curve corresponding to equation (59) shifts up and to the right as shown in Figure $8(b)$ and again, the property of the slopes of two curves at the intersection point remains the same, since it does not depend on the productivity distributions.

Thus, all these changes shift the curve corresponding to equation (59) to the right, leading to $\phi^{*B} > \phi^{*E}$, and hence, $\phi^{*B} > \phi^{*U}$. ■

Now, we are able to compare the productivity cutoff levels for firms exporting from Bangladesh to the EU and US: from (30) and (32) it follows that

$$\phi_x^{*BE} = A\phi^{*E}, \quad \phi_{xr}^{*BE} = A_{ROO}^{BE} A\phi^{*E}, \quad \phi_{xr}^{*BU} = A_{ROO}^{BU}\phi^{*U}. \tag{61}$$

Result 1. Since $A_{ROO}^{BU} > A$, $\phi_x^{*BE} < \phi_{xr}^{*BU}$. This shows that a more restrictive trade policy in the US results in only more productive Bangladeshi firms being able to compete there.

Result 2. The number of firms that export to the US is smaller than the number of firms who export to the EU in both woven and non woven industries. Follows from Result 1.

Result 3. If we consider firms who sell to only the EU, there should be a higher percentage of the exporters that invoke $ROOs$ in the non-woven industry than in the woven firms. This comes from a lower A_{ROO}^{BE} in the non woven industry.

Result 4. If documentation cost for firms who export to the EU and invoke $ROOs$, d^E, is high enough so that $A_{ROO}^{BE} > 1$, then $\phi_x^{*BE} < \phi_{xr}^{*BE}$. Moreover, stricter ROOs in the woven industry increase the gap between ϕ_x^{*BE} and ϕ_{xr}^{*BE} compared to the non woven industry. (Low costs of meeting $ROOs$ in the non woven sector lead to A_{ROO}^{BE} close to 1, thus, ϕ_x^{*BE} is approximately the same as $\phi_{xr}^{*BE} = A_{ROO}^{BE}\phi_x^{*BE}$.)

Result 5. Firms who export to both markets are more productive than those who do not.

Note that the definition of mass of firms exporting to the US and EU:

$$M_x^{BE} = p_x^{BE} M^B = \frac{1 - G\left(\phi_x^{*BE}\right)}{1 - G\left(\phi^{*B}\right)} M^B, \tag{62}$$

$$M_{xr}^{BE} = p_{xr}^{BE} M^B = \frac{1 - G\left(\phi_{xr}^{*BE}\right)}{1 - G\left(\phi^{*B}\right)} M_B, \tag{63}$$

$$M_{xr}^{BU} = p_{xr}^{BU} M^B = \frac{1 - G\left(\phi_x^{*BU}\right)}{1 - G\left(\phi^{*B}\right)} M^B. \tag{64}$$

Thus, from Result 1, it follows that $M_{xr}^{BU} < M_x^{BE}$ (Result 2), and Result 3 follows from Result 4.

Note that trade policy, which makes *ROOs* for Bangladeshi firms less restrictive, will lead to an increase in ϕ^{*B} and a fall in ϕ^{*U} and ϕ^{*E}, since this policy is equivalent to the fall in A_{ROO}^{BE} and A_{ROO}^{BU}.

Table 1: Sample Averages: by industry and export destination

	All firms			Woven firms			Non-woven firms		
	All firms	Majority EU exporters	Majority US exporters	All firms	Majority EU exporters	Majority US exporters	All firms	Majority EU exporters	Majority US exporters
sales	4046.8	3437.2	5596.5	4471.4	3546.0	5933.9	3129.7	3282.1	2679.4
export	4016.1	3403.3	5586.7	4463.8	3543.5	5923.0	3049.0	3203.4	2679.4
cost	3665.1	3122.2	5051.3	4007.0	3134.1	5376.5	2926.7	3105.3	2240.1
materials	2812.0	2386.7	3888.2	3183.3	2555.8	4178.7	2010.0	2145.6	1376.9
imported materials	2163.9	1746.1	3220.7	2501.4	1887.0	3461.8	1434.8	1545.3	1137.1
wage bill	441.0	393.9	539.4	456.9	374.9	557.3	406.7	421.0	384.7
employee	772.4	706.6	905.2	802.6	696.5	919.5	707.1	721.1	781.2
investment	250.3	326.0	119.5	88.4	55.5	125.9	600.0	711.6	64.4
capital	1889.7	2142.7	1424.9	1884.2	2187.4	1486.6	1901.8	2079.1	890.8
number of firms	232	154	75	160	94	68	72	60	7

Notes: Total number of firms is 232 with an unbalanced panel of 1027.
All values are in thousands of US$, except for number of employees.

Table 2: Dependent variable: Log of output

	(1) OLS	(2) Olley-Pakes (OP)	(3) Within OP	(4) Within OP	(5) Within OP
Materials	0.688***	0.683***	0.715***	0.715***	0.715***
	(0.037)	(0.038)	(0.066)	(0.065)	(0.065)
Labor	0.283***	0.285***	0.247***	0.255***	0.255***
	(0.036)	(0.037)	(0.088)	(0.089)	(0.089)
Capital	0.025***				0.021*
	(0.008)				(0.011)
Age					0.030
					(0.019)
Endogeneity correction[1]	No	Yes	Yes	Yes	Yes
Selectivity correction[2]	No	No	No	No	Yes
Firm fixed effects	No	No	Yes	Yes	Yes
Year fixed effects	No	No	No	Yes	Yes
Observations	1027	1027	1027	1027	795

Notes: Heteroskadasticity corrected white robust standard errors in parentheses.

[1]A 3rd order polynomial function of age, capital and investment are included.

[2]A 3rd order polynomial function of propensity to stay in business and the fitted output net of labor and capital are included.

Table 3: Dependent variable: Log of TFP

	(1) Within	(2) Within	(3) Between	(4) Between	(5) Between	(6) Between
Majority EU exporter	-0.072*		-0.268***			
	(0.037)		(0.103)			
Majority US exporter		0.085**		0.350***		
		(0.040)		(0.126)		
Woven*Majority EU export			0.233**			
			(0.114)			
Woven*Majority US exporter				-0.303**		
				(0.136)		
Export share of EU					-0.325***	
					(0.118)	
Woven*Export share of EU					0.299**	
					(0.133)	
Export share of US						0.445***
						(0.139)
Woven*Export share of US						-0.398***
						(0.152)
Firm fixed effects	Yes	Yes	No	No	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects			Yes	Yes	Yes	Yes
Observations	1013	1013	1013	1013	1013	1013

Notes: Sample consists of an unbalanced panel of 227 exporting firms, from 1999 to 2003.
Asymptotic standard errors in parentheses.

Table 4: First Order Stochastic Dominance test of Productivity Distribution for All Firms

	(1)	(2)
Distribution A	Majority EU exporters	Majority US exporters
Distribution B	other firms	other firms
Decile 1	1.644	-1.169
Decile 2	2.250	-1.707
Decile 3	2.993**	-3.266**
Decile 4	3.007**	-3.491***
Decile 5	2.710*	-2.707*
Decile 6	2.391	-2.455
Decile 7	2.350	-2.793*
Decile 8	2.561*	-3.168**
Decile 9	3.676***	-4.412***
Decile 10	0	0
PAT($\chi^2_{(9)}$)	**19.236****	**28.548*****

Note: *, **, *** denotes significant at 1, 5 and 10 percent level respectively.

Table 5: First Order Stochastic Dominance Test of Productivity Distribution: Non-Woven vs Woven

	(1)	(2)	(3)	(4)	(5)	(6)
		Non-Woven firms			Woven firms	
Distribution A	Solely EU exporters	Solely non-EU exporters	US exporters	Solely EU exporters	Solely non-EU exporters	US exporters
Distribution B	other firms	other firms	other firms	other firms	other firms	other firms
Decile 1	3.923***	0.694	-2.554	-1.073	0.682	1.406
Decile 2	4.988***	0.07	-3.553***	-0.305	-0.211	0.874
Decile 3	3.781***	0.516	-3.556***	1.17	-0.788	-0.89
Decile 4	4.068***	0.152	-2.728*	1.325	-1.833	-1.149
Decile 5	4.181***	-0.992	-3.089**	1.046	-2.103	-0.495
Decile 6	2.745*	-2.179	-1.285	1.122	-1.476	-0.485
Decile 7	1.123	-2.683*	-0.478	2.590*	-2.212	-1.76
Decile 8	-0.28	-2.068	0.057	0.905	-1.677	-0.194
Decile 9	1.573	-4.699***	-2.136	1.59	-1.972	-0.779
Decile 10	0	0	0	0	0	0
PAT(χ^2(9))	**43.952*** **	**32.932*** **	**30.890*** **	**19.386**	**11.786**	**18.217**

Note: *, **, *** denotes significant at 1, 5 and 10 percent level respectively.

Table 6: Dependent variable: Log of TFP

	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
Majority EU exporter	-0.374*	-0.090		
	(0.213)	(0.060)		
Majority EU exporter with GSP	0.078	0.112*		
	(0.052)	(0.062)		
Export share of EU			-0.381	-0.102
			(0.238)	(0.072)
Export share of EU with GSP			0.116*	0.202**
			(0.066)	(0.090)
Observations	64	132	64	132

Notes: Samples in Columns (1) and (3) cover 64 non-woven firms in 2003.
Samples in Columns (2) and (4) cover 132 woven firms in 2003.
Robust standard errors in parentheses.

Table 7: First Order Stochastic Dominance Test: ROOs and Quota

	(1)	(2)	(3)
	Majority EU exporters in Non-Woven	Majority EU exporters in Woven	Majority US exporters
Distribution A	with GSP (ROOs)	with GSP (ROOs)	Quota
Distribution B	without GSP	without GSP	no quota
1	-1.621	-3.491***	-.870
2	-2.326	-3.135**	-.292
3	-2.378	-3.312***	-.685
4	-2.150	-1.839	-1.321
5	-1.364	-.636	-1.657
6	0	0	0
PAT($\chi^2_{(5)}$)	**6.968**	**16.952*** **	**3.850**

Figure 1: Market Choice by Firms with Different Markets

Figure 2: Woven Industry's Cutoffs

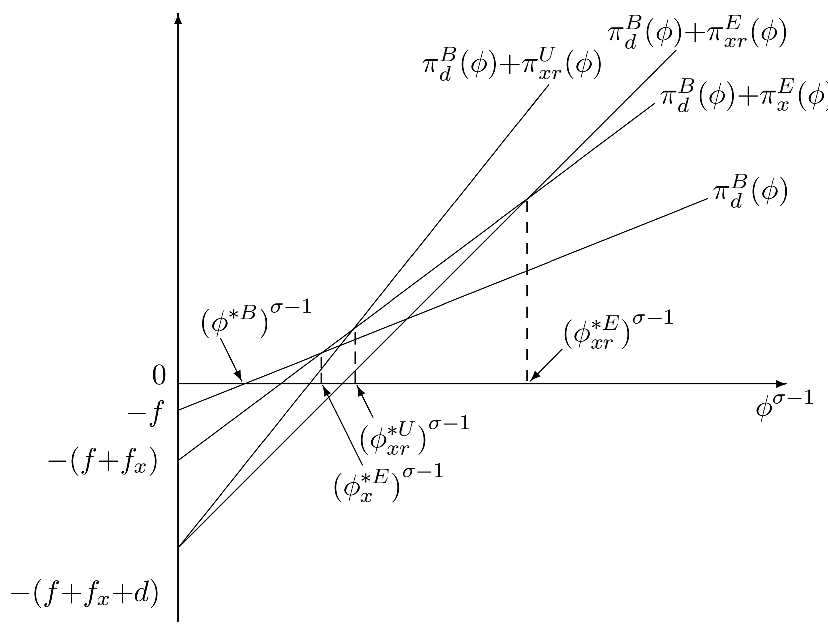

Figure 3: Non-Woven Industry's Cutoffs

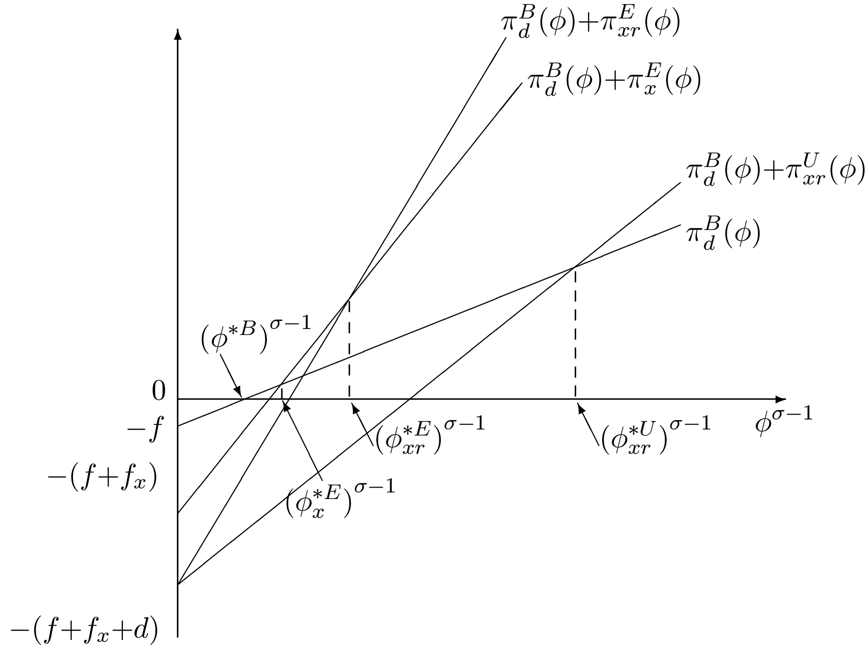

Figure 4: Cumulative Distribution of Productivity of EU exporters

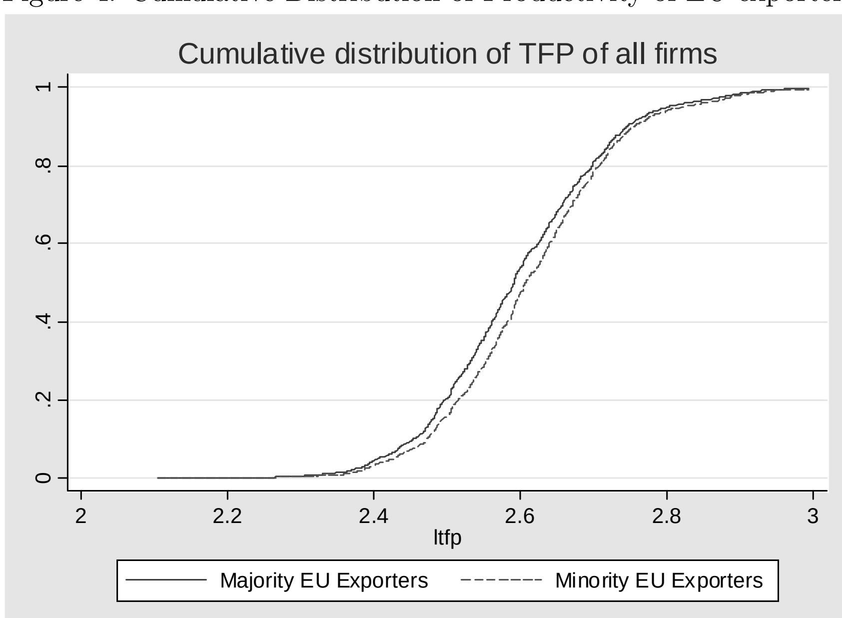

Figure 5: Cumulative Distribution of Productivity of US exporters

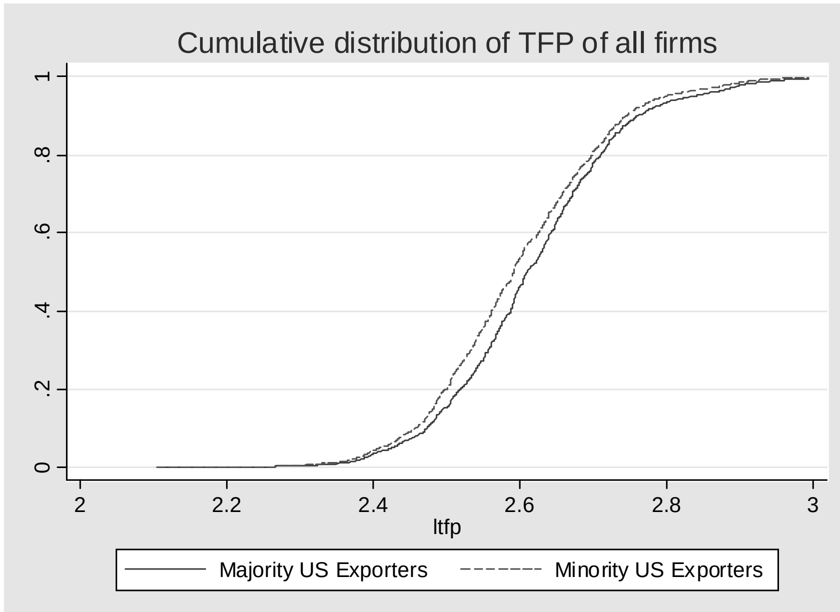

Figure 6: Cumulative Distribution of Productivity of US exporters with and without quota

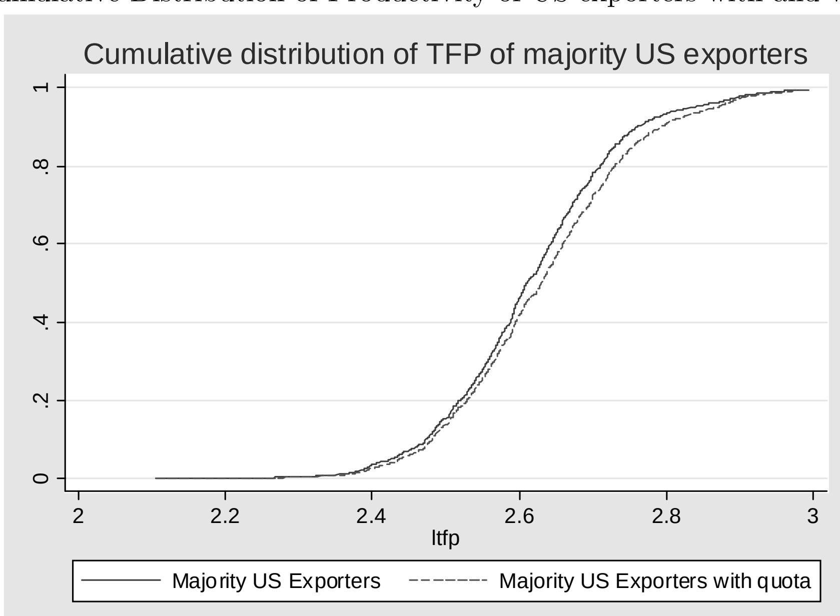

Figure 7: The Structure of Economy

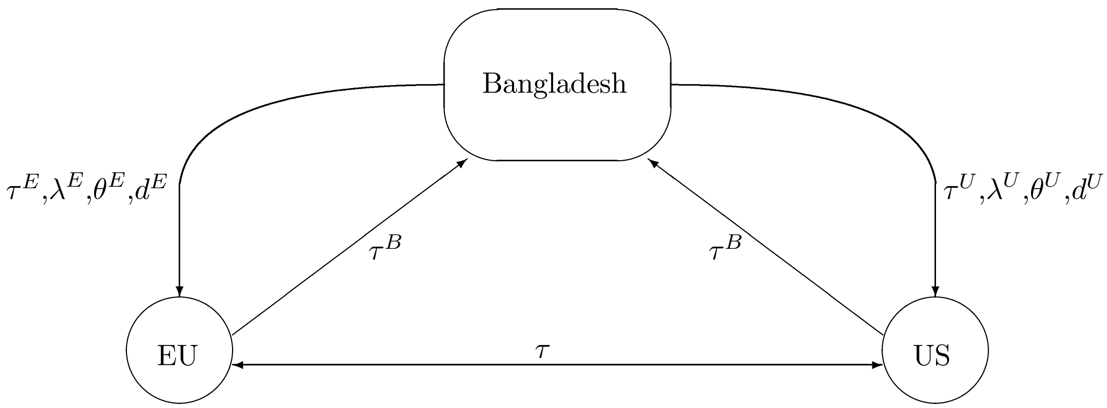

Figure 8: Proof of Lemma 2