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ABSTRACT

CHAPTER 1: Productivity Improvements and Falling Trade Costs: Boon or Bane?

This essay looks at two features of globalization, namely, productivity improvements and falling trade costs, and explores their effect on welfare in a monopolistic competition model with heterogeneous firms and technological asymmetries. Contrary to received wisdom, and for reasons unrelated to adverse terms of trade effects, it is shown that improvements in a partner's productivity reduce welfare. Moreover, with technological asymmetries, the more productive country gains significantly more from falling trade costs than does the backward one.

CHAPTER 2 (with Hiau Looi Kee and Kala Krishna): Do Trade Policy Differences Induce Sorting? Theory and Evidence from Bangladeshi Apparel Exporters.

This essay provides new testable predictions of heterogeneous firm (HF) models for trade. Variations in trade policy, trade preferences, and the rules of origin (ROOs) needed to obtain them are incorporated into the model and some analytical means of dealing with the resulting asymmetries are developed. The policy differences modeled correspond to differences across products and destination markets for Bangladeshi garment exports to the US and EU which turns out to provide an interesting natural experiment. Predictions of the model for the distributions of TFP of various groups of firms are tested non-parametrically and are supported by the data.

CHAPTER 3 (with Andres Rodriguez-Clare): Export Subsidies, Productivity and Welfare under Firm-Level Heterogeneity.

In this essay the monopolistic competition setting with heterogeneous firms is used to study the effect of an export subsidy on productivity and welfare of a small economy with a first best consumer subsidy already in place, which neutralizes the domestic distortion caused by the mark-up. It is shown that even though the export subsidy induces productivity growth in the economy, its effect on welfare is negative due to increasing input prices and falling variety.

CHAPTER 4 (with Kala Krishna): Trade and Trade Policy with Differentiated Products: A Chamberlinian-Ricardian Model: A Comment.

This essay shows that the results of Venables (1987) strongly depend on the assumption that there are no fixed costs of trade. The introduction of fixed costs of exporting, while making the model more consistent with the empirical evidence, leads to the opposite conclusion that technological progress in one country cannot harm the welfare of its trading partner. However, the results can be obtained in a richer setting with heterogeneous firms.

CHAPTER 5 (with Kala Krishna): Regulations, Regime Switches and Non-Monotonicity when Non-Compliance is an Option: An Application to Content Protection and Preference: A Comment.

This essay shows that the result of Ju and Krishna (2002), i.e., the non-monotonicity in the comparative statics across regimes, disappears, if exporters differ in their productivities. Taking into account firm heterogeneity not only makes the model more consistent with the empirical data, but also provides very different predictions about the results of policy changes.

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To my family.

Chapter 1

Productivity Improvements and Falling Trade Costs: Boon or Bane?

1.1 Introduction

Should a country welcome productivity improvements in its trading partners or should it be apprehensive? Should all countries welcome falling trading costs or are their welfare effects asymmetric across countries with some gaining and others losing? This is a question of fundamental importance today as globalization results in the spread of technology and concomitant productivity improvements from the North to the South, while concurrently falling trade costs and trade barriers improve market access. The standard mantra from trade economists has been that, by and large, such changes are beneficial for the economy as a whole, though some segments of society gain and others lose. *It is argued below, that though there are always gains from trade, improvements in a partner's productivity hurt us (for a new and different reason). Falling trade costs help the advanced country but by less than they help the backward one. This paper also provides new reasons for a country to invest in its infrastructure: more on this below.*

A monopolistic competition model with heterogeneous firms based on Melitz (2003) is used to identify a new effect, the technological potential effect.[1] The technological potential of a country consists of the distribution of productivities its firms draw from and the impact of this on its competitiveness in the marketplace. The technology a firm has access to interacts with market conditions to determine the equilibrium distributions of productivity, the extent of competition and variety in equilibrium. If countries have different technologies available to them, i.e., their firms draw from different distributions which are ordered in terms of hazard rate stochastic dominance (HRSD)[2], and there is no specialization, then productivity improvements in one country raise welfare there but reduce that of its trading partner. The intuition behind the results is that there is a monopoly distortion in the differentiated good sector so

[1] In the existing literature (see, for instance, Melitz (2003), Melitz and Ottaviano (2003), Baldwin and Forslid (2004)) all firms are assumed to draw from the same distribution. As a result, this effect has been neglected.

[2] Or in the case of a Pareto distribution, ordered in terms of the usual (first order) notion of stochastic dominance. Note that the case of the Pareto distribution with a difference in the supports is considered in Falvey, Greenaway and Yu (2005).

price exceeds marginal costs. As a result, the price of the differentiated goods relative to the competitively produced numeraire exceeds the ratio of their marginal costs. Hence, too little is produced and consumed of the differentiated goods. Anything that makes this distortion worse reduces welfare.

An improvement in the technological potential, which occurs when firms can draw from a “better” distribution of productivities, results in more entrants in the home country, and fewer abroad. Domestic entrants are drawn by the higher expected profits from being an exporter. Competition intensifies and the cutoff productivity level rises so that average domestic firm productivity rises. Though the number of foreign producers exporting to the home market falls, the surge in the entry of domestic firms overwhelms it. As a result, consumption of the differentiated goods at home rises and consumers gain, though the import of the differentiated goods from abroad decreases. As for the foreign country, a fall in its domestic production is not fully compensated for by the increase in the export of home firms and its differentiated good consumption and welfare falls. Note that the results are not coming from a terms of trade effect. If anything, a terms of trade effect should work in the opposite direction. The technological leader is a net exporter of the differentiated good. If its firms draw from an even better distribution, relative supply should shift out and its terms of trade should worsen which should raise the welfare of its partner, not reduce it!

Similarly, a fall in trade costs across the board makes it more advantageous to draw from the better productivity distribution enhancing the technological potential of the advanced country. The gains from falling trade costs accrue disproportionately to the advanced country. Firms are attracted to it and its output and consumption of the differentiated good rises. On the other hand, the backward country looks less attractive and the fall in domestic production there may not be fully compensated for by the rise in imported varieties. If this occurs, the lagging country can lose![3] When both countries draw from the same distribution, as in Melitz (2003), both gain from a fall in trade cost. Thus, only when the countries draw from the distributions that are different enough, can the backward country lose.

[3]Note that all these results still hold in the Melitz and Ottaviano (2003) setting, in which they incorporate endogenous markups using the linear demand system with horizontal product differentiation. An appendix with detailed proofs is available upon request.

Note that compared to the previous literature, the technological potential effect is a completely new channel, through which trade can affect welfare in trading countries. Traditional trade models (whether Ricardian or a variant of Heckscher-Ohlin) offer the basic insight that gains from trade arise when a country faces prices different from its autarky prices. Thus, aside from distributional issues, these models suggest that, ceteris paribus, one would prefer to trade with a country that is different rather than a country which is similar, and with a large country rather than a small one. Moreover, these models suggest that improvements in a trading partners productivity will benefit a country. For example, in the standard Ricardian model with a continuum of goods, productivity improvements by a trading partner raise the welfare of all agents as they weakly raise the real income of domestic labor, the only factor, in terms of each and every good. See Dornbush, Samuelson and Fischer (1977).[4] Also, a fall in trading costs tends to raise welfare as the price of imports falls which raises the real income of labor.

In a richer version of the Ricardian model, Krugman (1986) argues that technological catch up by the followers may hurt the leaders, while technological progress by the leaders helps all countries. The results follow from a combination of terms of trade and real income effects. Progress in the follower country results in greater competition with the leaders exports. This has adverse terms of trade effects for the leader, which creates the possibility of welfare losses for it. However, technological improvements by the leader raise welfare in both countries. Though the leader suffers adverse terms of trade effects, the productivity improvements more than compensate for them, while the follower country gains since the price of the technologically advanced goods it imports falls. These adverse terms of trade effects are one way for exogenous changes such as productivity improvements or falling trade costs to reduce welfare. However, this is not the channel by which the results are obtained here.

Monopolistic competition models with economies of scale where countries have access to the same technology (for example, Helpman and Krugman (1985)) offer a further insight into the effects of trade and technological change. Trade increases market size, which results in a greater variety of products as well as lower prices for the products offered as firms are better

[4]The introduction of nonhomothetic preferences (see Matsuyama (2000)) does not change this result.

able to exploit economies of scale in large markets. In this manner, trade can improve not just aggregate welfare, but the welfare of all agents.[5] However, even in these models, the size of countries plays a crucial role in the determination of gains from trade: the larger the trading partner, the greater the increase in market size due to trade and the greater the gains from trade. In this model, productivity improvements in a trading partner raise welfare as they raise effective market size![6]

Most recently, Melitz and Ottaviano (2003) highlight the role of market potential in trade. They consider a single factor (labor) monopolistic competition model with firm level heterogeneity. Countries differ in their size and in their trade costs but all firms, whether domestic or foreign, draw from the same Pareto productivity distribution. In other words, they have access to the same technological possibilities. Their work has implications for the effect of changing country size, unilateral, bilateral, and preferential liberalization. They show that the larger country gains more from trade than the smaller one.[7] The larger country has more "market potential" than the smaller one and as a result, is a better export base in the trading equilibrium. Thus, more firms produce in the larger country, competition is stronger, and prices are lower than in the smaller country which is why the larger country gains more from trade. In their model, an increase in the size of a country due to an increase in its labor force raises per capita welfare in the growing country leaving that in its partner unchanged.

Their results on the effects of liberalization are more striking. In standard models, unilateral liberalization is welfare improving in the absence of externalities, second best or profit shifting effects. In contrast, they show that unilateral liberalization hurts the liberalizing country while benefiting others through the market potential effect. Such liberalization makes a country a worse export base so that its market potential is reduced: firms prefer to locate behind high trade barriers and export to countries with low trade barriers. The liberalizing country suffers

[5] In the simple HOS model, trade always results in trade-offs: some agents gain while others lose. In monopolistic competition models, gains from trade due to variety effects accrue to all consumers. In fact, if countries are close enough in their relative factor availability, these gains swamp any losses from factor price changes. This explains why free trade with a similar country may be welcomed while free trade with a country that is very different in terms of its endowments is harder to sell.

[6] A formal proof that productivity improvements in one country do not hurt its trading partner in the monopolistic competition model with homogeneous firms is available upon request.

[7] This result is reminiscent of the standard variety effects in monopolistic competition.

a reduction in productivity of domestic firms and a reduction in domestic variety which is not fully compensated for by increased import variety. In addition, they show that preferential liberalization, like a customs union, raises welfare of the union members at the expense of non union ones. The market potential of the union rises, making it a better export base, with consequent beneficial effects on productivity and variety.

This paper focuses on the effect of falling trade costs and technological progress on the *absolute* welfare of asymmetric countries. It provides general results when the distributions countries draw from are ordered according to HRSD without having to make functional form assumptions. It also provides a complete characterization for the Pareto distribution, presenting clean results on absolute welfare changes.[8] In addition, the calibration of the model is used to show the magnitude of the effects described in the paper. For example, a 1% difference in the means of the productivity distributions leads to a 9% difference in welfare levels in two countries.

What lies behind differences in the distributions that firms draw from and what are the policy implications of the results? One way to interpret them is just as difference in the technology available to countries. However, there is a richer interpretation that is more useful. In developing countries, part of the reason why productivity is low is that infrastructure is inadequate. After all, if the power fails on a regular basis, either one has to invest in expensive backup generating equipment (which raises costs) or suffer from lower labor productivity. In such settings, it may also be inappropriate to use cutting edge technology if it is more sensitive to variations in voltage that are the norm in developing countries. As a result, the appropriate technology may differ depending on the infrastructure. Such an interpretation suggests that there may be a significant additional benefit from the government investing in infrastructure: namely, an increase in technological potential!

The paper is organized as follows. Section 1.2 presents the benchmark model with heterogenous firms. Section 1.3 describes the equilibrium in a closed economy and Section 1.4

[8] Falvey, Greenaway and Yu (2005) also use a Melitz (2003) setting to look at the effects of differences in productivity distributions across countries. However, they consider only the case of the Pareto distribution and a difference in its support and have no results regarding the effects on *absolute* welfare of falling trade costs or productivity differences of any form.

studies the properties of this equilibrium. Section 1.5 lays out the properties of the equilibrium in the open economy and proves the main result about productivity improvement. Section 1.6 discusses the Pareto distribution case and presents the results of a calibration of a model. Section 1.7 contains some concluding remarks.

1.2 The Model

The model is based on that of Melitz (2003), who extends Krugman's (1980) trade model by introducing firm level productivity differences. However, all countries in his model are symmetric in terms of the technologies available.[9] This paper allows for the difference in the countries' access to technology so that countries are no longer symmetric. Analytical results, without having to make specific distributional assumptions, are derived. Factor price equalization is achieved by introducing a homogenous good in both countries with constant return to scale production technology and zero costs of transportation. An economy consists of two sectors and has one production factor, labor. A homogenous good (the numeraire) is produced in the first sector. Firms in the second sector produce a continuum of differentiated goods indexed by z.

1.2.1 Preferences

There are L consumers in the economy. Each supplies one unit of labor and has the a utility function given by $U = (N)^{1-\beta} (C)^{\beta}$, where $1 > \beta > 0$. N is a homogenous good and $C = \left(\int_{z\in\Omega} q(z)^{\rho} dz\right)^{1/\rho}$ can be thought of as the number of services obtained from consuming $q(z)$ units of each variety z when there is a mass Ω of available varieties of the differentiated good. The elasticity of substitution between any two differentiated goods is $\sigma = \frac{1}{1-\rho} > 1$. Preference are Cobb Douglas over N and C so that the shares of a consumer's income spent on N and C are, respectively, $1-\beta$ and β. Denote the price of variety z by $p(z)$. It is easy to verify that the cost of a unit of C defines the perfect price index

$$P = \left[\int_{z\in\Omega} p(z)^{1-\sigma} dz\right]^{\frac{1}{1-\sigma}}. \tag{1}$$

[9] Ghironi and Melitz (2003) and Helpman, Melitz, and Yeaple (2003) also deal with symmetric countries. Bernard, Redding and Schott (2004) develop a heterogeneous agent HOS model and so allow for asymmetries in factor endowments. However, outside the FPE region they have to resort to simulations.

As originally shown by Dixit and Stiglitz (1977), the demand for variety z is given by

$$q(z) = C\left[\frac{p(z)}{P}\right]^{-\sigma}. \tag{2}$$

Using (32) shows that expenditure on variety z is

$$p(z)q(z) = PC\left[\frac{p(z)}{P}\right]^{1-\sigma}, \tag{3}$$

where $PC = \int_{z\in\Omega} p(z)q(z)dz$ is the aggregate expenditure on differentiated goods. Note that the share of expenditure on a particular variety depends only on the price of that variety relative to the price index.

1.2.2 Production and Firm Behavior

The homogeneous good is produced under constant returns to scale: one unit of labor makes a unit of this good. Hence, we can normalize the wage rate and the price of the homogenous good in a closed economy to unity. Moreover, as long as this good can be traded freely and there is incomplete specialization as we assume throughout, prices and nominal wages in both countries are also unity.[10] The expenditure on and (in a closed economy) the revenue earned is denoted by R^N. The labor used in the two sectors is denoted by L^N and L^C.

The differentiated good sector has a continuum of prospective entrants that are the same ex-ante. To enter, firms pay an entry cost of $f_e > 0$, which is thereafter sunk. Then they draw their productivity from a common distribution $g(\varphi)$ with positive support over $(0,\infty)$ and a continuous cumulative distribution $G(\varphi)$. At each point of time, there is a mass, M_e, of firms that make such a draw. Once a firm knows its productivity, it can choose to produce or exit. If its productivity draw is below a cutoff level, φ^*, it is best off exiting at once.[11] Any firm that stays in the market has a constant per period profit level. A firm exits (due to some unspecified catastrophic shock) with a constant probability δ in each period.[12] There is no discounting[13] and only stationary equilibria are considered. Note that because exit is random,

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

[11] The existence and uniqueness of φ^* will be shown in Section 1.3.

[12] It would be more plausible to make the probability of exit depend on the firm's productivity. For example, Hopenhayan (1992) models exit caused by series of bad shocks affecting the firm's productivity.

[13] Again, this assumption is made for simplicity.

the productivity distribution for successful entrants, exiting incumbents, and hence, for active firms is the same.

The productivity distribution of successful entrants in the economy is proportional to the initial productivity distribution with the factor of proportionality being the mass of firms that are alive in the stationary equilibrium denoted by M. In a stationary equilibrium, in every period the mass of new successful entrants should exactly replace the firms who face the bad shock and exit. As a result, this gives the aggregate stability condition: $p_{in}M_e = \delta M$, where $p_{in} = 1 - G(\varphi^*)$ is the probability of successful entry. In this manner, M_e and φ^* determine M and φ^* is endogenously determined.

The labor needed to produce q units of a variety is $l(\varphi) = f + q/\varphi$. $f > 0$ is a fixed overhead cost in terms of labor and $\frac{1}{\varphi}$ is the unit labor requirement of a firm with productivity $\varphi > 0$. All firms have the same fixed costs, but differ in their productivity levels. Due to symmetry, the constant elasticity of substitution form assumed, and the fact that there are a continuum of firms, each firm faces a downward sloping demand function with a constant demand elasticity of σ. And as expected in the CED case, it chooses its price so that its marginal revenue, $p(1 - \frac{1}{\sigma})$, equals it marginal costs, $\frac{1}{\varphi}$. From this, it follows that price is

$$p(\varphi) = \left(\frac{\sigma}{\sigma - 1}\right)\left(\frac{1}{\varphi}\right) = \frac{1}{\rho\varphi}. \tag{4}$$

Hence, profits are

$$\pi(\varphi) = r(\varphi) - \frac{p(\varphi)\, q}{p(\varphi)\, \varphi} - f = \frac{r(\varphi)}{\sigma} - f. \tag{5}$$

Variable profits are, thus, a constant share of revenue and this share is greater the less the substitutability between varieties. Also, note that

$$\frac{q(\varphi_1)}{q(\varphi_2)} = \left(\frac{\varphi_1}{\varphi_2}\right)^{\sigma}; \qquad \frac{r(\varphi_1)}{r(\varphi_2)} = \left(\frac{\varphi_1}{\varphi_2}\right)^{\sigma-1}, \tag{6}$$

so that a more productive firm has larger output and revenues, charges a lower price, and earns higher profits compared to a firm with the low productivity level.

Only a firm with $\pi(\varphi) \geq 0$ will find it profitable to produce once it has entered. A firm's value function is given by $\max\left\{0, \sum_{t=0}^{\infty} (1-\delta)^t \pi(\varphi)\right\} = \max\left\{0, \frac{1}{\delta}\pi(\varphi)\right\}$. Since $\pi(0) = -f$ is negative, and $\pi(\varphi)$ is increasing in φ, we can determine the lowest productivity level at which a firm will produce (the cutoff level φ^*) by $\pi(\varphi^*) = 0$. Any entering firm drawing a productivity level $\varphi < \varphi^*$ will exit immediately. Therefore, the distribution of productivity in equilibrium, $\mu(\varphi)$, is:

$$\mu(\varphi) = \begin{cases} \frac{g(\varphi)}{1-G(\varphi^*)}, & \text{if } \varphi \geq \varphi^*, \ \textit{and} \\ 0 & \text{otherwise.} \end{cases} \tag{7}$$

Since each firm produces a unique variety z and draws a productivity φ, with a mass M of firms, the price index is given by

$$P = \left[\int_{\varphi^*}^{\infty} \left[\int_0^M p(z,\varphi)^{1-\sigma} dz\right] \mu(\varphi)\, d\varphi\right]^{\frac{1}{1-\sigma}}.$$

As firms are symmetric ex-ante, p does not depend on z so that $\int_0^M p(z,\varphi)^{1-\sigma} dz = Mp(\varphi)^{1-\sigma}$. Hence,

$$P = M^{\frac{1}{1-\sigma}} \left[\int_{\varphi^*}^{\infty} p(\varphi)^{1-\sigma} \mu(\varphi)\, d\varphi\right]^{\frac{1}{1-\sigma}}.$$

Recall that $p(\varphi) = \frac{1}{\rho\varphi}$ and define $\tilde{\varphi}$[14] as:

$$\tilde{\varphi}(\varphi^*) \equiv \left[\int_0^{\infty} \varphi^{\sigma-1} \mu(\varphi)\, d\varphi\right]^{\frac{1}{\sigma-1}} = \left[\frac{1}{1-G(\varphi^*)} \int_{\varphi^*}^{\infty} \varphi^{\sigma-1} g(\varphi)\, d\varphi\right]^{\frac{1}{\sigma-1}}, \tag{8}$$

so that

$$P = M^{\frac{1}{1-\sigma}} p(\tilde{\varphi}). \tag{9}$$

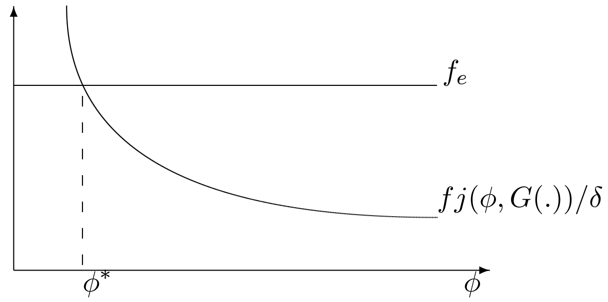
As in Melitz (2003), all aggregate variables can be written in terms of a representative firm, $\tilde{\varphi}$, and M.

$$Q = M^{1/\rho} q(\tilde{\varphi}), \quad R^C = PQ = Mr(\tilde{\varphi}) \equiv M\bar{r}, \quad \Pi^C = M\pi(\tilde{\varphi}) \equiv M\bar{\pi}. \tag{10}$$

where $Q = C = \left(\int_{z\in\Omega} q(z)^\rho\, dz\right)^{1/\rho}$, $R^C = \int_0^{\infty} r(\varphi) M\mu(\varphi)\, d\varphi$ and $\Pi^C = \int_0^{\infty} \pi(\varphi) M\mu(\varphi)\, d\varphi$ represent, respectively, aggregate revenue and profits in the differentiated good sector, $\bar{r}$ and $\bar{\pi}$ represent the average revenue and profit as well as the revenue and profit of the firm with productivity $\tilde{\varphi}$. Note that this allows a heterogeneous firm setting to be transformed to a homogenous firm one, where all firms have productivity $\tilde{\varphi}$.

[14] The assumption of a finite $\tilde{\varphi}$ requires the $(\sigma-1)^{th}$ un-centered moment of $g(\varphi)$ be finite.

Figure 1: The Closed Economy Equilibrium



1.3 Equilibrium in a Closed Economy

To derive the productivity cutoff level φ^* in the equilibrium, we use the free entry (FE) condition:

$$(1 - G(\varphi^*)) \frac{\bar{\pi}}{\delta} = f_e. \tag{11}$$

As shown in Melitz (2003), the average profit level $\bar{\pi}$ can be written as a function of φ^*: $\bar{\pi} = fk(\varphi^*)$, where $k(\varphi^*) = [\tilde{\varphi}(\varphi^*)/\varphi^*]^{\sigma-1} - 1$. Using this formula in (11) and denoting $(1 - G(\varphi^*))k(\varphi^*)$ by $j(\varphi^*, G(\cdot))$, we obtain a final equation for φ^*:

$$\frac{f}{\delta} j(\varphi^*, G(\cdot)) = f_e, \tag{12}$$

where $\frac{f}{\delta} j(\varphi^*, G(\cdot))$ is the present discounted value of the expected profits upon entering when drawing from $G(\cdot)$. As shown in Melitz (2003), $\frac{f}{\delta} j(\varphi^*, G(\cdot))$ is decreasing in φ^* and intersects the f_e line only once. This ensures the existence and uniqueness of φ^*. The solution of (12) does not depend on the labor stock in the economy. Moreover, a graphical representation of (12) in Figure 19 provides a simple way to analyze the changes in φ^* due to changes in the parameters of the model.

Since there are zero profits ex-ante and only one factor, labor, the value added in a sector, or a revenue in this case, equals the value of payments to factors.[15] As a result, the aggregate revenues in both sectors are exogenously fixed by the country size L: $L^N = (1 - \beta) L$ and $L^C = \beta L$.

In any period, the mass of firms, which produce differentiated goods, is given by $M =$

[15] Note that labor payments include those to cover sunk entry costs.

$R^C/\bar{r} = \beta L/\left(\sigma\left(\bar{\pi}+f\right)\right)$. Note that the larger the country size L, the more firms enter the market. As a result, the price index falls and welfare per worker[16] rises due to an increase in product variety.

1.4 Analysis of the Equilibrium

Now we turn to the effect of a better productivity distribution: in this section we will compare two closed economies, home and foreign, with different productivity distributions.

Definition 1 *The productivity distribution $G_H(\varphi)$ dominates the productivity distribution $G_F(\varphi)$ in terms of the hazard rate order, $G_H(\cdot) \succ_{hr} G_F(\cdot)$, if for any given productivity level φ,*

$$g_h(\varphi)/(1-G_H(\varphi)) < g_F(\varphi)/(1-G_F(\varphi)).$$

Hazard rate stochastic dominance (HRSD) allows a ranking of the expectations of an increasing function above some cutoff level, i.e., if $y(x)$ is increasing in x and $G_H(\cdot) \succ_{hr} G_F(\cdot)$, then for any given level φ, $E_H[y(x) \mid x > \varphi] > E_F[y(x) \mid x > \varphi]$.[17] In terms of the model, this means that for any given level φ, entrants in the home country with the productivity distribution $G_H(\cdot)$ have a better chance of obtaining a productivity draw above this level than do entrants in the foreign country with the productivity distribution $G_F(\cdot)$. Given this difference, we obtain

Lemma 1 *For any given level φ, $j(\varphi, G_H(\cdot)) > j(\varphi, G_F(\cdot))$*

Proof. *See Appendix A.* ■

Using Lemma 1 in Figure 20, we conclude that $\varphi_H^* > \varphi_F^*$. Intuitively, since home firms have a better chance of obtaining a productivity above any cutoff level, only more productive firms can survive. As a result, the home country has a lower price index and a higher welfare per worker than the foreign country.

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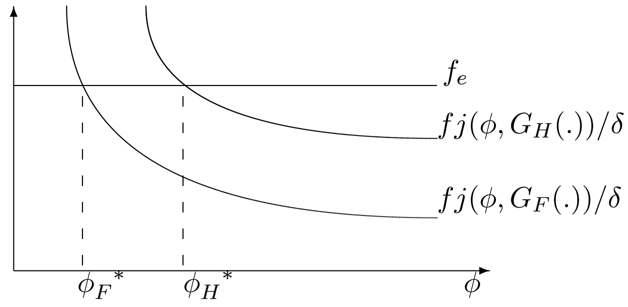
[16] It is determined by the indirect utility function: $W = \left(\frac{(1-\beta)w}{1}\right)^{1-\beta}\left(\frac{\beta w}{P}\right)^{\beta} = \frac{(1-\beta)^{1-\beta}\beta^{\beta}}{P^{\beta}}$.

[17] Note that the usual (first-order) stochastic dominance allows us to compare only the unconditional expectations, i.e., if $G_H(\cdot) \succ_{st} G_F(\cdot)$, then $E_H[y(x)] > E_F[y(x)]$. For more detail see Shaked and Shanthikumar (1994).

Figure 2: Two Closed Economies, Home and Foreign



1.5 The Open Economy

Trade has two basic effects in an economy: on the one hand, it provides an opportunity to sell in the new market; on the other hand, it brings new competitors from abroad. We consider trade with costs: when firms become exporters, they face new costs, such as transport costs, tariffs, etc. As in Melitz (2003), both countries are assumed to be of the same size, and in each country, after the firm's productivity is revealed, a firm who wishes to export must pay a per-period fixed cost, $f_x > 0$. Per-unit trade costs are modeled in the standard iceberg formulation: $\tau > 1$ units shipped result in 1 unit arriving.[18] Regardless of export status, a firm still incurs the same overhead production cost of f per period.

In order to ensure factor price equalization across countries and to focus the analysis on firm selection effects, assume that the homogenous good is produced using the same technology in both countries after trade[19], and that its export does not incur transport costs.[20] The next two sections consider trade with no specialization. Section 1.5.1 presents the equilibrium in the case of symmetric countries and studies the effect of falling trade costs on welfare of trading countries. Section 1.5.2 proves the main result about productivity improvement.

1.5.1 Equilibrium in the Open Economy

In each country under trade, the aggregate revenue earned by domestic firms in the differentiated good sector, R_i^C, can differ from the aggregate expenditure on the differentiated goods, E_i^C, $i = H, F$. ($R_i^C = \gamma_i L$, where γ_i is the fraction of labor employed in the differentiated good

[18] To simplify the analysis, the nominal exchange rate is normalized to one.
[19] This requires $2\beta < 1$.
[20] $\tau = 1$ for the homogenous good.

sector in country i, and $E_i^C = \beta L$.[21])

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, $\gamma_H + \gamma_F = 2\beta$. The export price is $p_x(\varphi) = \tau p(\varphi)$. Using (3), the revenues earned by a firm in country i from domestic sales can be written as $r_i(\varphi) = E_i^C (P_i \rho \varphi)^{\sigma-1}$, where P_i denotes the price index in the differentiated good sector. The revenue of a firm in country i is $r_i(\varphi)$, if the firm does not export, and $r_i(\varphi) + r_j(\tau^{-1}\varphi)$, $i \neq j$, if the firm exports. The actual bundle of goods available can differ across countries as not every firm in each country decides to export.

We assume that $G_H \succ_{hr} G_F$ and consider stationary equilibria only. Then, in country i, the profits earned by a firm from sales in the domestic and foreign markets are, respectively,

$$\pi_{di}(\varphi) = \frac{r_i(\varphi)}{\sigma} - f \quad \text{and} \quad \pi_{xi}(\varphi) = \frac{r_j(\tau^{-1}\varphi)}{\sigma} - f_x, \quad i = H, F. \tag{13}$$

Total profits can be written as $\pi_i(\varphi) = \max\{0, \pi_{di}(\varphi)\} + \max\{0, \pi_{xi}(\varphi)\}$. As in autarky, the productivity cutoff levels must satisfy $\pi_{di}(\varphi_i^*) = 0$ and $\pi_{xi}(\varphi_{xi}^*) = 0$.

Lemma 2 *The productivity cutoff levels in both countries are linked: $\varphi_{xH}^* = A\varphi_F^*$ and $\varphi_{xF}^* = A\varphi_H^*$, where $A = \tau\left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}}$.*

Proof. *See Appendix A.* ■

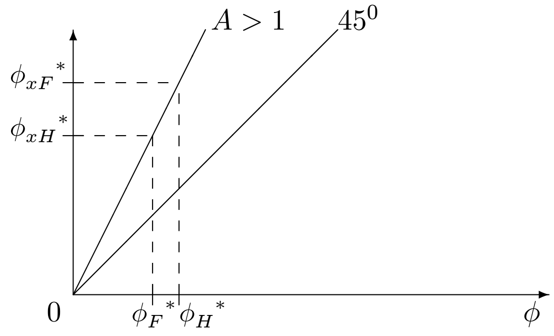
Assumption 1 *To ensure that in both countries only firms producing in the domestic market can export, assume that $f_x/f > X$, where X depends on the difference in the productivity distributions.* [22]

Note that Assumption 1 implies $\varphi_{xi}^* > \varphi_i^*$, thus, from Lemma 2, A should be more than 1. The results of Lemma 2 are depicted in Figure 3. The productivity cutoff level for exporting

[21] As in the autarky, 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 $R_i = R_i^N + R_i^C = L$, $i = H, F$.

[22] *As will be proved in Lemma 3, a country with better productivity distribution (home) is more productive and has a lower price index in the equilibrium. Thus, from (13), $\pi_{xH}(\varphi)$ may become steeper than $\pi_{dH}(\varphi)$ as $\pi_{d,H} = \frac{1}{\sigma}E_H^C (P_H\rho\varphi)^{\sigma-1} - f$ and $\pi_{x,H} = \frac{1}{\sigma}E_F^C \left(P_F\frac{\rho\varphi}{\tau}\right)^{\sigma-1} - f_x$. If $\pi_{xH}(\varphi)$ is too steep, then for any f and f_e, we will get $\varphi_{xH}^* < \varphi_H^*$, which can be prevented if f_x/f is large enough.*

Figure 3: The Open Economy Productivity Cutoff Levels



firms depends on the price index and the mass of domestic firms in the country they export to, which, in turn, depend on the productivity cutoff level for domestic firms in this country.

The ex-ante probabilities of successful entry and being an exporter conditional on successful entry are, respectively, $p_{in,i} = 1 - G(\varphi_i^*)$ and $p_{xi} = [1 - G_i(\varphi_{xi}^*)] / [1 - G_i(\varphi_i^*)]$. The productivity distribution for incumbent firms in country i is $\mu_i(\varphi) = g_i(\varphi) / [1 - G_i(\varphi_i^*)]$ $\forall \varphi \geq \varphi_i^*$ and zero otherwise. Let M_i denote the mass of firms in country i that are alive in the equilibrium. Then the mass of exporting firms and the total mass of varieties available in country i are $M_{xi} = p_{xi} M_i$ and $M_{ti} = M_i + M_{xj}$, respectively.

Using (8), define a representative domestic firm by $\tilde{\varphi}_i \equiv \tilde{\varphi}(\varphi_i^*, G_i(\cdot))$ and a representative exporting firm by $\tilde{\varphi}_{xi} \equiv \tilde{\varphi}(\varphi_{xi}^*, G_i(\cdot))$. The average revenue and profit in country i are

$$\bar{r}_i = r_i(\tilde{\varphi}_i) + p_{xi} r_j\left(\tau^{-1}\tilde{\varphi}_{xi}\right) \qquad \text{and} \qquad \bar{\pi}_i = \pi_{di}(\tilde{\varphi}_i) + p_{xi}\pi_{xi}(\tilde{\varphi}_{xi}). \tag{14}$$

For each country we can write all aggregate variables in terms of $\tilde{\varphi}_{ti}$[23], where:

$$\tilde{\varphi}_{ti} \equiv \left\{ \frac{1}{M_{ti}} \left[M_i \tilde{\varphi}_i^{\sigma-1} + M_{xj}\left(\tau^{-1}\tilde{\varphi}_{xj}\right)^{\sigma-1} \right] \right\}^{\frac{1}{\sigma-1}}, \; i = H, F, \; i \neq j. \tag{15}$$

$$\text{Then,} \quad P_i = M_{ti}^{\frac{1}{1-\sigma}} p(\tilde{\varphi}_{ti}) \qquad \text{and} \qquad E_i^C = M_{ti} r_i(\tilde{\varphi}_{ti}), \quad i = H, F. \tag{16}$$

As in autarky , the FE condition for country i is

$$(1 - G_i(\varphi_i^*)) \frac{\bar{\pi}_i}{\delta} = f_e \tag{17}$$

[23] $\tilde{\varphi}_{ti}$ is a productivity level of the representative firm in country i. Note that in contrast to Melitz (2003), $\bar{r}_i \neq r_i(\tilde{\varphi}_{ti})$ and $\bar{\pi}_i \neq \pi_i(\tilde{\varphi}_{ti})$ because of asymmetric countries.

Using the same technique as before, it can be shown that

$$\pi_{di}\left(\varphi_i^*\right) = 0 \iff \pi_{di}\left(\tilde{\varphi}_i\right) = f k_i\left(\varphi_i^*\right), \tag{18}$$

$$\pi_{xi}\left(\varphi_{xi}^*\right) = 0 \iff \pi_{xi}\left(\tilde{\varphi}_{xi}\right) = f_x k_i\left(\varphi_{xi}^*\right), \tag{19}$$

where $k_i(\varphi) = \left[\tilde{\varphi}_i(\varphi)/\varphi\right]^{\sigma-1} - 1$. Thus, $\bar{\pi}_i$ in an open economy is:

$$\bar{\pi}_i = f k_i\left(\varphi_i^*\right) + p_{xi} f_x k_i\left(\varphi_{xi}^*\right). \tag{20}$$

For the time being, denote $j(\varphi, G_i(\cdot))$ by $j_i(\varphi)$, $i = H, F$. Substituting (20) into (17) leads to a system of equations with two unknown variables (see Appendix A):

$$\frac{f}{\delta} j_H(\varphi_H^*) + \frac{f_x}{\delta} j_H(A\varphi_F^*) = f_e, \tag{21}$$

$$\frac{f}{\delta} j_F\left(\varphi_F^*\right) + \frac{f_x}{\delta} j_F\left(A\varphi_H^*\right) = f_e, \tag{22}$$

where $j_i(\cdot)$ is a decreasing function. The left-hand side of (21) ((22)) is the present discounted values of the expected profits earned by a firm in the home (foreign) country considering entry into the market.

Assumption 2 *The difference in the productivity distributions is not large enough for trade to result in specialization. In other words, in the equilibrium, each country produces both the homogenous and differentiated goods.*[24]

A necessary condition for Assumption 2 is $f_e < \frac{f}{\delta} j_F\left(\frac{1}{A} j_H^{-1}\left(\frac{\delta f_e}{f_x+f}\right)\right) + \frac{f_x}{\delta} j_F\left(A j_H^{-1}\left(\frac{\delta f_e}{f_x+f}\right)\right)$. (See Appendix A for the proof.)

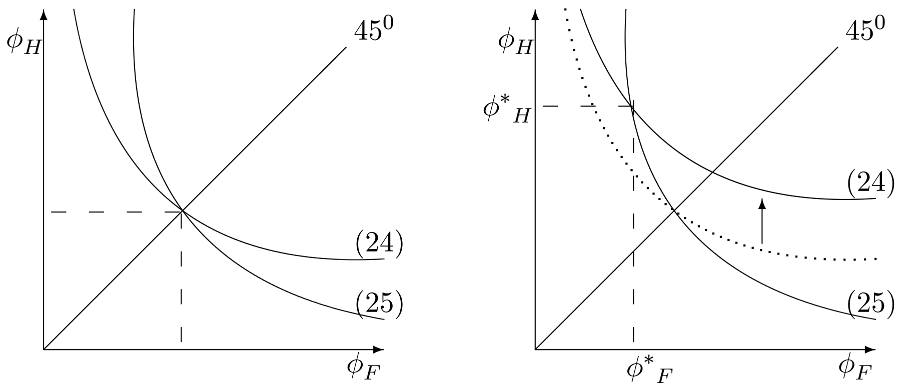
Lemma 3 *If Assumption 1 and Assumption 2 hold, there exists a unique solution $(\varphi_H^*, \varphi_F^*)$ of (21) and (22). Moreover, $\varphi_F^* < \varphi_H^* < \varphi_{xH}^* < \varphi_{xF}^*$.*

Proof. *The sketch of a proof is following.*[25] *First, for any productivity levels φ_H and φ_F,*

[24] *The home country with better productivity distribution is more productive and has a lower price index in the equilibrium. If the difference between counties is large, then P_H can become low enough so that the ex-ante profits from entering of firms in the foreign country do not cover the entry costs, thus, no firm there will choose to enter.*

[25] *See Appendix A for the complete proof.*

Figure 4: Proof of Lemma 3



(a) (b)

express φ_H *as a function of* φ_F*, using (21) and (22):*

$$(21) \implies \varphi_H = j_H^{-1}\left(\frac{\delta f_e}{f} - \frac{f_x}{f} j_H(A\varphi_F)\right), \tag{23}$$

$$(22) \implies \varphi_H = \frac{1}{A} j_F^{-1}\left(\frac{\delta f_e}{f_x} - \frac{f}{f_x} j_F(\varphi_F)\right). \tag{24}$$

Then, plot both functions in the same figure and find the equilibrium pair $(\varphi_H^*, \varphi_F^*)$ *as an intersection of two curves. Note that both curves are decreasing in* φ_F *and for any pair of distributions* $G_H(\cdot)$ *and* $G_F(\cdot)$*, the curve corresponding to equation (23) is flatter than the curve corresponding to equation (24) at any intersection point. This ensures the uniqueness of the intersection. (If there is another intersection, at this point, the curve corresponding to equation (23) should be steeper than the curve corresponding to equation (24), which violates the property proved above.)*

Finally, if countries have the same productivity distribution, i.e., if they are symmetric, the intersection of two curves lies on the 45^0 *line as shown in Figure 4(a) and in the equilibrium* $\varphi_H^* = \varphi_F^*$*. Then, if the productivity distribution in a country improves (worsens) in terms of HRSD, the curve corresponding to the equation for this country shifts up (down). In particular, if the home country has a better distribution in terms HRSD* $(G_H(\cdot) \succ_{hr} G_F(\cdot))$*, the curve corresponding to equation (23) shifts up as shown in Figure 4(b) and in the equilibrium* $\varphi_F^* < \varphi_H^*$*. From Lemma 2,* $\varphi_{xi}^* = A\varphi_j^*$*,* $i \neq j$*, which leads to* $\varphi_F^* < \varphi_H^* < \varphi_{xH}^* < \varphi_{xF}^*$*.* ■

The resulting productivity cutoff levels are depicted in Figure 3. Ex-ante, home firms receive productivity draws from a better distribution. As a result, the home productivity cutoff level for surviving firms, φ_H^*, is higher than φ_F^*. However, while making an export decision, home firms face less severe competition abroad compared to that faced by foreign firms in the home country. Thus, $\varphi_{xH}^* < \varphi_{xF}^*$.

Given φ_H^* and φ_F^*, the trade balance equation allows to derive γ_H and γ_F, the shares of labor in the differentiated good sectors in both countries, as the functions of φ_H^* and φ_F^*. (See Appendix A for details.)

Lemma 4 *If Assumption 1 and Assumption 2 hold, then the home country imports the homogenous good and exports the differentiated goods. The foreign country also exports the differentiated goods, but unlike the home country, it exports the homogenous good as well.*

Proof. *See Appendix A.* ■

Having φ_H^* and φ_F^*, $\bar{\pi}_i$ and $M_i = \frac{R_i^C}{\bar{r}_i} = \frac{\gamma_i L}{\sigma(\bar{\pi}_i + f + p_{xi} f_x)}$ can be obtained. In turn, this determines the price index and the mass of variety available in each country. Note that from (16), the price index in country i depends on the average productivity there, $\tilde{\varphi}_{ti}$, and the mass of variety available, M_{ti}. In turn, M_{ti} depends on $\tilde{\varphi}_{ti}$ and the productivity cutoff level φ_i^*. This allows to write P_i as a function of φ_i^* (see equation (97) in Appendix A) and the welfare per worker as:

$$W_i = \frac{(1-\beta)^{1-\beta}\beta^{\beta}}{P_i^{\beta}} = (1-\beta)^{1-\beta}\beta^{\beta}\left(\frac{\beta L}{\sigma f}\right)^{\beta/(\sigma-1)}(\rho\varphi_i^*)^{\beta}. \tag{25}$$

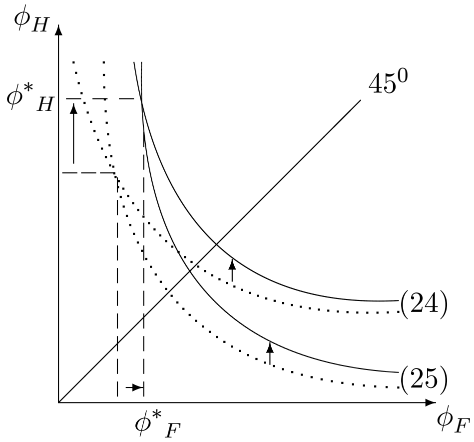
Thus, comparative advantage in the differentiated good sector (a better distribution in terms of HRSD) leads to a greater technological potential and a higher welfare per worker at home than abroad.[26]

Note that a fall in the per-unit trade cost τ due to globalization shifts both curves corresponding to equations (23) and (24) up. As a result, φ_H^* (and, consequently, φ_{xF}^*) increases.[27] However, as shown in Figure 5, φ_F^* (and, consequently, φ_{xH}^*) may increase or decrease. In other words, there is a possibility of welfare loss in the less developed country. Intuitively, when identical countries draw from the same distribution, as in Melitz (2003), a fall in trade

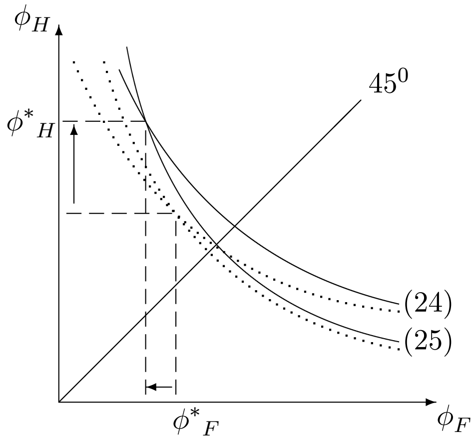
[26] Note that both countries gain from trade compared to autarky.

[27] An increase in φ_H^* can be shown mathematically using equation (96) from Appendix A. ($\psi(\varphi_H^*)$ decreases as A falls.)

Figure 5: A Fall in Trade Cost.



(a) Both Home and Foreign Countries Gain.



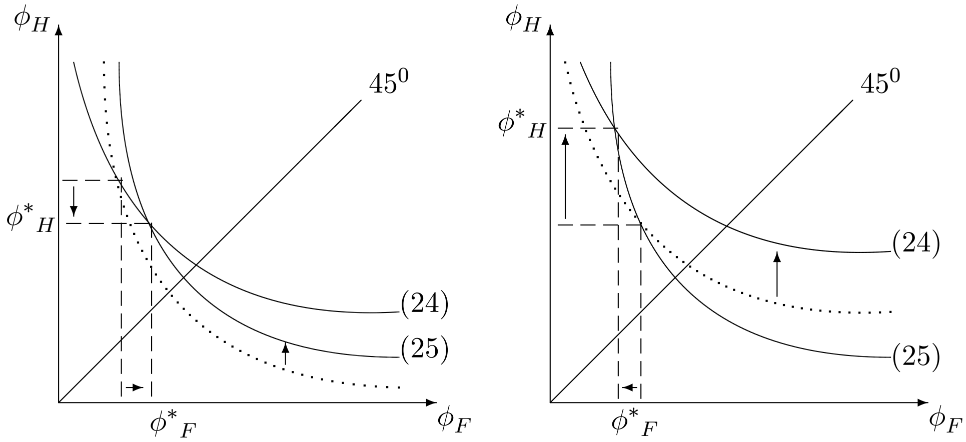
(b) Home Country Gains, Foreign Country Loses.

costs raises both countries welfare. A fall in transport costs creates more export opportunities, which intensifies competition, and this raises the cutoff level, and hence, welfare. However, this result is crucially dependent on symmetry all around. As everything is continuous, when countries draw from similar distributions, Melitz (2003) result must go through. However, when countries draw from very different distributions, the backward one may lose. All firms lose a part of their domestic market, but exporting firms more than make up for this loss. However, when home firms are more advanced, the home market is a tougher one for foreign firms than vice versa. Hence, home firms expand at the expense of foreign ones. As not all firms export, the productivity cutoff level (and hence, welfare) at home rises while that abroad falls. Proposition 1 presents the first result of a paper:

Proposition 1 *In the absence of specialization, falling trade costs raise welfare in the advanced country. The laggard country may gain or lose: it must gain if it is not too different from its trade partner and may lose if it is very backward.*

Proposition 1 offers an explanation of why globalization may adversely affect developing countries whose technology is likely to be dominated by that of the developed world.

Figure 6: Proof of Lemma 5



(a) Productivity Improvement in the Foreign Country

(b) Productivity Improvement in the Home Country

1.5.2 Productivity Improvement and Trade

How does technological progress in a country affect its trading partner? What is the effect of productivity improvement in a trading partner on welfare in each country? To answer this question, the same technique as in the proof of Lemma 4 can be used: productivity improvement in terms of HRSD in the foreign country shifts the curve corresponding to equation (24) up as shown in Figure 6(a), which proves Lemma 5:

Lemma 5 *In the absence of specialization, the productivity improvement in terms of HRSD in the foreign country raises* φ_F^* *and* $\varphi_{xH}^* = A\varphi_F^*$*, and reduces* φ_H^* *and* $\varphi_{xF}^* = A\varphi_H^*$*.*[28]

The interpretation of this result is that when the foreign country faces the productivity improvement, firms there have a better chance of receiving a high productivity draw. Thus, some foreign firms with low productivities, which survive before, exit and φ_F^* rises. As for the home country, a more competitive foreign market decreases the present discounted value of the expected profits of firms at home. Hence, fewer firms enter the market and the productivity cutoff level φ_H^* falls.

[28] *Productivity improvements may result in Assumption 1 and/or Assumption 2 being violated. Note that this case is excluded from the analysis as we assume both Assumption 1 and Assumption 2 hold true after the productivity improvement.*

In the absence of specialization, trade occurs according to Lemma 4. Productivity improvements in the foreign country lead to a fall in the volume of trade. The home country produces and exports fewer differentiated goods. (See Appendix A.) Productivity improvements in the foreign country raise the technological potential there while reducing it at home. Using the same technique, it can be shown that technology improvement in the home country reduces welfare abroad while raising it at home. (See Figure 6(b).)

The intuition for these results is actually quite simple. Monopolistic competition in the differentiated good sector results in firms charging prices above their marginal costs. As a result, the relative price ratio of a differentiated good relative to the numeraire exceeds the ratio of marginal costs. Thus, too little of the differentiated good is produced and consumed in equilibrium. Anything that makes this distortion worse reduces welfare. An improvement in the partner's productivity distribution does exactly this: domestic production of the differentiated good falls, and so does consumption as the fall in consumption of domestic varieties is not fully compensated for by increases in consumption of foreign varieties. Proposition 2 summarizes the main result.

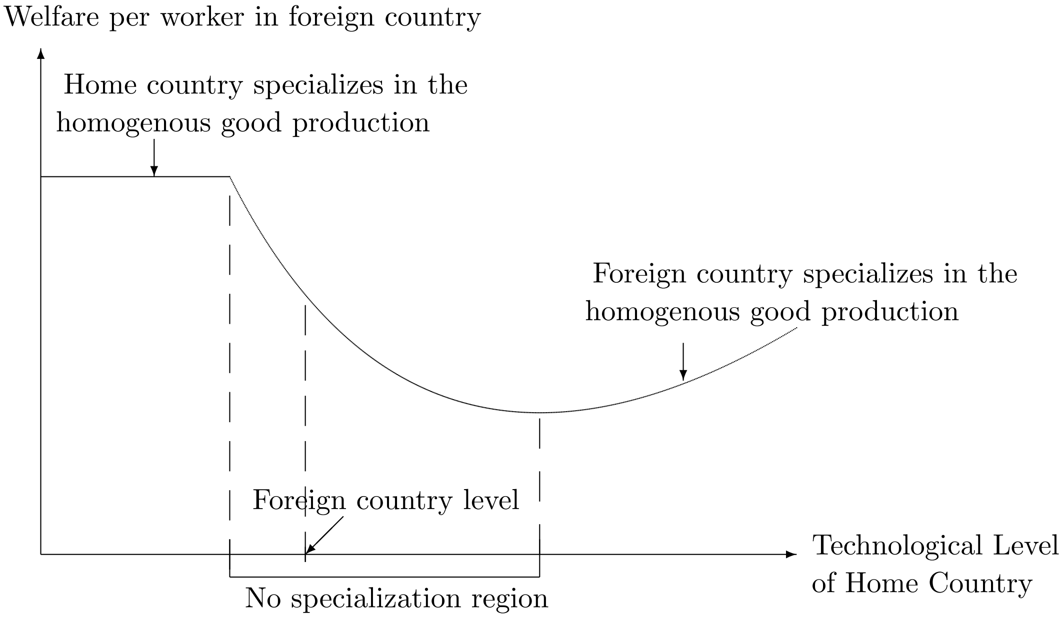
Proposition 2 *In the absence of specialization, productivity improvement in one country raises the productivity cutoff level there while reducing it in the other country. As a result, consumers in the country, which makes the progress and raises its technological potential, gain, while consumers in the other country lose.*

Figure 7 depicts the relationship between welfare per worker in the foreign country and the technological level of the home country.[29] It shows that in the absence of specialization, productivity improvement in the home country decreases welfare per worker in the foreign country.

Note that at some point, productivity improvement in the leading home country makes the gap between the two countries large enough so that the foreign country specializes in the

[29] There is no parameter in the model that describes the technological level of a country, since the productivity distributions are not specified. Thus, each point on the horizontal axes is an abstract representation of the technological level of the home country: the home country is the more advanced the further to the right the point.

Figure 7: Welfare per Worker in Foreign Country



homogenous good, while the home country produces and exports the differentiated goods[30], and the productivity cutoff levels for domestic producers and exporters there, φ_H^* and φ_{xH}^*, determine the price indices, volume of trade, and welfare in both countries. A difference between trade with no specialization and the case in this section is that now welfare at home does not depend on the productivity distribution in the foreign country and the foreign country gains from productivity improvement at home. This increase in welfare in the foreign country is shown in the right part of Figure 7. The horizontal part in Figure 7 corresponds to the case of the home country specialization in the homogenous good, in which the welfare in the foreign country depends only on its own productivity distribution.

1.6 The Pareto Distribution Case

In the case of the Pareto productivity distribution, the assumption of HRSD can be relaxed to the usual (first order) stochastic dominance (USD) instead.[31] To show this, assume that the Pareto productivity distribution is given by $G_i(\varphi) = 1 - \left(\frac{\varphi_{\min,i}}{\varphi}\right)^{k_i}$, where $\varphi > \varphi_{\min,i}$, $k_i > \sigma - 1$, $i = H, F$. The hazard rate for the Pareto distribution is $\frac{g_i(\varphi)}{1-G_i(\varphi)} = \frac{k_i}{\varphi}$. Therefore, if $k_H < k_F$ (or $k_H > k_F$), i.e., the productivity distribution in the home country dominates

[30] In terms of the model, this means that $\gamma_H = 2\beta$ and $\gamma_F = 0$.
[31] Note that HRSD implies USD, however, the opposite is not always true.

that in the foreign country in terms of HRSD, $G_H(\cdot) \succ_{hr} G_F(\cdot)$ (or $G_H(\cdot) \prec_{hr} G_F(\cdot)$), then lemmas 3 and 4 and propositions 1 and 2 can be used to describe the equilibrium in the economy and the effects of productivity improvements and a fall in trade cost on welfare in both countries.

We need to consider the case when $k_H = k_F = k$, but $\varphi_{\min,H} > \varphi_{\min,F}$, i.e., the productivity distribution in the home country dominates that in the foreign country in terms of USD, however, the productivity distributions in both countries are equivalent in terms of HRSD.[32] Using the same techniques as before, it can be shown straightforwardly that the results of this paper still hold.[33] Thus, in the case of the Pareto productivity distribution, the assumption of HRSD can be replaced by the assumption of USD without any change in the results.

1.6.1 Calibration

The goal of this section is to estimate the magnitude of the effects described in the model. To calibrate the parameters, consider the case when both countries have the same productivity distribution. We interpret periods as years and set the size of the exogenous firm exit shock $\delta = 0.1$, which reflects destruction of one in ten jobs a year. As in Ghironi and Melitz (2004), we set $\sigma = 3.8$,a number that comes from Bernard, Eaton, Jensen and Kortum (BEJK, 2003), who show it fits to the US plant and macro trade data. To set the shape parameter k of the Pareto productivity distribution, we use the standard deviation of log US plant domestic sales, 0.84, reported by BEJK for the simulated data.[34] In the model this is equal to $(\sigma - 1)/k$.[35] Thus, given $\sigma = 3.8$, $k = 3.3$. We set $\tau = 1.3$ in line with Obstfeld and Rogoff (2001). To derive the ratio of the fixed costs of exporting to the fixed costs of production for the domestic market, f_x/f, the proportion of exporting plants, 21%, reported in BEJK, is used. In the

[32] Falvey, Greenaway and Yu (2005) consider this case, however, they have no results regarding the effects on absolute welfare.

[33] An appendix with detailed proofs is available upon request.

[34] We use the standard deviation of log domestic sales reported for the simulated data (0.84) instead of that reported for the actual data (1.67), since the latter is inflated for several reasons: it is computed across all the sectors, and not within a sector; it includes sources of heterogeneity outside the scope of the model; and lastly, it is inflated relative to the dispersion of product level sales as more productive plants are much more likely to produce multiple products.

[35] Note that this formula differs from that derived by Ghironi and Melitz (2004) of $1/(k - \sigma + 1)$. This is due to an algebraic error in their paper, which does not affect their theoretical results as confirmed in personal communication with the authors.

model this proportion is equal to $p_x = (1 - G(\varphi_x^*)) / (1 - G(\varphi^*)) = \left(\tau (f_x/f)^{1/(\sigma-1)}\right)^{-k}$, thus, $f_x/f = 1.8$.

Note that the equilibrium condition in the case of symmetric countries with the Pareto productivity distribution can be written as

$$\frac{\sigma-1}{k-(\sigma-1)} \left(\frac{\varphi_{\min}}{\varphi^*}\right)^k \left[1 + \frac{f_x}{f}\left(\tau\left(\frac{f_x}{f}\right)^{1/(\sigma-1)}\right)^{-k}\right] = \delta \frac{f_e}{f}. \tag{26}$$

Thus, without loss of generality, $\varphi_{\min}$ can be normalized to 1. To get the ratio of entry costs to the fixed costs of production for the domestic market, f_e/f, the proportion of the US firms that entered the market and failed within the first two years, which equals to approximately 17%, according to Bartelsman, Haltiwanger and Scarpetta (2004), is used.[36] In our model this number equals to $G(\varphi^*)$. Using the value of φ^* from this relationship in (26) leads to $f_e/f = 64$. Finally, we set $\beta = 0.5$.[37]

We want to compare the case when countries are symmetric ($k_H = k_F = 3.3$) with two cases when the home country has better productivity distribution than the foreign one, i.e., when k_H is 1% smaller than k_F and when k_H is 2% smaller than k_F.[38] This comparison depends on the value of trade costs, τ. Consider τ between 1.16 and 1.62. Figure 8 depicts the level of welfare at home and abroad.[39] As shown in Figure 8, falling trade costs, while beneficial for both countries, widen the difference in welfare of two countries: when the difference in the means of the productivity distributions is 1%[40], a fall in trade costs from 62% to 16% raises the welfare in the home and foreign countries by, respectively, 7.4% and 2% so that the difference in the welfare levels rises from 3.4% to 9%. Moreover, when $\tau = 1.16$, the welfare in the home country is 6.2% higher and the welfare in the foreign country is 2.6% lower compared to the

[36] We take this value as the best approximation of the failure rate, since according to Bartelsman, Haltiwanger and Scarpetta (2004), in the US, the time when the firm is registered differs from that when its employment is recorded, giving rise to the possibility that firms are recorded as having zero employees in the first year and positive employment in the second year, so that entrant firms include zero-employees firms.

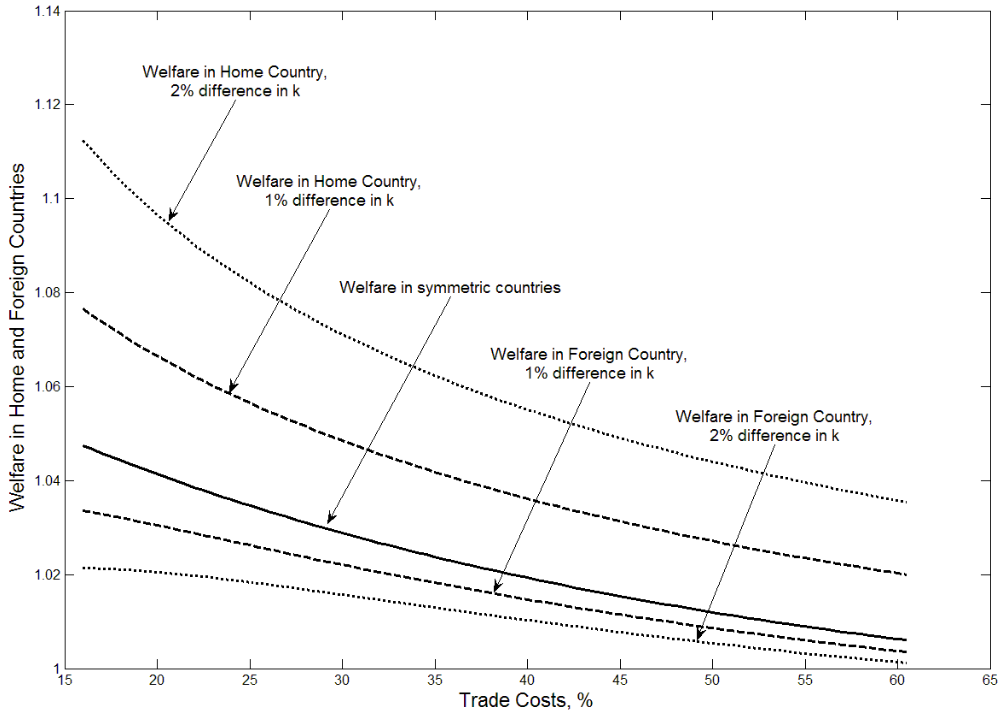
[37] Note that changes in β do not affect the values of productivity cutoffs in the equilibrium. The only way β affects the results of calibration is through welfare, which is proportional to $(\varphi^*)^\beta$. Thus, higher β will magnify any change in welfare, while lower β will make the change in welfare smaller.

[38] Note that 1% and 2% differences in the shape parameters result in approximately 0.5% and 1% differences in the distribution means, respectively.

[39] Both countries are of the same size L, which is chosen so that welfare in country i defined in (25) becomes $W_i = (\varphi_i^*)^\beta$. Note that larger L will lead to higher welfare in both countries, while lower L will make the welfare in each country smaller.

[40] Recall that this difference results from a 2% difference in k.

Figure 8: Welfare in Home and Foreign Countries



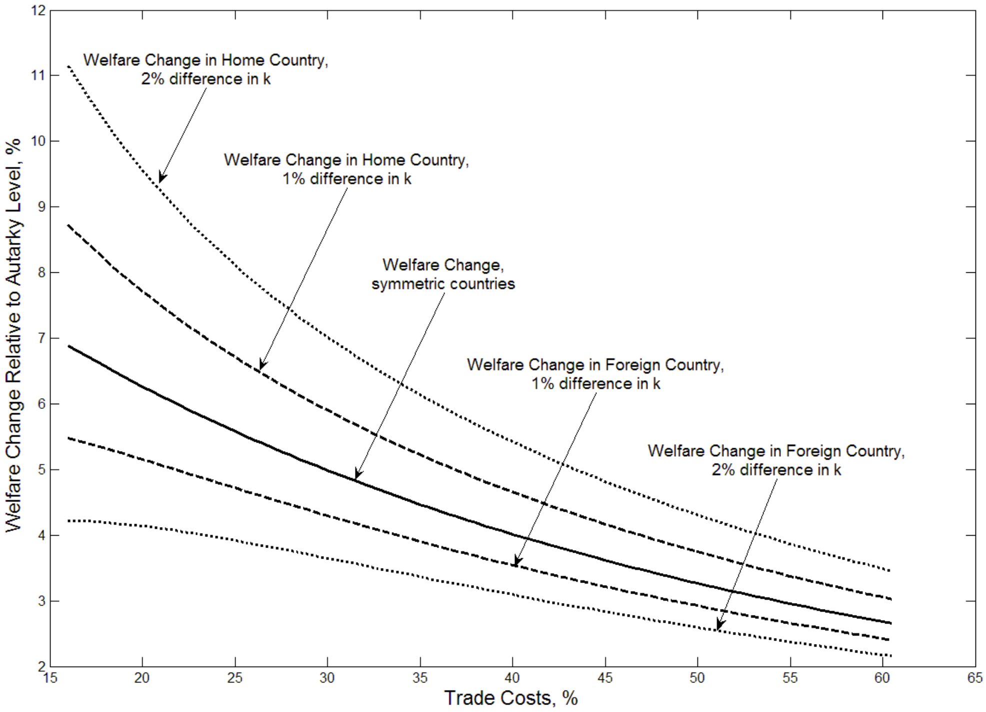
case of symmetric countries.

Figure 9 depicts the change in welfare relative to that in autarky for each country. As shown in 9, both countries gain from trade. However, the technologically advanced country always gains more than the laggard one. Also, the larger is the technological gap between countries, the larger are the gains from falling trade costs for the advanced country. As to the backward country, falling trade costs bring lower gains to it and may even hurt it if this country is backward enough.

1.7 Conclusion

This paper uses a simple stochastic, general equilibrium model of international trade between two asymmetric countries, one of which has a comparative advantage over another in terms of the productivity distribution. The results are derived without resorting to simulations or imposing strong restrictions on the model. It is shown that in the absence of specialization, falling trade costs may hurt the laggard country while helping the advanced one. Moreover, productivity improvement in one country increases its technological potential, and hence, welfare but

Figure 9: Welfare Relative to Autarky Level in Home and Foreign Countries



hurts its trading partner. In contrast, if a country is the only producer of the differentiated goods (the other one specializes in the homogenous good), then its welfare does not depend on the productivity distribution in the differentiated good sector abroad and the laggard country gains from productivity improvement in the advanced country.

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Chapter 2

Trade and Trade Policy with Differentiated Products: A Chamberlinian-Ricardian Model: A Comment

(with Hiau Looi Kee and Kala Krishna)

2.1 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: 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. As a result, their predictions and policy prescriptions could be quite misleading.[41] For example, it was believed for many years that exporting raised productivity and that this was reason to encourage exports. However, work in the late 90's suggested that causation might actually flow the other way: that exporters tend to be the more productive firms, so that this policy advice might well be misleading.[42] This work provided the impetus for developing general equilibrium models of trade with monopolistic competition and firm heterogeneity – where firms differ in terms of their productivity.[43] That firms in an industry do behave very differently is now widely 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.

[41] 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.

[42] See, for example, Roberts and Tybout (1997), Clerides, Lach and Tybout (1998), Bernard and Jensen (1999), and Aw, Chung and Roberts (2000).

[43] See Eaton and Kortum (2002) and Melitz (2003).

Why look at Bangladesh? First, Bangladesh is among the major garment suppliers to both the EU and US markets.[44] 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. 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 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. Thus, our work can be seen as a further test of heterogeneous firm models.

We estimate firm productivity using Olley and Pakes (1996), while allowing for firm and

[44] 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.

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[45], 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.[46] This is important because the effects of policy in such models can differ significantly 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. Rules of origin also turn out to provide significant preferences in non woven apparel, which is twice as capital intensive as woven apparel. Consequently, exports are biased away from the direction of natural comparative advantage.[47] As a result, even liberal preferences may be far less effective in promoting development than expected.[48] 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

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

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

[47] The non woven apparel industry is relatively new in Bangladesh but is the recipient of a lions share of new investment.

[48] We will focus on this issue in future work.

Kramarz (2004, 2005).[49]

The paper is organized as follows. Section 2.2 contains a brief discussion of the trade environment in which the industry operates. Section 2.3 describes the data. Section 2.4 lays out the theoretical model and outlines its predictions. The estimation of firm productivity and tests of the model's predictions are presented in Section 2.5. Section 2.6 concludes. The details of the proofs are in the Appendix B.

2.2 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.

2.2.1 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.[50] 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.[51]

2.2.2 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

[49] 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.

[50] 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.

[51] Note that less competitive countries 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 would be highly priced.

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.

2.2.3 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.[52] 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 *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.[53] 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.

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 *ROOs* of all products, for an apparel product to be considered originated from a country, it must start its local manufacturing process from yarn.[54] In other words, the use of imported

[52] For a relatively comprehensive and up to date survey see Krishna (2005).
[53] For details, please, refer to the following website:
http://www.washingtonwatchdog.org/documents/usc/ttl19/ch22/subchIII/ptB/sec3592.html
[54] 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

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 the 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[55], 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 $70 - 75\%$ for shirts, dresses, and trousers[56], so that this directly translates into a 15% cost disadvantage.[57] 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 makes 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.

2.3 The Data

We use two data sets. The first is 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

[55] 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.

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

[57] 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.

data set. This allows us to perform a number of cross checks on the results based on the firm level survey data.

2.3.1 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 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 was US$11.6 billion, with more than 400 million dozen garments exported. Overall, in terms of value, nearly 79% of garments were exported to the EU, 10% to the US, and the remaining 11% went to other countries such as Canada and Australia. Of the 2387 firms, 1967 or roughly 82% exported under the GSP (mostly to the EU) and hence met GSP *ROOs*. 1039 or 43.5% of the firms exported to the US, of which 709 (29.7%) exported under quota allocations, and 1231 (51.6%) firms exported to other countries.[58]

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 10 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 to 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. 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.

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 com-

[58] 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.

petitiveness 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.[59] Therefore, our data is consistent with their conjectures.

2.3.2 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, 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.[60] 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.[61]

Before we move on to our theoretical model and the empirical tests, are there any signs in

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

[60] This is likely to be a result of differences in the composition of imports to the two countries: in general, the US import mix is biased towards knits rather than sweaters in non-wovens which tend to be cheaper. Also, import quality, and hence unit value, tends to be higher for Europe.

[61] 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.

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.

Why is a heterogeneous firm setup 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 in terms of their productivity as we show below.

2.4 The Model

There has been an explosion of interest in heterogeneous firm models in trade in the last few years.[62] 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.[63]

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

[62] See Tybout (2002) for a very nice survey of much of the empirical work.

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

based on the setup in Melitz (2003). This will serve as the basis for the intuition behind the results.[64] 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 B.

2.4.1 Utility

Utility is given by

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

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

$$Q = \left[\int_{\omega} q(\omega)^{\rho} d\omega \right]^{\frac{1}{\rho}}, \tag{27}$$

where

$$\sigma = \frac{1}{1-\rho} > 1 \tag{28}$$

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

$$P = \left[\int_{\omega} p(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}, \tag{29}$$

which is the price of the 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 :

$$q(\omega) = \left[\frac{p(\omega)}{P} \right]^{-\sigma} Q. \tag{30}$$

2.4.2 Pricing and Equilibrium

Q and P are taken as given by each firm since there is a continuum of firms. Firms differ in their productivity level ϕ and a firm with productivity ϕ has a unit labor requirement (ULR)

[64] The complete general equilibrium model is laid out and solved in the Appendix B.

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

$$p(\phi) = \frac{1}{\rho\phi}. \tag{31}$$

Revenue is

$$\begin{aligned} r(\phi, .) &= p(\phi)q(\phi) \\ &= p(\phi)^{1-\sigma}P^{\sigma}Q \\ &= \left(\frac{p(\phi)}{P}\right)^{1-\sigma} PQ, \end{aligned} \tag{32}$$

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 (31) and (32), it follows that per period profits are

$$\pi(\phi, .) = \frac{r(\phi, .)}{\sigma} - f. \tag{33}$$

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 gets realizations according to $g(\phi)$, where

$$\begin{aligned} \mu(\phi) &= \frac{g(\phi)}{1 - G(\phi^*)} \; for \; \phi \geq \phi^* \\ &= 0 \qquad\qquad for \; \phi < \phi^*. \end{aligned}$$

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

$$(1 - G(\phi^*)) M_e = \delta M. \tag{34}$$

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 (29) and (31), the fact that the cutoff level is ϕ^*, and that a mass of M firms is in the market gives

$$P = \left[M \int_{\phi^*} \left(\frac{1}{\rho\phi} \right)^{1-\sigma} \frac{g(\phi)}{1 - G(\phi^*)} d\phi \right]^{\frac{1}{1-\sigma}} \tag{35}$$

$$= p(\tilde{\phi}(\phi^*)) M^{\frac{1}{1-\sigma}}. \tag{36}$$

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.

2.4.3 Trade and Trade Policy

Next we turn to how trade and trade policy can be incorporated into our model. 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 trade costs (transport costs or tariffs) τ of the iceberg form so that if $\tau > 1$ units leave, one unit arrives. As a result, the profits of a Bangladeshi firm with productivity ϕ, from exporting to market F 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, which we assume, then the cutoff for exports will exceed that for domestic production and only the more productive firms will be exporters.

2.4.3.1 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. 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 $\frac{\phi}{\tau^U \lambda^U \theta^U}$. 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 $r(\frac{\phi}{\tau^E \lambda^E \theta^E}, P^E, E^E)$.[65] Note that for any firm to choose to meet *ROOs*, $\lambda\theta$ must be less than unity. Quotas are equivalent to a specific tariff only on Bangladesh equal to the license price and can be incorporated as such.

2.4.3.2 Bangladeshi Firms Choices Bangladeshi firms have several options to choose from in terms of serving each of their three potential markets in our model. As marginal costs are constant, their decisions in each market are independently made and a firm chooses to serve a market if it makes positive profits from doing so.

[65] 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.

When it comes to their domestic market, firms can not produce, 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 $\max\left(0, \frac{r(\frac{\phi}{\tau^E}, P^E, E^E)}{\sigma} - f_x, \frac{r(\frac{\phi}{\tau^E \lambda^E \theta^E}, P^E, E^E)}{\sigma} - f_x - d^E\right)$.

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 $\max\left(0, \frac{r(\frac{\phi}{\tau^U(\lambda^U\theta^U + t^U)}, P^U, E^U)}{\sigma} - f_x - d^U\right)$, where $\tau^U t^U = s^{UB}$ is the equilibrium price of a quota license for exporting to the US from Bangladesh.

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

$$\begin{aligned}\Pi^B(\phi) \quad = \quad & \max\left(0, \frac{r(\phi, P^B, E^B)}{\sigma} - f\right) \\ & + \max\left(0, \frac{r(\frac{\phi}{\tau^E}, P^E, E^E)}{\sigma} - f_x, \frac{r(\frac{\phi}{\tau^E\lambda^E\theta^E}, P^E, E^E)}{\sigma} - f_x - d^E\right) \\ & + \max\left(0, \frac{r_d(\frac{\phi}{\tau^U\left(\lambda^U\theta^U + t^U\right)}, P^U, E^U)}{\sigma} - f_x - d^U\right). \end{aligned} \tag{37}$$

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 j, ϕ_x^{*ij}, below which firms choose not to export to country j, and ϕ_{xr}^{*ij}, above which exporters choose to invoke preferences offered by country j. 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 (37). Let $\pi_x^{ij}(\phi)$ and $\pi_{xr}^{ij}(\phi)$ denote the profits from also exporting from country i to country j $(i, j = B, E, U)$ without invoking preferences and with invoking preferences, respectively. Thus, the second and third lines of equation (37) are $\max\left(0, \pi_x^{BE}(\phi), \pi_{xr}^{BE}(\phi)\right)$ and $\max\left(0, \pi_{xr}^{BU}(\phi)\right)$.[66]

Now we know the following must hold, whatever be the levels of E^i and P^i as depicted in Figures 11 and 12:

[66] 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.

(1) $\pi_d^B(\phi)$ must be flatter than $\pi_d^B(\phi) + \pi_x^{Bj}(\phi)$, and have a higher intercept, as f is always less than $f + f_x$. In addition, we assume f_x is large enough so that $\phi_x^{*Bi} > \phi^{*B}$.

(2) $\pi_d^B(\phi) + \pi_x^{Bj}(\phi)$ must be flatter than $\pi_d^B(\phi) + \pi_{xr}^{Bj}(\phi)$, and have a higher intercept. The former is ensured by $\lambda\theta < 1$, which is needed for *ROOs* to be worth invoking. The latter is ensured by $f + f_x$ always being less than $f + f_x + d$. Finally, we also assume that d^i, λ^i, θ^i are such that $\phi_{xr}^{*Bi} > \phi_x^{*Bi}$.

We can make some further comparisons, but these are more subtle. First, note that ceteris paribus, an increase in the aggregate price index in a country, or an increase in its expenditure, makes profits as a function of ϕ steeper. A more restrictive trade policy, i.e., a rise in tariffs (τ), a dilution of preferences (a rise in λ so tariffs are reduced by less or a rise in θ so preferences are more costly to obtain) or a more restrictive quota (an increase in the implicit ad valorem tariff equivalent t), makes the profit function flatter. Since the aggregate price index is endogenous, to proceed further, we need to show how differences in exogenous variables affect P and the various cutoff levels (the ϕ^*'s) we are interested in.

In the Appendix B using the same technique as in Demidova (2005), we show that[67] if the US and EU are similar in size (so $E^U = E^E$) and set the same tariffs on each other as they do on Bangladesh[68], and Bangladesh is the most protectionist, followed by the US, with the EU being the least protectionist, then the domestic cutoffs follow the same ranking as trade barriers, i.e., the higher the trade barrier, the higher the cutoff, while aggregate price indices follow the opposite ranking, i.e., the higher the trade barrier the lower the price index.[69] This makes the price index in the US lie below that in the EU, which, ceteris paribus, makes profits from exporting to the US lower relative to those from exporting to the EU. This, in turn, widens the gap between the export cutoffs in the US and the EU as depicted. Moreover, this difference in price indices is greater, the greater the difference in the trade policy stances, which magnifies the differences in the export cutoffs for Bangladeshi firms exporting to the US and

[67] We ignore effect via tariff revenues on income as is standard in these models. In any case, tariff revenues on apparel are a small part of income.

[68] In other words, they set MFN tariffs as they are obligated to do under GATT.

[69] This is the same result as in Melitz and Ottaviano (2005) and occurs for the same reason: a more protectionist stance increases the market potential of a country and results in more entry, more competiton, and hence, a higher cutoff.

EU in non-wovens relative to wovens.

As the two industries, woven and non-woven apparel, differ in terms of the trade policies they face, we construct Figures 11 and 12 to reflect these differences. In both industries, as the trade policy stance of the US is more protectionist, the aggregate price index is lower in the US. Both the more protectionist stance and the lower price index work in the same direction to flatten the profit curves of a Bangladeshi firms from selling in the US relative to those from selling in the EU.

Thus, we also know that:

(3) $\pi_d^B(\phi) + \pi_{xr}^{BU}(\phi)$ is flatter than $\pi_d^B(\phi) + \pi_{xr}^{BE}(\phi)$ and has the same vertical intercept. $\pi_d^B(\phi) + \pi_x^{BU}(\phi)$ is flatter than $\pi_d^B(\phi) + \pi_x^{BE}(\phi)$ and has the same intercept. The former is not drawn since the US has quotas so *ROOs* have to be met to export.

In the woven industry, see Figure 11, there are fewer advantages of selling in the EU relative to selling in the US. Meeting *ROOs* does not 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. It is also not much steeper than the line for exporting to the US (where *ROOs* must be met anyway). As a result, few firms choose to export to the EU and meet the *ROOs*, i.e., ϕ_{xr}^{*BE}, where firms are indifferent between exporting to the *EU* with and without *ROOs*, is quite high. It is also significantly larger than ϕ_{xr}^{*BU}, where firms are indifferent between exporting under *ROOs* to the *US* and not doing so at all.[70]

Figure 12 depicts the situation for non-woven garments. As preferences can be obtained cheaply in the EU in this industry, $\pi_d^B(\phi)+\pi_{xr}^{BE}(\phi)$ is much steeper than $\pi_d^B(\phi)+\pi_x^{BE}(\phi)$ though the former has a lower intercept. Hence, ϕ_{xr}^{*BE} is close to ϕ_x^{*BE} so that most Bangladeshi firms will meet *ROOs* and invoke preferences. A higher tariff, binding quotas, and an induced lower aggregate prices in the US flatten the profit line $\pi_{xr}^{BU}(\phi)$, and this increases ϕ_{xr}^{*BU} so that it may even lie above ϕ_{xr}^{*BE} as depicted.

In summary, the model has the following predictions:

[70]Note the difference in the definition of ϕ_{xr}^{*BE} and ϕ_{xr}^{*BU} which arises as firms exporting to the US have no choice but to meet *ROOs*.

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

    (a) As trade policy in the EU is less restrictive overall, its price index is higher and firms that export mostly to the EU will need to be less productive than others. More precisely, the productivity distribution of Bangladeshi majority exporters to the EU is overall likely to be first order stochastically dominated by that of other firms.

    (b) As trade policy in the US is more restrictive overall, firms that export mostly to the US will need to be more productive than others. More precisely, the productivity distribution of Bangladeshi majority exporters to the US is overall likely to first order stochastically dominate (FOSD) that of other exporters to the EU.

    (c) As the difference in the trade policy stance in the US and EU in wovens is smaller, their export cutoffs will be closer, and firms that export to them will be more similar than in non-wovens. Hence, it will be harder to reject the null hypothesis that both their distributions are the same.

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

    (e) Firms that invoke $ROOs$ are more productive than those that do not. More precisely, the productivity distribution of Bangladeshi exporters to the EU who invoke $ROOs$ must FOSD that of all exporters to the EU or of exporters who do not invoke $ROOs$.

2. 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 productivity, such that the single market firms are the least productive.

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

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

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

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

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

2.5 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 materials, which we use to deflate sales and material costs to obtain real output and material levels.[71] This is considerably better than what the existing literature has been doing, which is to use an industry price index to deflate firm sales, which by construction will overestimate the price, and thus, underestimate the output of the more productive firms.

We estimate the following Cobb Douglas production function,

$$\begin{aligned} Y_{it} &= \phi_{it} L_{it}^{\alpha_L} M_{it}^{\alpha_M} K_{it}^{\alpha_K}, \\ \ln Y_{it} &= \ln \phi_{it} + \alpha_L \ln L_{it} + \alpha_M \ln M_{it} + \alpha_K \ln K_{it}, \end{aligned} \tag{38}$$

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

[71] Moreover, the data on the prices of both the product and material inputs allows us to avoid a possible bias in productivity estimates due to quality differences. In particular, since more costly inputs are used to produce goods of higher quality, then deflating by a firm level price index for inputs will reduce the input side proportionally, so that there will be no bias in productivity.

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 (38), 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 firms 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, $\ln \phi_{it}$.[72] 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.

Second, since we use head counts 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. Firm specific effect should help with this as well.

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

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

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, suggesting 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:

$$\ln \phi_{it} = \ln Y_{it} - 0.715 \ln M_{it} - 0.255 \ln L_{it} - 0.021 \ln K_{it}, \text{ or} \tag{39}$$

$$\phi_{it} = \exp\left(\ln Y_{it} - 0.715 \ln M_{it} - 0.255 \ln L_{it} - 0.021 \ln K_{it}\right), \tag{40}$$

which forms the basis of our empirical exercise.

2.5.1 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

$$F_A(\phi) \leq F_B(\phi), \; F_A(\phi_i) \neq F_B(\phi_i), \text{ for some } i, \; \forall \phi \in \Phi. \tag{41}$$

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 $p_i = \left(p_i^1, ..., p_i^J\right)$, and

$$p_i^j = F_i\left(\phi^j\right) - F_i\left(\phi^{j-1}\right) = \frac{x_i^j}{n_i}, \; i = A, B, \text{ and } j = 1, ..., J, \tag{42}$$

is the discrete empirical analogue of the probability density function, namely, the relative frequency in each interval, and x_i^j is the frequency of observations in sample i in interval j, and n_i is the size of sample i. Given that sum of all x_i^j must equal to n_i, vector $x_i = \left(x_i^1, ..., x_i^J\right)$ is distributed as a multinomial distribution with

$$E(x_i) = n_i p_i, \text{ and } Var(x_i) = \Omega_i = \left(\Omega_i^{jk}\right)_{J\times J} = \begin{cases} n_i p_i^j \left(1 - p_i^j\right), \text{ if } j = k \\ -n_i p_i^j p_i^k, \text{ if } j \neq k \end{cases}. \tag{43}$$

By the multivariate central limit theorem, x_i being multinomial distributed implies that as n_i approaches infinitely, x_i asymptotically follows a normal distribution:

$$x_i \sim N\left(n_i p_i, \Omega_i\right). \tag{44}$$

This allows us to form test statistics based on $p_i = x_i/n_i$.

Define I_f as the J by J cumulative sum matrix, which is a J-dimensional lower triangular matrix (including the diagonal) of 1's:[73]

$$I_f = \begin{bmatrix} 1 & 0 & 0 & \dots & \dots & 0 \\ 1 & 1 & 0 & \dots & \dots & 0 \\ 1 & 1 & 1 & 0 & \dots & 0 \\ \vdots & \vdots & \vdots & & & \vdots \\ \vdots & \vdots & \vdots & & & 0 \\ 1 & 1 & 1 & \dots & \dots & 1 \end{bmatrix}_{J\times J}. \tag{45}$$

[73] Since pre-multiply any vector of discrete empirical analogue of the probability density function with I_f gives the discrete empirical analogue of the cumulative density function.

The test that distribution A FOSD B boils down to:

$$H_0 : I_f \left(p^A - p^B\right) = 0 \text{ vs. } H_1 : I_f \left(p^A - p^B\right) < 0, \tag{46}$$

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).

$$\upsilon \sim N\left(0, m\Omega\right), \text{ and } \upsilon_f \sim N\left(0, I_f m\Omega I_f'\right), \tag{47}$$

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

$$n^{-1}\Omega = \begin{bmatrix} p_1\left(1-p_1\right) & -p_2p_1 & \dots & -p_Jp_1 \\ -p_2p_1 & p_2\left(1-p_2\right) & \dots & -p_Jp_2 \\ \vdots & & & \vdots \\ -p_Jp_1 & -p_Jp_2 & \dots & p_J\left(1-p_J\right) \end{bmatrix}, \tag{48}$$

$$\text{with } p_j = \frac{x_A^j + x_B^j}{n^A + n^B}, \tag{49}$$

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 use this multiple comparison test coupled with the $\chi^2_{(J-1)}$ statistic to check the prediction of our model with data.[74]

2.5.2 Majority EU vs. Majority US Exporters

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.[75] This is controlling for firm and year fixed effects, and therefore, is independent of the industry in which the firm is operating. 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.

The above 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. We present the nonparametric test for first order stochastic dominance in Table 4. 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

[74] To be sure that our results were robust, we also used Kolmogorov Smirnov type tests that compare the distributions at all points, not just at the deciles, as suggested by Barret and Donald (2003). This did not affect any of our results.

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

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

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 the productivity distributions of these two sets of firms are the same, which further supports our findings. Thus, overall, not only is the mean of the former is less than that of the latter, the hypothesis that the productivity distribution of majority EU exporters is first order stochastic dominated by the non-majority EU exporters is statistically supported.[76] Figure 13 further shows the continuous representation of the sample CDFs of the two distributions. As expected, we see that the CDF for majority EU exporters lies above that of the non-majority EU exporters.[77]

Similarly, Column (2) of Table 4 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. We also see in Figure 14 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. Overall, the results of these nonparametric tests of stochastic dominance support our regression results, which are that firms sort themselves into markets of different toughness according to their productivity.

2.5.3 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

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

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

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 present 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 also 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 ten elements in υ_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 the 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 preferences 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 distributions 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 ten are statistically negative, suggesting 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 the productivity distributions 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.[78]

[78] The careful reader, looking at Table 1, might ask whether the higher investment rates in non-wovens for majority EU exporters together with our capital construction technique drive our results. After all, higher investment would translate into higher capital and this would tend to bring TFP down. To reassure ourselves,

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.

2.5.4 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 the firm survey data set for, 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

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we recalculated TFP using only asset information, redid Table 5, and confirmed that our results still hold.

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 the productivity distribution of firms that meet *ROOs* is not statistically different from that of 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.

2.5.5 Effects of Quota

In this matched data set, we can further test the effects of US quota on firm productivity. In theory, by making the trade policies of the US more restrictive, a quota should reduce the price index in equilibrium via the market potential effect which would raise the export productivity cutoff for Bangladeshi firms. The quota would also reduce the profitability of exporting to the US at a given price index, as *ROOs* have to be met and documented, which would also raise this cutoff. Thus, firms exporting under quota should be more productive.

Figure 15 presents the CDF of US exporters with or without quota restrictions. This seems to suggest that firms exporting under quota tend to be more productive. 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 is statistically significant, so we cannot reject the hypothesis that the productivity distributions are the same. This highlights the importance of statistically testing for stochastic dominance, rather than just eyeballing the CDFs.

2.5.6 The Number of Export Destinations

Finally, we look at the number of export destinations using the customs 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 10. 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.

2.6 Conclusion

Our findings are important for a number of reasons. First, our work is the first to predict how firms would tend to sort themselves across markets in response to differences in trade policy, preferences, and the costs of obtaining these preferences.

Second, we are also the first to test for these predictions in the data. We feel our results renew one's 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!

Third, our work shows how the apparently liberal preferences provided by developed countries may well be far less liberal than they seem as they are undone by strict ROOs. This is the case with EU preferences for woven apparel exports from Bangladesh. Preferences are more liberal for non-woven apparel but as this is about twice as capital intensive as the woven sector, investment is directed away from the direction of natural comparative advantage. In a second best world with capital constraints, this could end up significantly eroding the gains from preferences. It might even end up being worse than having no preferences!

Another interesting recent policy issue of some importance in the Indian subcontinent as a whole is the issue of regional cumulation. 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%.[79] 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% (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.

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

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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: Heteroscedasticity 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)	(2)	(3)	(4)	(5)	(6)
	Within	Within	Between	Between	Between	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($\chi^2(9)$)	**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 10: Market Choice by Firms with Different Markets

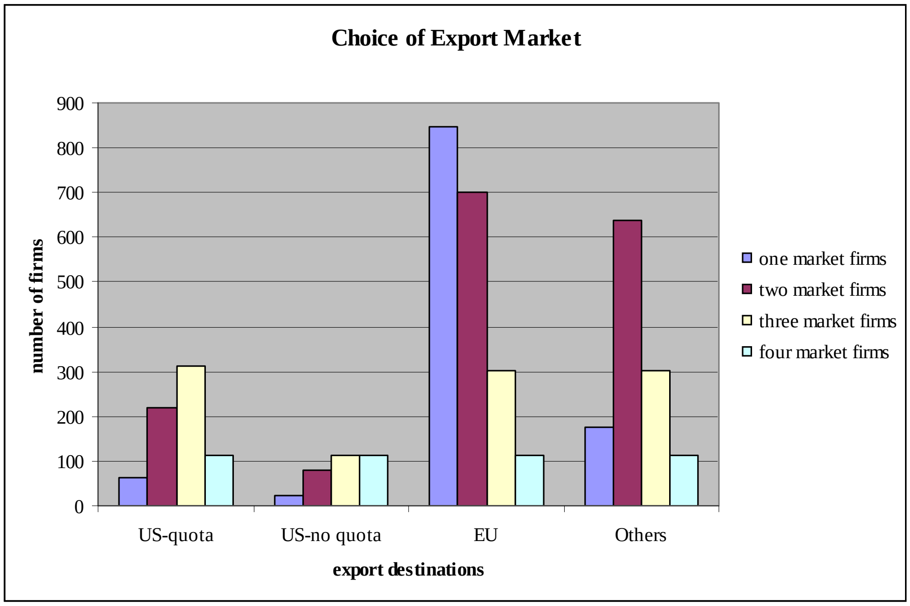


Figure 11: Woven Industry's Cutoffs

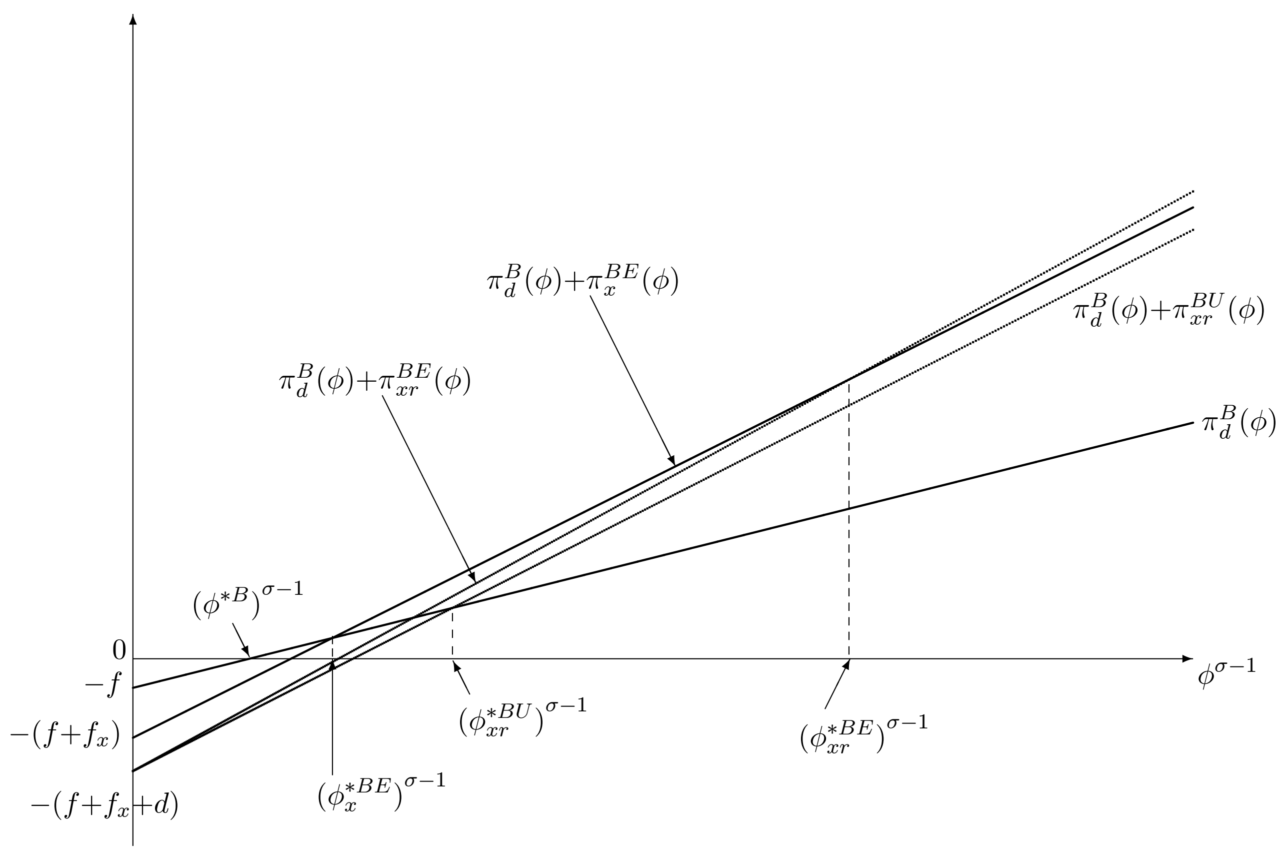


Figure 12: Non-Woven Industry's Cutoffs

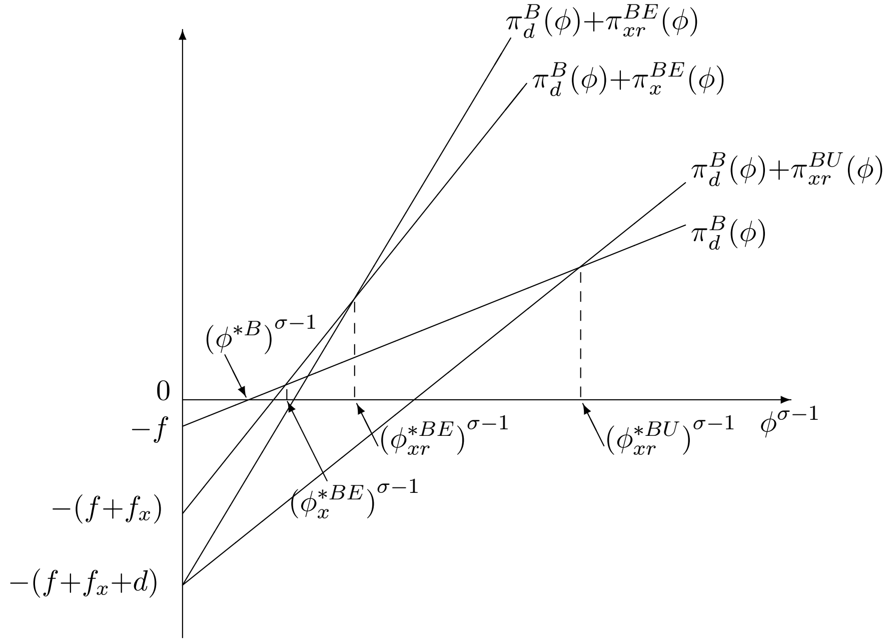


Figure 13: Cumulative Distribution of Productivity of EU exporters

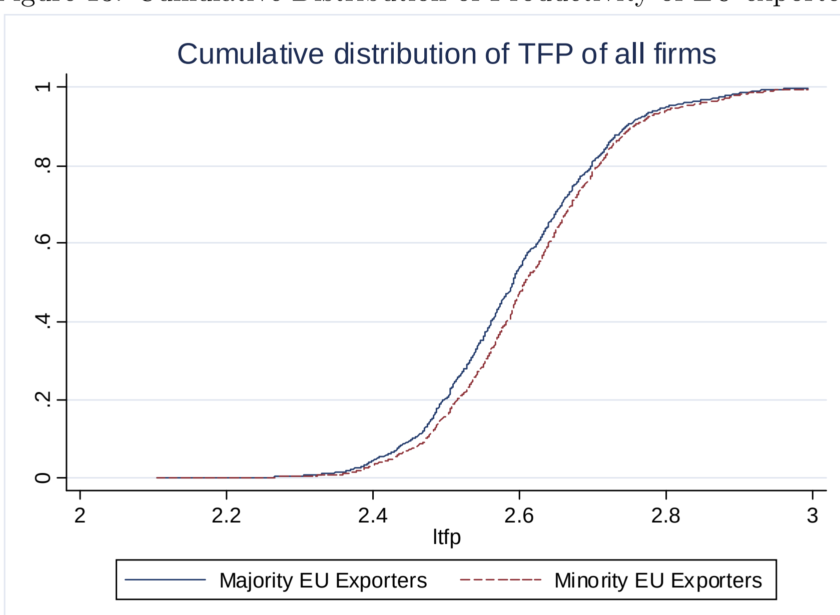


Figure 14: Cumulative Distribution of Productivity of US exporters

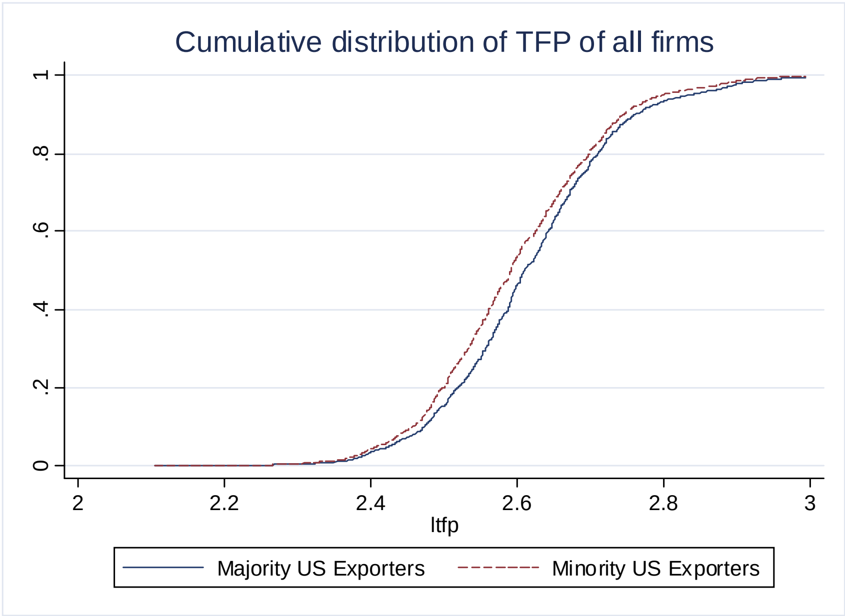
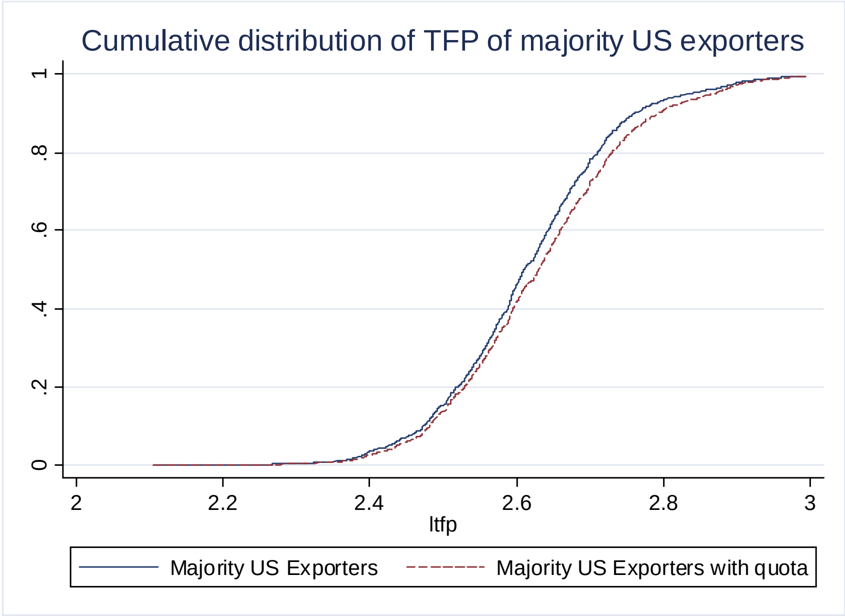


Figure 15: Cumulative Distribution of Productivity of US exporters with and without quota



Chapter 3

Export Subsidies, Productivity and Welfare under Firm-Level Heterogeneity

(with Andres Rodriguez-Clare)

3.1 Introduction

Governments all over the world encourage exports in different ways.[80] There are, of course, several theoretical reasons why doing so may be in a country's best interest. There may be rents associated with some export markets, and a subsidy may be effective in increasing a country's share of those rents (Eaton and Grossman, 1986). This is the "strategic trade policy" argument for export subsidies. Alternatively, there may be positive externalities generated by exporting, such as in the presence of external "learning by exporting," although empirically it has been hard to verify the significance of such externalities (Clerides, Lach and Tybout, 1998). In this paper we explore a different idea, associated with the recent models of trade with heterogenous firms. In these models firms that export are generally more productive than domestically-oriented firms, and hence, it is conceivable that by reallocating resources from low productivity to high productivity firms, an export subsidy may increase aggregate productivity. This may actually be the idea behind the claim that industrial policy in East-Asian countries was better (or at least less distortionary) than in Latin America, since it promoted exporting firms rather than those oriented to the domestic market.

In this paper we study the effect of export subsidies on productivity and welfare in a small economy. Our model is based on Melitz (2003) and features increasing returns, product differentiation, and productivity differences across firms. It is well known that in this kind of model trade policy affects welfare through several channels. To focus on the effect of export subsidies through reallocation and productivity, we construct a model in which some of these channels are "neutralized". There is, of course, the possible effect of trade policy through the

[80] See, for example, World Trade Organization Secretariat background paper "Export subsidies" with the details on export subsidies imposed by WTO members on a wide range of the products: http://docsonline.wto.org/DDFDocuments/t/tn/ag/S8.doc.

terms of trade, which in standard models generates a positive optimal tariff. This channel is neutralized in our model by considering a "small economy" that does not affect the demand function for the varieties it produces. Thus, although the individual exports (each of which sells a domestically produced variety abroad) do have market power, the country as a whole does not, and hence export prices are not distorted. Another issue arises because of the mark-up charged by monopolists in the domestic market. If consumers can buy imports at the country's opportunity cost (or international price) but must pay mark-ups on their purchases of domestically-produced varieties, this creates a distortion that makes a small import tariff or export tax have a positive effect on welfare. We show that a consumption subsidy on domestically produced varieties equal in size to the mark-up neutralizes this distortion and allows the economy to reach the first best allocation.

In this setting, it is obvious that an export subsidy would have a negative effect on welfare. But we show that the positive productivity effect mentioned above is present: an export subsidy leads to a reallocation of resources from less productive firms oriented to the domestic market to exporters, and this increases overall productivity. What other effects could then (more than) compensating this positive productivity effect of export subsidies? We show that welfare can be seen as the product of three components: productivity, terms of trade, and variety. Then we prove that the product of the terms of trade and variety components falls with the export subsidy, and that this effect always dominates the productivity effect.

The separate behavior of the terms of trade and the variety index is also interesting. There is, of course, a standard negative effect of export subsidies on the terms of trade. However, recall that we are considering here a small country that takes as given the demand function for its products. Moreover, exports may increase through the extensive margin (i.e., more variety) and not only through the intensive margin. In fact, we show that the terms of trade as we define them do not always fall with the export subsidy. Similarly, intuition would suggest that export subsidies would decrease domestic variety, as low productivity firms exit. But it also increases imports and hence, defining the variety index as a weighted average of the domestic and imported varieties, variety does not always fall with the export subsidy.

The rest of the paper is organized as follows. The model is laid out and the equilibrium conditions are derived in Section 3.2. Section 3.3 shows that the consumption subsidy equal in size to the mark-up is optimal. Section 3.4 demonstrates the effect of the export subsidy on the economy. Section 3.5 concludes. The details of the proofs are available in the Appendix C.

3.2 The Model

Consider a small country with L consumers. Each consumer supplies one unit of labor and spends his income on a continuum of domestically produced goods indexed by v and imported good z. Preferences are given by

$$U = \left(z^{\rho} + \int_{v \in \Omega} q(v)^{\rho} dv \right)^{1/\rho}, \; 0 < \rho < 1,$$

where Ω is the set of available domestic varieties, and $\sigma = \frac{1}{1-\rho}$ is the elasticity of substitution. We assume that there is a consumption subsidy $1-\eta \geq 0$ for domestic goods, so that consumers pay $\eta p(v)$ given prices $p(v)$ charged by producers. Then we can define the price index P by $P^{1-\sigma} = p_z^{1-\sigma} + \int_{v\in\Omega} (\eta p(v))^{1-\sigma} dv$ and derive the domestic demand for any variety:

$$q(v) = RP^{\sigma-1} (\eta p(v))^{-\sigma} \text{ and } z = RP^{\sigma-1} {p_z}^{-\sigma}, \tag{50}$$

where R denotes aggregate expenditure.

There is only one factor of production, labor, used by a continuum of monopolistically competitive heterogenous firms. Each firm pays a fixed cost f_e to enter the market. After paying this cost, it derives its productivity draw according to the cumulative distribution function $G(\varphi)$. To simplify the analysis, we assume that the productivity distribution is Pareto, with cumulative function $G(\varphi) = 1 - \left(\frac{b}{\varphi}\right)^{\beta}$, $\beta > \sigma$, for $\varphi \geq b$, and $G(\varphi) = 0$ for $\varphi < b$.[81] In addition, there is a probability $\delta < 1$ that in each period firms can be hit by a bad shock and forced to exit.

A firm with productivity level φ has a labor requirement $f + \frac{q}{\varphi}$ to produce q units of variety v for the domestic market. Thus, it has a marginal cost $\frac{w}{\varphi}$, where w denotes the wage in the economy, and given the demand function from (50), it charges a price $\frac{w}{\rho\varphi}$.

[81] Note that compared to the standard assumption of $\beta > \sigma - 1$, we assume $\beta > \sigma$, which allows us to calculate the aggregate quantities produced for the home and foreign markets.

Then, the quantity sold domestically, the revenues and profits from domestic sales of a firm with productivity φ are, respectively,

$$
\begin{aligned}
q_d(\varphi) &= RP^{\sigma-1}\left(\frac{\eta w}{\rho\varphi}\right)^{-\sigma}, & (51)\\
r_d(\varphi) &= RP^{\sigma-1}w^{1-\sigma}\eta^{-\sigma}(\rho\varphi)^{\sigma-1}, & (52)\\
\pi_d(\varphi) &= \frac{r_d(\varphi)}{\sigma} - wf. & (53)
\end{aligned}
$$

Foreign demand for domestic variety v is given by $Ap_x(v)^{-\sigma}$, where A is exogenously fixed and $p_x(v)$ is the price charged by an exporter. A firm which decides to export must pay a fixed cost f_x to access the foreign market. Also, we assume that it receives an ad-valorem export subsidy $s > 1$, calculated over export revenues, so that an exporter with productivity φ gets $sp_x(\varphi)$ for each unit sold abroad.[82] Thus, exporters maximize

$$sA{p_x}^{1-\sigma} - (w/\varphi)\,Ap_x^{-\sigma} - wf,$$

and charge price $p_x(\varphi) = \frac{w}{s\rho\varphi}$. The quantity exported, and the revenues and profits from exporting are, respectively,

$$
\begin{aligned}
q_x(\varphi) &= A\left(\frac{w}{\rho s\varphi}\right)^{-\sigma}, & (54)\\
r_x(\varphi) &= sp_x(\varphi)\,q_x(\varphi) = As^{\sigma}w^{1-\sigma}(\rho\varphi)^{\sigma-1}, & (55)\\
\pi_x(\varphi) &= \frac{r_x(\varphi)}{\sigma} - wf_x. & (56)
\end{aligned}
$$

Since profits of domestic producers and exporters are increasing in φ, we can define two productivity cutoffs, x and y, for domestic producers and exporters, respectively, so that only firms with productivity above x produce for the domestic market, and only firms with productivity above y export. The conditions for these cutoffs are derived from equalizing profits from each option to 0. Thus, from (53) and (56),

$$
\begin{aligned}
RP^{\sigma-1}\eta^{-\sigma}\frac{1}{\rho}\left(\frac{\rho x}{w}\right)^{\sigma-1} &= \sigma wf, & (57)\\
\text{(EXP) condition}\quad As^{\sigma}w^{1-\sigma}(\rho y)^{\sigma-1} &= \sigma wf_x. & (58)
\end{aligned}
$$

[82] We chose to look at this particular type of subsidy, since as was empirically estimated by Das, Roberts and Tybout (2003), such policy is far more effective at stimulating exports than policies that subsidize exporters' costs of entering foreign markets.

Note that we consider only equilibria with $y > x$, i.e. there are some firms that do not export, which is consistent with the empirical evidence. Specifically, firms with productivity below x exit without production, firms with productivity between x and y produce only for the domestic market, and firms with productivity above y produce for both home and foreign markets. Thus, if M_e is the mass of entrants in the economy and M is the mass of active firms in the economy, then in steady state

$$(1 - G(x)) M_e = \delta M.$$

This equation states that new successful entrants exactly replace exiting firms. In addition, the mass of exporters, conditional on successful entry, is given by

$$M_x = (1 - G(y)) M.$$

Following Melitz (2003), define

$$\tilde{\varphi}(x) = \int_x^\infty \varphi^{\sigma-1} \mu(\varphi) \, d\varphi, \text{ where } \mu(\varphi) = \frac{g(\varphi)}{1 - G(x)}.$$

Then one can show that the expected profits from entering are given by

$$\frac{\bar{\pi}}{w} = f(\theta - 1) + m_x f_x (\theta - 1),$$

where $m_x = \frac{1-G(y)}{1-G(x)}$ is the share of exporters among the whole population of active firms in the economy, and $\theta = \frac{\beta}{\beta-(\sigma-1)}$. Then, the free entry condition,[83] $\frac{\bar{\pi}}{\delta}(1 - G(x)) = wf_e$, can be written as

$$\text{(FE) condition} \quad (\theta - 1) x^{-\beta} [f + m_x f_x] = \frac{\delta f_e}{b^\beta}. \tag{59}$$

So far we derived two equilibrium conditions, (58) and (59), with four unknown variables, x, y, w, and M. We obtain the third equation from the trade balance condition. First, let us calculate the expenditures in the economy:

$$R = wL + T,$$

[83] The free entry condition equalizes the costs of entry to the present value of average profits multiplied by the probability of successful entry.

where T is a lump sum transfer defined as

$$T = -(s-1)\int_y \frac{r_x(\varphi)}{s} M\mu(\varphi)\,d\varphi - (1-\eta)\int_x r_d(\varphi)\,M\mu(\varphi)\,d\varphi.$$

Using (57) and (58), and some simplification, we obtain

$$R = wL - w\sigma\theta M\left[\frac{s-1}{s} f_x m_x + (1-\eta) f\right].$$

The trade balance condition implies that

$$\int_y \frac{r_x(\varphi)}{s} M\mu(\varphi)\,d\varphi = p_z z = RP^{\sigma-1},$$

where $P^{1-\sigma} = 1 + \theta M\left(\frac{\rho x}{\eta w}\right)^{\sigma-1}$. Then, using (9), and some further simplification, the trade balance condition can be rewritten as

$$\text{(TB) condition} \quad L = \sigma\theta M\left[f_x m_x\left(1 + \frac{1}{s}\theta M\left(\frac{\rho x}{\eta w}\right)^{\sigma-1}\right) + (1-\rho) f\right]. \tag{60}$$

We also need to derive the formula for the mass of firms in the economy. Note that the total revenue obtained by domestic producers, $M\sigma(\bar{\pi} + w(f + m_x f_x))$, must be equal to wL.[84]. Using (59), we get

$$\text{(M) condition} \quad M = \frac{L}{\sigma\theta(f + m_x f_x)} = \frac{(\theta-1) b^\beta L}{\sigma\theta\delta f_e} x^{-\beta} \tag{61}$$

Now we have our equilibrium system of equations (58), (59), (60), and (61). Before analyzing the equilibrium, let us rewrite the utility per capita as

$$\frac{U}{L} = \frac{Q_{produced}}{L}\frac{Q_{\text{consumed}}}{Q_{produced}}\left[\left(\frac{z}{Q_{\text{consumed}}}\right)^\rho + M^{1-\rho}\left(\frac{M(\int_x q^\rho(\varphi)\mu(\varphi)\,d\varphi)^{1/\rho}}{Q_{\text{consumed}}}\right)^\rho\right]^{1/\rho},$$

where $Q_{\text{consumed}} \equiv z + Q_d$ is the total quantity consumed in the economy, and

$$Q_d \equiv M\int_x q(\varphi)\,\mu(\varphi)\,d\varphi = f(\sigma-1)\frac{\beta}{\beta-\sigma} Mx,$$

is the total quantity consumed of the domestic goods, and where $Q_{produced} \equiv Q_x + Q_d$ is the

[84] To prove, note that the total expenditure at home is $R_m + R_d = V + R_d = wL + T = wL - (s-1)V - \frac{1-\eta}{\eta}R_d$, where R_d and R_m are expenditures on the domestic and foreign goods, respectively, and V is the value of exports. This implies $sV + R_d/\eta = wL$. But note that while consumers pay $\eta p(\varphi)$, a domestic producer with productivity φ receives only $p(\varphi)$. However, while foreign consumers pay $p_x(\varphi)$, exporters receive $sp_x(\varphi)$ Thus, the total revenues of domestic firms are $sV + \frac{R_d}{\eta}$, which equals wL.

total quantity produced by the economy, and

$$Q_x = M \int_y q_x (\varphi) \mu (\varphi) d\varphi = f_x (\sigma - 1) \frac{\beta}{\beta - \sigma} M_x y$$

is the total quantity exported. It is important to note here that we are simply adding physical units of different goods to arrive at a concept of aggregate quantities consumed and produced. In this way, utility per capita consists of three components: the productivity index, which is simply total output per worker; the trade-adjusted terms of trade (TOT) index, which tells us the ratio of consumption to production in an open economy; and the variety index. To better understand the latter component, it is useful to imagine for a moment that there were no heterogeneity in domestic varieties, so that $q(\varphi) = q$ for all φ. Then $Q_{\text{consumed}} = z + Q_d = z + Mq$, and

$$\text{Variety index} = \left[\left(\frac{z}{z + Mq} \right)^{\rho} + M^{1-\rho} \left(\frac{Mq}{z + Mq} \right)^{\rho} \right]^{1/\rho}.$$

The variety index of imports is one, since there is no variety, and the variety index of domestic goods is $M^{1-\rho}$.[85] With heterogeneity, instead of q we have the average quantity of domestic variety consumed: $\bar{q} = \left(\int_x q^{\rho} (\varphi) \mu (\varphi) d\varphi \right)^{1/\rho}$, and Q_{consumed} instead of $z + Mq$.[86]

To sum up, the utility function can be written as

$$\frac{U}{L} = (\text{Productivity Index}) * (\text{TOT index}) * (\text{Variety Index}), \tag{62}$$

These are the three channels through which trade policy affects welfare in our "small" economy.

3.3 The First Best Allocation

Now let us look at the social planner's choice of the consumption subsidy. As shown in Appendix C, the consumption subsidy $\eta = \rho$ leads to the highest level of welfare in the economy. In particular, consider the social planner's problem, who chooses an allocation that maximizes $\left(z^{\rho} + \int_x q(\varphi)^{\rho} M \mu (\varphi) d\varphi \right)^{1/\rho}$ and that has no goods produced for $\varphi < \varphi^*$, exports only goods with $\varphi > y > x$, subject to full employment, balanced trade, and "zero profit" conditions for

[85] Note that $1 - \rho = \frac{1}{\sigma - 1}$, i.e., $M^{1-\rho}$ is the same index as in Melitz (2003), who consider $M_t^{\frac{1}{\sigma-1}}$.

[86] If instead of one good, z, we considered the Melitz (2003) type foreign country, then we would have $(M_x^*)^{1-\rho} \left(\frac{\left(\int_{y^*} \left(q_x^* (\varphi) \right)^{\rho} \mu(\varphi) d\varphi \right)^{1/\rho}}{Q_{\text{consumed}}} \right)^{\rho}$ instead of $\left(\frac{z}{z + Mq} \right)^{\rho}$.

goods with productivity $\varphi = x$, i.e., $p(x) q(x) = \sigma\rho\varphi$. Then, as shown in Appendix C, the first order conditions for this problem coincide with those for the problem of the choice of the consumption subsidy, if $\eta = \rho$. Thus, we proved the following proposition:

Proposition 3 *A consumption subsidy equal to the size of the mark-up (i.e., $\eta = \rho$) leads to the first best outcome.*

The intuition behind this result is that there is a domestic distortion created by the mark-up: domestic goods are sold at a price above the opportunity cost, whereas imported goods are sold at a price equal to the opportunity cost, so in equilibrium there is too little consumption of domestic relative to foreign varieties. This distortion is neutralized with the consumption subsidy, which allows consumers to pay a price equal to the producer's marginal cost. In addition, Proposition 3 leads to the following straightforward conclusion:

Corollary 1 *In the presence of the optimal consumption subsidy, any trade policy results in welfare losses.*

3.4 The Effects of Export Subsidies

In this section, we assume that the government has in place the optimal consumption subsidy (i.e., $\eta = \rho$) and explore how export subsidies affect the three components of the utility function in (62). Note that from Corollary 1, an introduction of the export subsidy worsens the equilibrium outcome compared to the case with no subsidy at all. Moreover, in the Appendix we prove the following result:

Proposition 4 *An introduction of an export subsidy leads to the welfare losses: the higher is the subsidy, the lower is the welfare level.*[87]

To understand better why the increasing the export subsidy causes a welfare reduction, we want to look at the three components of the per capita utility function in (62). Before analyzing them, we first look at the effect of the export subsidy on the basic variables in the

[87] *Although Proposition 3 is more than enough to prove Proposition 4, in Appendix C we present the direct proof of Proposition 4, which does not rely on Proposition 3.*

economy (Section 3.4.1). In Section 3.4.2 we show that the productivity index rises. In spite of this, welfare falls with the export subsidy because the other two components in (62) *together* fall and more than compensates for the productivity increase. In Section 3.4.3 we analyze the behavior of the second and third components separately.

3.4.1 The equilibrium effects of export subsidies

First, note that from the (FE) condition, if the productivity cutoff for domestic producers x rises (falls), then the productivity cutoff for exporters y falls (rises). In other words, the cutoffs for domestic producers and exporters always move in opposite directions in response to changes in the export subsidy s. Moreover, as shown in the Appendix C, as s rises, y must fall and x must increase. In turn, from (61), M falls, $M_e = \frac{\delta M}{1-G(x)} = \frac{(\theta-1)L}{\sigma\theta f_e}$ remains constant, and $M_x = M\frac{1-G(y)}{1-G(x)} = \frac{(\theta-1)b^{\beta}L}{\sigma\theta\delta f_e}y^{-\beta}$ rises. Finally, as shown in the Appendix C, the wage is an increasing function of x. Since x increases with s, the wage increases with s as well. The next Proposition records these results:

Proposition 5 *As the export subsidy increases, the productivity cutoff for domestic producers rises, the productivity cutoff for exporters falls, the wage rises, the mass of entrants remains unchanged, the mass of domestic producers falls, and the mass of exporters increases.*

The intuition behind the results is that an increasing export subsidy allows less productive firms to export, so that the cutoff for exporters falls and their mass increases. At the same time, the demand for labor in the economy rises, which leads to a higher wage and makes it harder to produce for the domestic market, so that the cutoff for domestic producers rises and their mass falls. The two effects compensate each other so that there is no additional entry as a result, and the mass of entrants remains unchanged.

3.4.2 The Effect of Increasing Export Subsidy on Productivity Index

Recall that the productivity index is

$$\frac{Q_{produced}}{L} = \frac{Q_d + Q_x}{L},$$

where

$$\begin{aligned} Q_d &= M \int_x q(\varphi)\,\mu(\varphi)\,d\varphi = f(\sigma-1)\frac{\beta}{\beta-\sigma} M x, \\ Q_x &= M \int_y q_x(\varphi)\,\mu(\varphi)\,d\varphi = f_x(\sigma-1)\frac{\beta}{\beta-\sigma} M_x y. \end{aligned}$$

Thus,

$$\frac{Q_{produced}}{L} = \frac{\beta(\sigma-1)}{\beta-\sigma} M \left[\frac{f}{L} x + m_x \frac{f_x}{L} y\right].$$

Using the (M) and (FE) conditions, we can rewrite it as

$$\frac{Q_{produced}}{L} = \frac{\beta(\sigma-1)}{\sigma\theta(\beta-\sigma)} \frac{\delta f_e}{(\theta-1)\,b^\beta} \left[f + f_x \left(\frac{x}{y}\right)^{\beta-1}\right] x^{\beta+1}.$$

Since $\beta > 1$, and x and $\frac{x}{y}$ rise with s, the productivity index rises as well. This leads to the following proposition:

Proposition 6 *The productivity index is an increasing function of the export subsidy.*

Intuitively, the increasing export subsidy raises the expected profits from exporting, thus, more firms enter the market. Competition becomes more severe and only the most productive firms can survive. As a result, labor is reallocated from less to more productive firms, and productivity increases.

3.4.3 The Effect of Increasing Export Subsidy on TOT and Variety Indices

Using Corollary 1 and Proposition 5 together, it is clear that the TOT and variety indices together fall with s. Now we want to look at the behavior of these indices separately. We use numerical exercises to show that anything can happen, i.e., depending on the parameters, each index can rise or fall with s. Thus, it is impossible to make unambiguous predictions about the behavior of these two indices in general case (without knowing the values of the parameters). We provide below the values of parameters together with the figures, which depict the behavior of the two indices as functions of the export subsidy. Note that difference between cases below is in the values of A/f, σ, and the highest value of s.[88]

[88] We change the highest value of s to exclude the situation when $y < x$.

(1) TOT index falls, Variety index falls

Consider the following parameters: $\delta = 0.1$, $\beta = 4.1$, $\sigma = 3.8$, $b = 1$, $\frac{f_x}{f} = 15$, $\frac{f_e}{f} = 6$, $\frac{A}{f} = 100$, $\frac{L}{f} = 10,000$. Then $\theta = \frac{\beta}{\beta-(\sigma-1)} = 3.1$ and $\rho = \frac{\sigma-1}{\sigma} = 0.73$. We will vary s between 1 and 10.8. Then we get the following figure with the exporting subsidy on the horizontal axes:

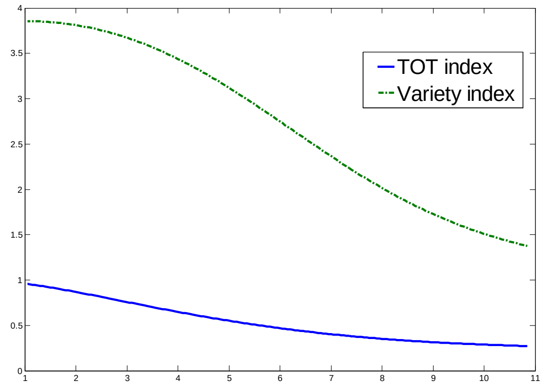


Figure 16. Case (1)

(2) TOT index falls, Variety index rises

Now let us change the following parameters: $\sigma = 4$ and $\frac{A}{f} = 10$. Then $\theta = 3.1$ and $\rho = 0.74$. We vary s between 1 and 2, and the figure we get is[89]

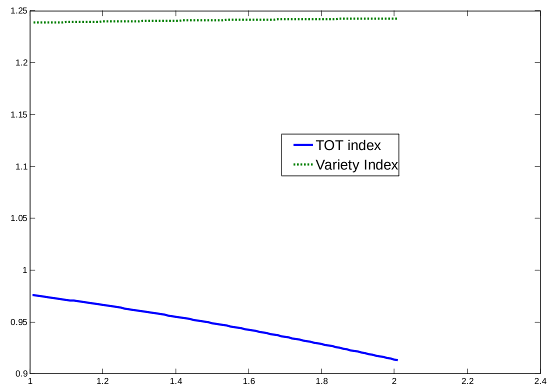


Figure 17. Case (2)

[89] Note that in this case Variety index starts to fall, if we increase s above 2, but we did not include the "falling" part into the figure.

(3) TOT index rises, Variety index falls

Finally, we change the parameters $\sigma = 3$ and $\frac{A}{f} = 10,000$ and get $\theta = 1.95$ and $\rho = 0.667$. We vary s between 1 and 7.1 so that the figure is

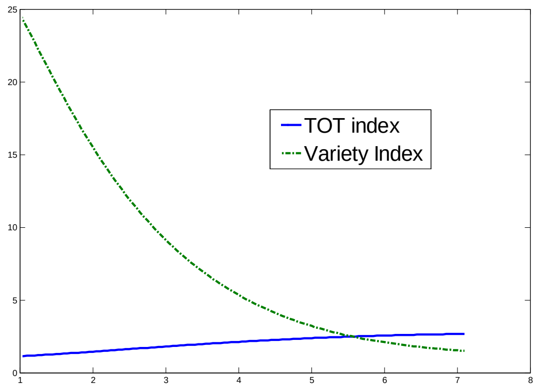


Figure 18. Case (3)

The intuition behind these results is the following. First, let us look at the TOT index. Recall that the TOT index falls in the first two cases and rises in the third one. Note that the main difference between these cases is the size of the Foreign market (A/f variable), which is the highest in case (3). The intuition here is that the export subsidy affects the terms of trade through two channels. The first is the intensive margin, i.e., the export subsidy allows the original exporters to increase the quantity they sell abroad, which leads to the standard negative effect on the terms of trade. The second one is along the extensive margin, as the export subsidy leads some firms to become exporters. Since new exporters are less productive than the original ones, this leads to a fall in average exporters' productivity, which pushes the terms of trade up. The latter effect prevails in case (3), when the foreign market is so large that it allows the productivity cutoff for exporters, and in turn their average productivity, to be very low.

Now consider the variety index. It rises only in case (2) when the size of the foreign market is the smallest. The explanation is that while the export subsidy increases the share of the imported variety in domestic consumption (the first component in the variety index), it forces the least productive domestic firms to exit the market, resulting in a decreasing domestic variety. If the foreign market is large enough, the second effect dominates. However, when the foreign market is very small relative to the domestic one, consumers value the imported variety much more than the domestic varieties. Thus, the variety index rises up to the point when the subsidy becomes large enough so that its negative impact on the domestic consumption outweighs the rise in the imported good, and the variety index starts to fall.[90]

3.5 Conclusion

Recent models trade with heterogenous firms suggest that export subsidies can indeed increase productivity by inducing a reallocation of labor from less to more productive firms. We have shown in this paper that, with an appropriate measure of productivity, this effect is in fact present, but is dominated by the effects of the export subsidy on the country's terms of trade and variety. The main message that arises is that an exclusive focus on productivity can be counterproductive: a broader analysis is necessary.

[90] As we mentioned in footnote 8, this is exactly what happens in case (2), when s exceeds 2.

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Chapter 4

Trade and Trade Policy with Differentiated Products: A Chamberlinian-Ricardian Model: A Comment

(with Kala Krishna)

4.1 Introduction

Venables (1987) studies the impact of differences in countries' sizes and technologies on welfare as well as the consequences of trade policies. He uses the standard monopolistic competition setting with homogeneous firms. One of his results is that technological progress in the monopolistically competitive industry in one country raises welfare there, but reduces it abroad.[91]

Among the assumptions used by Venables (1987) to derive this result is that the only additional costs paid by firms wishing to export are per-unit costs. However, this assumption is at odds with the empirical evidence, which shows that exporting firms face significant fixed costs associated with entry into export markets. (See, for instance, Roberts and Tybout (1997).) This leads to the natural question whether adding such costs to the model changes its predictions. In this paper, we show that including the fixed costs of exporting into the model developed by Venables (1987)[92] eliminates the result mentioned above: in the presence of such costs, technological progress in the monopolistically competitive industry in one country cannot result in welfare losses anywhere.

4.2 The Model

There are two countries, Home and Foreign, each of which has the same number of workers, L. Labor is assumed to be the only factor of production.[93] Each country produces a homogeneous good, N, under constant returns to scale and conditions of perfect competition. It is chosen as the numeraire, which allows to normalize the wage to 1 in each country. In addition, each country may produce a variety of the differentiated goods. Preferences are given by $U = (N)^{1-\beta} (Q)^{\beta}$, $1 > \beta > 0$, where $Q = \left(\int_{v\in\Omega} q(v)^{\rho}\, dv\right)^{1/\rho}$ is the sub-utility from consuming

[91] See Proposition 3 on page 708 of the paper.

[92] We use the ideas from the model developed by Venables (1987) in the setting a la Melitz (2003).

[93] Introducing differences in countries' size would not change the results, but complicates the analysis.

$q(v)$ units of each variety v when there is a mass Ω of available varieties of the differentiated good.[94]

Denote the domestic price of variety v produced in country i, $i = H, F$, by $p_i(v)$ and its exporting price by $p_{x,i}(v)$ Then the cost of a unit of Q_i defines the perfect price index in country i

$$P_i = \left[M_{ii}\left(p_i(v)\right)^{1-\sigma} + M_{ij}\left(p_{x,j}(v)\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \ \sigma = \frac{1}{1-\rho} > 1, \tag{63}$$

where M_{ii} is the mass of domestic firms in country i, and M_{ij} is the mass of exporters from country i to country j. As originally shown by Dixit and Stiglitiz (1977), the demand in countries i and j for variety v produced in country i is, respectively,

$$q_i(v) = Q_i\left[\frac{p_i(v)}{P_i}\right]^{-\sigma} \text{ and } q_{x,i}(v) = Q_j\left[\frac{p_{x,i}(v)}{P_j}\right]^{-\sigma}. \tag{64}$$

In country i, the differentiated goods are produced by a continuum of identical firms with the same productivity level φ_i and marginal cost $\frac{1}{\varphi_i}$, $i = H, F$. Each firm has two options: it can produce for domestic market and/or export abroad.[95] The fixed costs of these options are, respectively, f and f_x.[96] Also, exporters have to pay per-unit trade costs $\tau > 1$. Thus, in country i, firms set prices as

$$p_i(\varphi_i) = \frac{1}{\rho\varphi_i} \text{ and } p_{x,i}(\varphi_i) = \frac{\tau}{\rho\varphi_i}.$$

and maximize

$$\max\left\{0, \pi_i(\varphi_i, P_i)\right\} + \max\left\{0, \pi_j\left(\frac{\varphi_i}{\tau}\right)\right\}, \ i \neq j,$$

where $\pi_i(\varphi_i, P_i)$ is profit earned by firm from country i in the domestic market with price index P_i, and $\pi_j\left(\frac{\varphi_i}{\tau}, P_j\right)$ is profit earned by an exporter from country i to country j.[97] In particular,

$$\pi_i(\varphi_i, P_i) = p_i(\varphi_i)\, q_i(\varphi_i) - \frac{q_i(\varphi_i)}{\varphi_i} - f, \quad \text{and} \quad \pi_j\left(\frac{\varphi_i}{\tau}\right) = p_{x,i}(\varphi_i)\, q_j\left(\frac{\varphi_i}{\tau}\right) - \tau\frac{q_j\left(\frac{\varphi_i}{\tau}\right)}{\varphi_i} - f_x.$$

[94] Note that Venables (1987) considers a more general case, when $U = U(N, Q)$. In other words, he requires only the separability of the utility function between the numeraire commodity and the differentiated goods. We chose to specify the utility function to simplify the analysis. Without this simplification, the conclusions will be the same.

[95] Note that since firms in each country are the same, either all firms use the option or none of them does.

[96] The introduction of the differences in the fixed costs between countries does not change the results.

[97] It is easy to show that profits earned by an exporter from country i to country j with productivity level φ_i equal to profits earned by a domestic firm from country j with productivity level $\frac{\varphi_i}{\tau}$.

Using the demand functions and the usual formulas for prices, it can be shown that

$$\begin{aligned}\pi_i(\varphi_i, P_i) &= \frac{r_i(\varphi_i, P_i)}{\sigma} - f = \frac{E_i(P_i\rho\varphi_i)^{\sigma-1}}{\sigma} - f, \\ \pi_j\left(\frac{\varphi_i}{\tau}, P_j\right) &= \frac{r_j\left(\frac{\varphi_i}{\tau}, P_j\right)}{\sigma} - f_x = \frac{E_j\left(P_j\frac{\rho\varphi_i}{\tau}\right)^{\sigma-1}}{\sigma} - f_x,\end{aligned}$$

where $r_i(\varphi, P_i)$ is the revenue earned by a domestic firm from country i with productivity φ, and E_i is the expenditures on the differentiated goods in country i, $E_i = P_iQ_i = \beta(wL) = \beta L$.[98] Now we are ready to describe the equilibrium.

4.3 The Equilibrium

Given free entry in each country, profits from choosing any option cannot exceed zero. Thus, we can write four sets of conditions which define the equilibrium:

$$\pi_H(\varphi_H, P_H) \le 0, \ \pi_H(\varphi_H, P_H) M_{HH} = 0, \tag{65}$$

$$\pi_F\left(\frac{\varphi_H}{\tau}, P_F\right) \le 0, \ \pi_F\left(\frac{\varphi_H}{\tau}, P_F\right) M_{HF} = 0, \tag{66}$$

$$\pi_F(\varphi_F, P_F) \le 0, \ \pi_F(\varphi_F, P_F) M_{FF} = 0, \tag{67}$$

$$\pi_H\left(\frac{\varphi_F}{\tau}, P_H\right) \le 0, \ \pi_H\left(\frac{\varphi_F}{\tau}, P_H\right) M_{FH} = 0. \tag{68}$$

They are the familiar zero profit and complementary slackness conditions. If profits are positive, entry will occur and compete these profits away. If firms at Home sell in the domestic market ($M_{HH} > 0$), then $\pi_H(\varphi_H, P_H)$ must be zero. If profits are negative, then $M_{HH} = 0$. Similarly for the other three sets of conditions.

Note that if firms from both countries sell in the Home country's market, i.e., $M_{HH} > 0$ and $M_{FH} > 0$, then from (65) and (68)

$$\varphi_H = \left[\tau\left(\frac{f_x}{f}\right)^{1/(\sigma-1)}\right]^{-1} \varphi_F = A^{-1}\varphi_F, \tag{69}$$

where $A = \tau\left(\frac{f_x}{f}\right)^{1/(\sigma-1)}$. Similarly, if firms from both countries sell in the Foreign country's

[98] Note that due to free entry, consumers' income in country i is equal to labor payments, wL, which is equal to L, since wage w is normalized to 1 by the choice of the numeraire commodity.

market, i.e., $M_{FF} > 0$ and $M_{HF} > 0$, then from (67) and (66)

$$\varphi_H = \left[\tau \left(\frac{f_x}{f} \right)^{1/(\sigma-1)} \right] \varphi_F = A \varphi_F. \tag{70}$$

Since (69) and (70) cannot be held together unless $A = 1$ and $\varphi_H = \varphi_F$, it is clear that the analysis of the equilibrium depends on the assumptions about φ_H, φ_F, and A. We will consider the three mutually exclusive and exhaustive cases, $A > 1$, $A < 1$, and $A = 1$. As we will see, in the first case, when the costs of exporting are high relative to the cost of production for the domestic market, i.e., it is easier to become the domestic producer than an exporter, no firm exports the differentiated goods without selling them in the domestic market. And in the second case, when costs of producing for the domestic market are higher than those of exporting, no firm produces the differentiated goods domestically without exporting them abroad.[99] In the last case, only when $\varphi_H = \varphi_F$, is it possible for both countries to produce the differentiated goods. If there are productivity differences, the less productive country specializes in the homogeneous good.

First, assume that $A > 1$ and $\varphi_H > \varphi_F$. (The same logic is used for the case of $A > 1$ and $\varphi_H < \varphi_F$.) Then, (69) does not hold in the equilibrium. Thus, it is not possible to have $M_{HH} > 0$ and $M_{FH} > 0$ at the same time. As a result, in the absence of specialization, i.e., when both countries produce both homogeneous and differentiated goods, there are only two possible equilibrium outcomes:

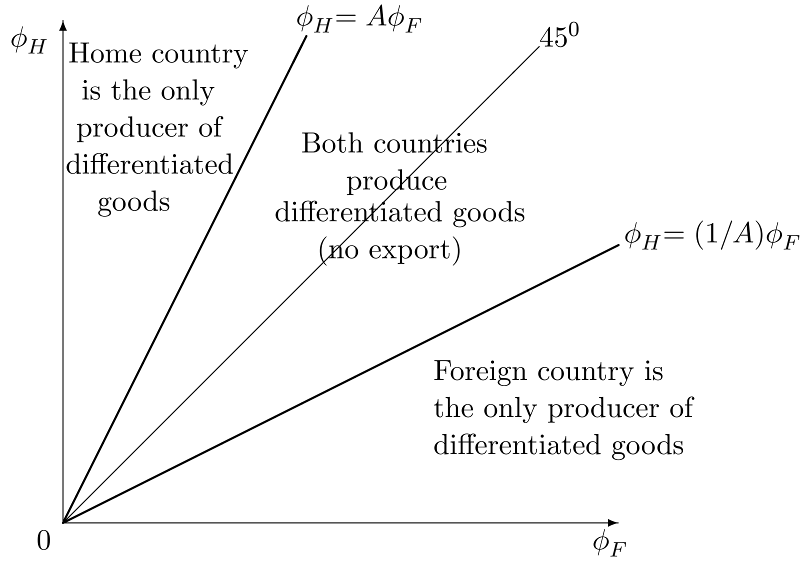
(1) $M_{HH} > 0$, $M_{FH} = 0$ (only the domestic firms sell the differentiated goods in the Home country);

(2) $M_{HH} = 0$, $M_{FH} > 0$ (only the exporters from the Foreign country sell the differentiated goods in the Home country).

Note that case (2) cannot happen in the equilibrium, since if $M_{HH} = 0$ and $M_{FH} > 0$,

[99] Note that since the second case is at odds with the empirical evidence, we can make the usual assumption that costs of exporting are high enough so that exporters always produce for the domestic market. We chose not to do so to derive more general results.

Figure 19: The equilibrium outcomes when A>1



then from (68) and (65),

$$M_{FH} > 0 \Longrightarrow \frac{E\left(P_H\rho\right)^{\sigma-1}}{\sigma} = \left(\frac{\tau}{\varphi_F}\right)^{\sigma-1} f_x, \tag{71}$$

$$M_{HH} = 0 \Longrightarrow \frac{E\left(P_H\rho\varphi_H\right)^{\sigma-1}}{\sigma} < f, \tag{72}$$

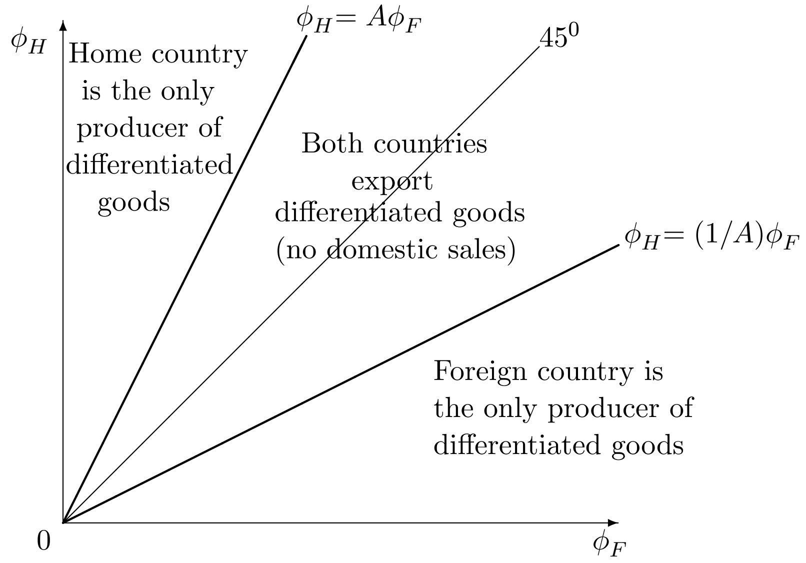
and combining (71) and (72) leads to $\frac{\varphi_H}{\varphi_F} < A^{-1}$,which is not possible, since $\varphi_H/\varphi_F > 1$ and $A^{-1} \leqq 1$. As a result, in the absence of specialization, there are two possible outcomes in the equilibrium:

(1.a) $M_{HH} > 0$, $M_{FH} = 0$, $M_{FF} > 0$, $M_{HF} = 0$ (in each country firms produce only for domestic market);

(1.b) $M_{HH} > 0$, $M_{FH} = 0$, $M_{FF} > 0$, $M_{HF} > 0$ (firms at Home both export and produce for domestic market, Foreign firms only produce for domestic market);

Using the same logic as above, it can be shown that case (1.a) requires $\frac{\varphi_H}{\varphi_F} < A$ and case (1.b) requires $\frac{\varphi_H}{\varphi_F} = A$. Finally, if $\frac{\varphi_H}{\varphi_F} > A$, then the Home country is the only producer of the differentiated goods and the Foreign country specializes in the homogeneous good. Figure 19 shows all possible outcomes of trade between the countries, when $A > 1$. The intuition behind this figure is the following. Assume $\varphi_F < \varphi_H$. (Consider the part of Figure 19 above the 45^0 line.) When $A > 1$, i.e., fixed costs of exporting are high, and the difference between countries'

Figure 20: The equilibrium outcomes when A<1



productivities is not very large ($\frac{\varphi_H}{\varphi_F} < A$), then firms in both countries choose not to export. As φ_H increase, i.e., firms at Home become more productive, at some point ($\frac{\varphi_H}{\varphi_F} = A$) Home firms start to export to the Foreign country. However, only at this point they share the market with the Foreign firms: as φ_H continues to rise ($\frac{\varphi_H}{\varphi_F} > A$), the Foreign country specializes in the production of the homogenous goods, so that the Home country is the only producer of the differentiated goods.

Now, we can use the same technique as in the case of $A > 1$ for the case of $A < 1$. Then, the equilibrium outcomes for different pairs of φ_H and φ_F are depicted in Figure 20. The intuition here is similar to that in the first case: when $A < 1$, i.e., fixed costs of domestic production are high relative to exporting costs, and the difference in technologies is small ($\frac{\varphi_H}{\varphi_F} < A^{-1}$, if $\varphi_H > \varphi_F$, and $\frac{\varphi_F}{\varphi_H} < A^{-1}$, if $\varphi_H < \varphi_F$), then firms in both countries only export. As one country, say Home, becomes more and more productive, at some point (and only in this point when $\frac{\varphi_H}{\varphi_F} = A^{-1}, \varphi_H > \varphi_F$), it starts to produce for both markets. Further technological progress there makes the Home country a unique producer of the differentiated goods, while its trading partner specializes in the homogeneous good.

To complete the analysis, assume that $A = 1$. It is easy to verify that if $\varphi_H > \varphi_F$, then the only producer of the differentiated goods is the Home country, while if $\varphi_H < \varphi_F$, it is the Foreign country. In other words, if firms have the same costs of exporting abroad and producing for the domestic market, the most productive country will be the only producer of the differentiated goods. Finally, if countries are the same, the patterns of trade are undetermined, i.e., any share of the world output of the differentiated goods, which is determined in the equilibrium, can be produced by any country.

4.4 Technological Progress and Welfare

The indirect utility function can be written as

$$U_i = \frac{(1-\beta)^{1-\beta}\,\beta^{\beta}}{(P_i)^{\beta}}.$$

What happens to it when the technological progress in the differentiated good sector occurs in the Home country, i.e., if φ_H rises? If $A > 1$, an increase in φ_H does not affect welfare in the Foreign country, if $\varphi_H < A\varphi_F$, since in this case the Foreign country is the only producer of the differentiated goods here, and it raises welfare in the Foreign country, if $\varphi_H > A\varphi_F$. In the latter case the Home country is the only producer of the differentiated goods, thus, the price index in the Foreign country falls as the Home country becomes more productive. Similar logic can be used to show that there are no welfare losses in any country if $A \leq 1$. As a result, we can conclude that technological progress in any country cannot reduce welfare of its trading partner.

4.5 Conclusion

In this paper we have shown that the results obtained by Venables (1987) strongly depend on his assumption that there are no fixed costs of trade. The introduction of fixed costs of exporting, while making the model more consistent with the empirical evidence, leads to the opposite conclusion that technological progress in one country cannot harm the welfare of its trading partner. However, his results can be obtained in a richer model. Demidova (2005) shows that technological progress in one country can lead to welfare losses abroad, if we relax the assumption that firms are homogeneous, and allow for firm heterogeneity as in Melitz (2003).

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Chapter 5

Regulations, Regime Switches and Non-Monotonicity when Non-Compliance is an Option: An Application to Content Protection and Preference: A Comment

(with Kala Krishna)

5.1 Introduction

Ju and Krishna (2002) shows that even when firms are homogeneous, assuming they all make the same choices is not correct. Ex ante identical firms can behave differently in equilibrium if they are indifferent between alternatives. They show that there are in two possible regimes: in the first regime (called the homogeneous regime) all firms prefer one option to another so that they all make the same choices. In their example with content protection requiring the use of a domestic input, this makes demand for the input shift out when the restriction becomes stricter. As a result, its price rises. In the other regime (the heterogeneous one) firms are indifferent between the two options and some choose one while others choose the other. This indifference must be maintained as the restriction becomes stricter. At given input prices, a stricter requirement makes profits from meeting the requirement fall. To keep these profits given by the alternative involving not meeting the requirement and paying a penalty, input prices have to fall! As a result, the comparative statics for input prices, and through them for other variables, are exact opposites in the two regimes.

In this paper, we show that their result is a very special one and arises from the assumption that firms are homogeneous. We introduce the differences in firms' productivity and show that this leads to another margin of adjustment in the model: namely the productivity of the marginal firm, and this eliminates the non-monotonicity in the comparative statics which is the key result in Ju and Krishna (2002)! In other words, if firms behave differently not because they are identical and indifferent between satisfying the requirements and not doing so, but because they differ in terms of productivity, which is more consistent with the empirical evidence[100], then stricter requirements lead to changes in the composition of firms. Firms with

[100] See, for example, Eaton, Kortum and Kramarz (2004, 2005).

a productivity below a cutoff do not meet the requirement, while firms with a productivity above a cutoff choose to meet it. These composition changes produce monotonic adjustments in endogenous variables, (in wage, the average productivity of exporters who use each option, their masses) both when all firms choose to meet the restriction and when only some firms do so.

We model the special requirements, the rules of origin (*ROOs*), which specify the constraints that must be met in order to obtain origin and thereby qualify for country specific trade preferences, similarly to Demidova, Kee and Krishna (2006). In particular, we allow for *ROOs* to affect both the fixed costs and marginal costs of exporting (both costs are higher if *ROOs* are met, but meeting *ROOs* reduces the tariff paid by exporters) and model firm heterogeneity as in Melitz (2003).

5.2 The Model

Consider a small country with L consumers, each of which supplies one unit of labor. Preferences over a continuum of domestically produced goods indexed by v and imported good z are given by

$$U = \left(z^{\rho} + \int_{v \in \Omega} q(v)^{\rho} dv \right)^{1/\rho}, \ 0 < \rho < 1,$$

where Ω is the set of available domestic varieties, $q(v)$ is the consumption of variety v, and $\sigma = \frac{1}{1-\rho}$ is the elasticity of substitution between domestic varieties. Then, the demand functions are

$$q\left(v\right) = RP^{\sigma-1} p\left(v\right)^{-\sigma} \text{ and } z = RP^{\sigma-1} {p_z}^{-\sigma},$$

where R denotes the aggregate expenditure, and P is the price index,

$$P^{1-\sigma} = p_z^{1-\sigma} + \int_{v \in \Omega} p(v)^{1-\sigma} dv.$$

There is a continuum of monopolistically competitive heterogenous firms of mass M in the economy. The productivity distribution is assumed to be Pareto with cumulative density function $G\left(\varphi\right) = 1 - \left(\frac{1}{\varphi}\right)^{\beta}$, $\beta > \sigma$. A firm with productivity level φ uses $\frac{1}{\phi}$ units of labor for every unit of a unique variety v it produces for the domestic market at marginal cost $\frac{w}{\varphi}$. it also incurs a fixed cost of wf per period it produces.

The firm may also choose to export. The foreign demand for domestic variety v is $Ap_x(v)^{-\sigma}$. By abstracting from foreign general equilibrium conditions, we have in effect assumed that we are dealing with a small open economy that has no impact on the rest of the world. Each exporter has two options: it can either export and pay a tariff τ which is levied on marginal cost, and a fixed cost f_x. Or it pays in addition a documentation fixed cost d and invokes preferences it has been given. However, to access these preferences, it has to meet some rules of origin or $ROOs$. Meeting $ROOs$ allows the firm to escape paying $\lambda < 1$ share of tariff τ, but it involves an additional per-unit cost $\theta > 1$, since now the product has to satisfy origin requirements. The cost functions[101] of producing q units for domestic and foreign markets with and without invoking $ROOs$ are, respectively,

$$C_d(\varphi, q) = \frac{w}{\varphi}q, \quad C_x(\varphi, q) = \frac{w\tau}{\varphi}q + wf_x, \quad C_{x,ROO}(\varphi, q) = \frac{w\tau(\lambda\theta)}{\varphi}q + wf_x + wd,$$

where w is the wage. As a result, the prices set in each case are, respectively,

$$p_d(\varphi) = \frac{w}{\rho\varphi}, \quad p_x(\varphi) = \frac{w\tau}{\rho\varphi}, \quad \text{and} \quad p_{x,ROO}(\varphi) = \frac{w\tau(\lambda\theta)}{\rho\varphi},$$

and the price of the imported variety z is normalized to 1. For simplicity we assume there are no fixed costs of producing for the domestic market. Thus, all firms in the economy use this option. It can be shown straightforwardly that revenues and profits earned by a firm with productivity level φ are, respectively,

$$r_d(\varphi) = RP^{\sigma-1}\left(\frac{w}{\rho\varphi}\right)^{1-\sigma}, \ r_x(\varphi) = A\left(\frac{w\tau}{\rho\varphi}\right)^{1-\sigma}, \ \text{and } r_{x,ROO}(\varphi) = A\left(\frac{w\tau(\lambda\theta)}{\rho\varphi}\right)^{1-\sigma},$$

and

$$\pi_d(\varphi) = \frac{r_d(\varphi)}{\sigma}, \quad \pi_x(\varphi) = \frac{r_x(\varphi)}{\sigma} - wf_x, \quad \text{and } \pi_{x,ROO}(\varphi) = \frac{r_{x,ROO}(\varphi)}{\sigma} - w(f_x + d).$$

Thus, a firm maximizes

$$\pi_d(\varphi) + \max\{0, \pi_x(\varphi), \pi_{x,ROO}(\varphi)\}.$$

[101] The subscript denotes the option used by a firm, i.e., "d" denotes domestic production, "x" denotes exporting without $ROOs$, and "x,ROO" denotes exporting with $ROOs$.

Note that we can rewrite $\pi_{x,ROO}(\varphi)$ as $\pi_{x,ROO}(\varphi) = \pi_x(\varphi) + \pi_{x,r}(\varphi)$,where $\pi_{x,r}(\varphi)$ is additional profits from invoking *ROOs*, $\pi_{x,r}(\varphi) = \frac{A}{\sigma}\left(\frac{w\tau}{\rho\varphi}\right)^{1-\sigma}\left((\lambda\theta)^{1-\sigma} - 1\right) - wd$. Let us define two productivity cutoffs, φ_x^* and $\varphi_{x,ROO}^*$, so that

$$\pi_x(\varphi_x^*) = 0 \Leftrightarrow A\left(\frac{w\tau}{\rho\varphi_x^*}\right)^{1-\sigma} = \sigma w f_x, \quad \text{and} \tag{73}$$

$$\pi_{x,r}\left(\varphi_{x,ROO}^*\right) = 0 \Leftrightarrow A\left(\frac{w\tau}{\rho\varphi_{x,ROO}^*}\right)^{1-\sigma}\left((\lambda\theta)^{1-\sigma} - 1\right) = \sigma w d. \tag{74}$$

Only firms with productivity above φ_x^* choose to export, and firms with productivity above $\varphi_{x,ROO}^*$ invoke *ROOs* while exporting. Note that if $\lambda\theta > 1$, then no firm will invoke *ROOs*. We assume that $\lambda\theta < 1$.

Moreover, from (73) and (74),

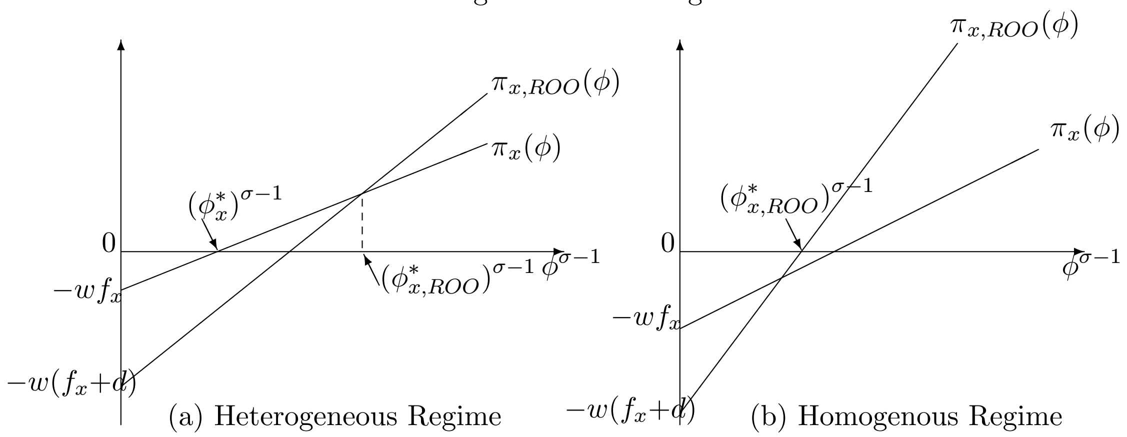
$$\varphi_{x,ROO}^* = A_{ROO}\varphi_x^*, \text{ where } A_{ROO} \equiv \left(\frac{d}{f_x}\frac{1}{(\lambda\theta)^{1-\sigma} - 1}\right)^{\frac{1}{\sigma-1}}, \tag{75}$$

i.e., $\varphi_{x,ROO}^* > \varphi_x^*$ only if $A_{ROO} > 1$. Thus, we need to consider two cases. In the first, *ROOs* are relatively strict and documentation costs are large so $A_{ROO} > 1$. As a result, only the most productive exporters choose to meet *ROOs*. This is analogous to the heterogenous regime in Ju and Krishna (2002), where the restriction is strict enough so that firms are not strictly better off meeting it. In the second case, *ROOs* are relatively lax and documentation costs are small so $A_{ROO} \leq 1$. As a result, all exporting firms choose to meet ROOs This is analogous to the homogeneous regime in Ju and Krishna (2002).

5.2.1 The Heterogenous Regime

Since $A_{ROO} > 1$, then $\varphi_{x,ROO}^* > \varphi_x^*$, i.e., only some share of exporters invoke *ROOs*. We depict the profits of firms who export with and without meeting *ROOs* as functions of $\varphi^{\sigma-1}$ in Figure 21(a). Note that these profits are linear functions of $\varphi^{\sigma-1}$. Moreover, the line corresponding to $\pi_x(\varphi)$ is flatter than the line corresponding to $\pi_{x,ROO}(\varphi)$, since $\lambda\theta < 1$, and has a higher intercept, since $-wf_x > -w(f_x + d)$. The intersection of these lines gives the productivity cutoff $\varphi_{x,ROO}^*$, so that firms with productivity $\varphi \in [\varphi_{x,ROO}^*, \infty)$ export with invoking *ROOs* and getting tariff preferences, since additional profits from doing so cover the documentation cost d. Firms with $\varphi \in [\varphi_x^*, \varphi_{x,ROO}^*)$ export without meeting *ROOs*, while firms with $\varphi \in (0, \varphi_x^*)$

Figure 21: Two Regimes



(a) Heterogeneous Regime (b) Homogenous Regime

do not export at all in order to avoid negative profits from export. Aggregate expenditure in the economy is given by

$$R = wL + \Pi_d + \Pi_x + \Pi_{x,r},$$

where

$$\begin{aligned}
\Pi_d &= \int_1^\infty \pi_d(\varphi)\, MdG(\varphi) = \frac{1}{\sigma} M\eta R P^{\sigma-1}\left(\frac{\rho}{w}\right)^{\sigma-1}, \\
\Pi_x &= \int_{\varphi_x^*}^\infty \pi_x(\varphi)\, MdG(\varphi) = M_x\left[\frac{1}{\sigma}\eta A\left(\frac{\rho}{w\tau}\right)^{\sigma-1}(\varphi_x^*)^{\sigma-1} - wf_x\right] = wM_x f_x[\eta-1], \\
\Pi_{x,r} &= \int_{\varphi_{x,ROO}^*}^\infty \pi_{x,r}(\varphi)\, MdG(\varphi) = M_{x,ROO}\left[\frac{1}{\sigma}\eta A\left(\frac{\rho}{w\tau}\right)^{\sigma-1}\left((\lambda\theta)^{1-\sigma}-1\right)\left(\varphi_{x,ROO}^*\right)^{\sigma-1} - \right. \\
\left. -wd\right] &= wM_{x,ROO}d[\eta-1], \\
\eta &= \frac{\beta}{\beta-(\sigma-1)},\ P^{1-\sigma} = 1 + \left(\frac{\rho}{w}\right)^{\sigma-1}\eta M, \\
M_x &= (1-G(\varphi_x^*))\,M = (\varphi_x^*)^{-\beta} M,\ M_{x,ROO} = \left(1-G\left(\varphi_{x,ROO}^*\right)\right)M = \left(\varphi_{x,ROO}^*\right)^{-\beta} M.
\end{aligned}$$

Therefore,

$$R = \frac{wL + \Pi_x + \Pi_{x,r}}{1 - \frac{1}{\sigma}M\eta P^{\sigma-1}\left(\frac{\rho}{w}\right)^{\sigma-1}} = \frac{wL + wf_x M_x(\eta-1)\left[1 + \frac{d}{f_x}(A_{ROO})^{-\beta}\right]}{1 - \frac{1}{\sigma}M\eta P^{\sigma-1}\left(\frac{\rho}{w}\right)^{\sigma-1}}$$

Note that we are assuming that there are a given number of firms in the market, i.e., M is fixed. We do so to follow the assumptions in Ju and Krishna (2002) as closely as possible since their analysis deals with the medium run, where firms can choose what to do but where their mass is given.

There are two unknown variables in the economy, φ_x^* and w[102]. By using the definition of φ_x^* and the trade balance condition (as we assume home imports z and is the sole producer of differentiated goods) we get the following equilibrium conditions:

$$A\left(\frac{w\tau}{\rho\varphi_x^*}\right)^{1-\sigma} = w\sigma f_x, \tag{76}$$

which defines w in terms of the cutoff φ_x^* from equation (73).

$$p_z z = \int_{\varphi_x^*}^{\infty} r_x(\varphi)\, M dG(\varphi) + \int_{\varphi_{x,ROO}^*}^{\infty} r_{x,r}(\varphi)\, M dG(\varphi), \tag{77}$$

where

$$p_z z = RP^{\sigma-1} = \frac{wL + wf_x M_x(\eta-1)\left[1+\frac{d}{f_x}(A_{ROO})^{-\beta}\right]}{1+\rho M\eta\left(\frac{\rho}{w}\right)^{\sigma-1}}, \quad \text{and}$$

$$\int_{\varphi_x^*}^{\infty} r_x(\varphi)\, M dG(\varphi) + \int_{\varphi_{x,ROO}^*}^{\infty} r_{x,r}(\varphi)\, M dG(\varphi) = wf_x M_x(\sigma\eta)\left[1+\frac{d}{f_x}(A_{ROO})^{-\beta}\right]$$

Note that from (76), wage is increasing with φ_x^*. We can rewrite the equilibrium conditions as

$$w = \left[\frac{A}{\sigma f_x}\left(\frac{\rho}{\tau}\right)^{\sigma-1}\right]^{1/\sigma} (\varphi_x^*)^{\rho}, \tag{78}$$

$$L = f_x M (\varphi_x^*)^{-\beta}\left[1+\frac{d}{f_x}(A_{ROO})^{-\beta}\right]\left[\sigma\eta-(\eta-1)+(\sigma-1)\eta^2 M\left(\frac{w}{\rho}\right)^{1-\sigma}\right], \tag{79}$$

where $\sigma\eta-(\eta-1)=\frac{\sigma\beta-(\sigma-1)}{\beta-(\sigma-1)}>0$ since $\sigma>1$.

It can be easily verified that as *ROOs* become stricter, i.e., if d, λ, or θ rises, then $\left[1+\frac{d}{f_x}(A_{ROO})^{-\beta}\right]$ falls. Thus, φ_x^* and w must fall to keep the right-hand side of (79) constant. Moreover, since $\varphi_x^* = \varphi_{x,ROO}^*/A_{ROO}$, (79) can be written as

$$L = f_x M\left(\varphi_{x,ROO}^*\right)^{-\beta}\left[(A_{ROO})^{\beta}+\frac{d}{f_x}\right]\left[\sigma\eta-(\eta-1)+(\sigma-1)\eta^2 M\rho^{\sigma-1}\left(\frac{A_{ROO}}{\varphi_{x,ROO}^*}\right)^{\rho(\sigma-1)}\right]. \tag{80}$$

Therefore, stricter *ROOs* raise $\varphi_{x,ROO}^*$.

The intuition behind these results is the following. First, assume that wage does not change as *ROOs* become stricter. Then, the profits of exporters, who do not invoke *ROOs*, remain unchanged. However, the productivity cutoff of exporters who choose to meet *ROOs*

[102] $\varphi_{x,ROO}^*$ can be found from (75).

rises, while their mass falls. Thus, the aggregate profits from exporting, $\Pi_x + \Pi_{x,r}$, as well as consumers' income, fall. This leads to a fall in the demand for each domestic variety, and as a result, to a fall in the demand for labor. The equilibrium in the labor market cannot be restored through the exit of firms, since the mass of firms is fixed. Thus, wage must fall. This, in turn, makes exporting without *ROOs* more attractive so the productivity cutoff for exporters φ_x^* falls.

5.2.2 The Homogeneous Regime

The analysis is very similar to that in the heterogeneous regime even when $A_{ROOs} \leq 1$. In this case, all exporters invoke *ROOs*. The profits of exporters in this case are depicted in Figure 21(b). Now the intersection of two lines lies below the horizontal axis. Thus, there is only one productivity cutoff in the equilibrium, $\varphi_{x,ROO}^*$, defined as

$$\pi_{x,ROO}\left(\varphi_{x,ROO}^*\right) = 0 \Leftrightarrow A\left(\frac{w\tau}{\rho\varphi_x^*}\right)^{1-\sigma}(\lambda\theta)^{1-\sigma} = \sigma w\left(f_x + d\right). \tag{81}$$

Aggregate expenditure in the economy is given by $R = wL + \Pi_d + \Pi_{x,ROO}$, where

$$\begin{aligned}
\Pi_d &= \int_1^\infty \pi_d(\varphi)\, M dG(\varphi) = \frac{1}{\sigma} M\eta R P^{\sigma-1}\left(\frac{\rho}{w}\right)^{\sigma-1}, \\
\Pi_{x,ROO} &= \int_{\varphi_{x,ROO}^*}^\infty \pi_{x,ROO}(\varphi)\, M dG(\varphi) = M_{x,ROO}\left[\frac{1}{\sigma}\eta A\left(\frac{\rho}{w\tau}\right)^{\sigma-1}(\lambda\theta)^{1-\sigma}\left(\varphi_{x,ROO}^*\right)^{\sigma-1} - \right. \\
&= M_{x,ROO}\left[\frac{1}{\sigma}\eta A\left(\frac{\rho}{w\tau}\right)^{\sigma-1}(\lambda\theta)^{1-\sigma}\left(\varphi_{x,ROO}^*\right)^{\sigma-1} - w\left(f_x + d\right)\right] \\
&= wM_{x,ROO}\left(f_x + d\right)[\eta - 1], \\
P^{1-\sigma} &= 1 + \left(\frac{\rho}{w}\right)^{\sigma-1}\eta M, \quad M_{x,ROO} = \left(1 - G\left(\varphi_{x,ROO}^*\right)\right) M = \left(\varphi_{x,ROO}^*\right)^{-\beta} M.
\end{aligned}$$

There are two unknown variables, $\varphi_{x,ROO}^*$ and w, and two equilibrium conditions, (81) and the trade balance condition:

$$p_z z = \int_{\varphi_{x,ROO}^*}^\infty r_{x,ROO}(\varphi)\, M dG(\varphi), \tag{82}$$

which can be rewritten as

$$L = \left(f_x + d\right) M \left(\varphi_{x,ROO}^*\right)^{-\beta}\left[\sigma\eta - (\eta - 1) + (\sigma - 1)\eta^2 M\left(\frac{w}{\rho}\right)^{1-\sigma}\right]. \tag{83}$$

Using (81) in the equation above leads to

$$L = \left[M \frac{\tau}{\rho} A^{\frac{1}{1-\sigma}} \right] (f_x + d)^{1-\frac{\beta}{\sigma-1}} (\lambda\theta)^{-\frac{\beta}{\sigma-1}} w^{-\frac{\beta}{\rho}} \left[\sigma\eta - (\eta - 1) + (\sigma - 1)\eta^2 M \left(\frac{w}{\rho}\right)^{1-\sigma} \right]. \quad (84)$$

It can be easily verified that as *ROOs* become stricter, i.e., if d, λ, or θ rises, then w must fall to keep the right-hand side of (84) constant. Moreover, as w falls, from (83), $(f_x + d)\left(\varphi^*_{x,ROO}\right)^{-\beta}$ must fall, meaning that $\varphi^*_{x,ROO}$ must rise. The intuition in this case is the same as in the heterogeneous regime. At a given w, stricter *ROOs* increase the productivity cutoff of exporters all of whom invoke *ROOs*. This reduces their number, which, in turn, translates into lower aggregate income and lessens the labor demand, so that wage has to fall.

Finally, note that there is no non-monotonicity in the comparative statics when regimes switch as *ROOs* become more strict. Wage fall in both cases, while the productivity of *ROOs* users rises and their mass falls.

5.3 Conclusion

This paper shows that the main result in Ju and Krishna (2002), i.e., the non-monotonicity in the comparative statics, disappears, if firm heterogeneity is allowed. It seems like allowing for another margin of adjustment removes the need for the regime switch that occurs in their setting.

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Appendix A

Proofs to Chapter 1

Proof of Lemma 1. Using (8), we can write $j(\varphi^*, G_i(\cdot))$ as

$$j_i(\varphi^*) \equiv j(\varphi^*, G_i(\cdot)) = \frac{1}{(\varphi^*)^{\sigma-1}} \int_{\varphi^*}^{\infty} \varphi^{\sigma-1} g_i(\varphi)\, d\varphi - [1 - G_i(\varphi^*)] \tag{85}$$

$$= [1 - G_i(\varphi^*)] \left(E_i \left[\left(\frac{\varphi}{\varphi^*} \right)^{\sigma-1} \mid \varphi > \varphi^* \right] - 1 \right), \quad i = H, F. \tag{86}$$

Thus, for any given level φ^*,

$$j_H(\varphi^*) - j_F(\varphi^*) = [1 - G_H(\varphi^*)] \left(E_H \left[\left(\frac{\varphi}{\varphi^*} \right)^{\sigma-1} \mid \varphi > \varphi^* \right] - 1 \right) - [1 - G_F(\varphi^*)] \left(E_F \left[\left(\frac{\varphi}{\varphi^*} \right)^{\sigma-1} \mid \varphi > \varphi^* \right] - 1 \right).$$

If $G_H(\cdot) \succ_{hr} G_F(\cdot)$, then, for any given level φ^*, $1 - G_H(\varphi^*) > 1 - G_F(\varphi^*)$. Moreover, since $\left(\frac{\varphi}{\varphi^*}\right)^{\sigma-1}$ is increasing in φ, $E_H\left[\left(\frac{\varphi}{\varphi^*}\right)^{\sigma-1} \mid \varphi > \varphi^*\right] > E_F\left[\left(\frac{\varphi}{\varphi^*}\right)^{\sigma-1} \mid \varphi > \varphi^*\right]$. Note that $E_i\left[\left(\frac{\varphi}{\varphi^*}\right)^{\sigma-1} \mid \varphi > \varphi^*\right] > 1$, $i = H, F$. Therefore, $j_H - j_F > 0$. ■

Proof of Lemma 2. Recall that $r_i(\varphi) = \beta L (P_i \rho \varphi)^{\sigma-1}$, $r_{xi}(\varphi) = \tau^{1-\sigma} r_j(\varphi)$, $i \neq j$, $r_i(\varphi_i^*) = \sigma f$, and $r_{xi}(\varphi_{xi}^*) = \sigma f_x$. Define $A \equiv \tau \left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}}$. Then,

$$\frac{r_H(\varphi_H^*)}{r_F(\varphi_F^*)} = 1, \Longrightarrow \frac{\varphi_H^*}{\varphi_F^*} = \frac{P_F}{P_H}; \quad \frac{r_{xH}(\varphi_{xH}^*)}{r_{xF}(\varphi_{xF}^*)} = 1, \Longrightarrow \frac{\varphi_{xH}^*}{\varphi_{xF}^*} = \frac{P_H}{P_F}, \tag{87}$$

$$\frac{r_{xi}(\varphi_{xi}^*)}{r_i(\varphi_i^*)} = \frac{f_x}{f}, \Longrightarrow \frac{\varphi_{xH}^*}{\varphi_H^*} = A \frac{P_H}{P_F}; \text{ and } \frac{\varphi_{xF}^*}{\varphi_F^*} = A \frac{P_F}{P_H}. \tag{88}$$

$$\text{Thus,} \quad \varphi_{xH}^* = A \varphi_F^*, \quad \varphi_{xF}^* = A \varphi_H^*. \tag{89}$$

■

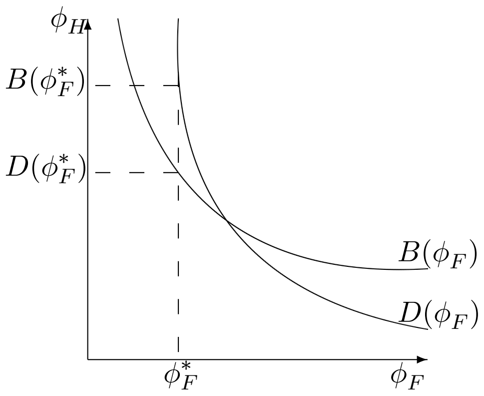
The equilibrium conditions in the case of open trade. As in autarky, substituting (20) in (17) for each country leads to the system:

$$\frac{f}{\delta}(1 - G_H(\varphi_H^*)) k_H(\varphi_H^*) + \frac{f_x}{\delta}(1 - G_H(\varphi_{xH}^*)) k_H(\varphi_{xH}^*) = f_e, \tag{90}$$

$$\frac{f}{\delta}(1 - G_F(\varphi_F^*)) k_F(\varphi_F^*) + \frac{f_x}{\delta}(1 - G_F(\varphi_{xF}^*)) k_F(\varphi_{xF}^*) = f_e. \tag{91}$$

Using the definition of $j_i(\varphi)$ and Lemma 2, (21) and (22) are obtained from the system above.

Figure 22: Example



■

Proof of Lemma 3. First, note that the function $j(\varphi, G_i(\cdot))$, $i = H, F$, is a decreasing function of φ.[103] Thus, both curves corresponding to equations (23) and (24) are decreasing in φ_F.

From (21), the slope of the curve corresponding to equation (23) is

$$-\frac{f_x}{f} A \frac{j_1(A\varphi_F, G_H(\cdot))}{j_1(\varphi_H, G_H(\cdot))}, \text{ where } \varphi_H \equiv B(\varphi_F) \text{ is defined by (23).}$$

From (22), the slope of the curve corresponding to equation (24) is

$$-\frac{f}{f_x} \frac{1}{A} \frac{j_1(\varphi_F, G_F(\cdot))}{j_1(A\varphi_H, G_F(\cdot))}, \text{ where } \varphi_H \equiv D(\varphi_F) \text{ is defined by (24).}$$

Note that $\varphi_H \equiv B(\varphi_F)$ and $\varphi_H \equiv D(\varphi_F)$ could differ for the same φ_F as, for example, shown in Figure 22.

The comparison of the slopes leads to :

$$\left| -\frac{f_x}{f} A \frac{j_1(A\varphi_F, G_H(\cdot))}{j_1(B(\varphi_F), G_H(\cdot))} \right| \gtrless \left| -\frac{f}{f_x} \frac{1}{A} \frac{j_1(\varphi_F, G_F(\cdot))}{j_1(AD(\varphi_F), G_F(\cdot))} \right|$$

or

$$\left(\frac{f_x}{f}\right)^2 \gtrless \frac{|j_1(B(\varphi_F), G_H(\cdot))|}{A|j_1(A\varphi_F, G_H(\cdot))|} \cdot \frac{|j_1(\varphi_F, G_F(\cdot))|}{A|j_1(AD(\varphi_F), G_F(\cdot))|}. \tag{92}$$

Using the formula for $j_1(\varphi, G_i(\cdot)) = -\frac{1}{\varphi}(\sigma-1)\varphi^{1-\sigma}\int_{\varphi}^{\infty} x^{\sigma-1} g_i(x)\,dx$ and Assumption 1, we

[103] $j_1(\varphi, G_i(\cdot)) = -\frac{1}{\varphi}(\sigma-1)[1-G(\varphi)][k(\varphi)+1] < 0$. (See Melitz (2003).)

obtain

$$\frac{|j_1(B(\varphi_F), G_H(\cdot))|}{A|j_1(A\varphi_F, G_H(\cdot))|} = \frac{B(\varphi_F)^{-\sigma}\displaystyle\int_{B(\varphi_F)}^{\infty} x^{\sigma-1} g_H(x)\,dx}{A^{1-\sigma}(\varphi_F)^{-\sigma}\displaystyle\int_{A\varphi_F}^{\infty} x^{\sigma-1} g_H(x)\,dx} \equiv A^{\sigma-1}\frac{B(\varphi_F)^{-\sigma}}{(\varphi_F)^{-\sigma}} Q_H, \tag{93}$$

$$\frac{|j_1(\varphi_F, G_F(\cdot))|}{A|j_1(AD(\varphi_F), G_F(\cdot))|} = \frac{A^{\sigma-1}(\varphi_F)^{-\sigma}\displaystyle\int_{\varphi_F}^{\infty} x^{\sigma-1} g_F(x)\,dx}{D(\varphi_F)^{-\sigma}\displaystyle\int_{AD(\varphi_F)}^{\infty} x^{\sigma-1} g_F(x)\,dx} \equiv A^{\sigma-1}\frac{(\varphi_F)^{-\sigma}}{D(\varphi_F)^{-\sigma}} Q_F, \tag{94}$$

where $Q_H > 1$, $Q_F > 1$. Thus, we can rewrite (92) as

$$\left(\frac{f_x}{f}A^{1-\sigma}\right)^2 \gtreqless Q_H Q_F \frac{D(\varphi_F)^{\sigma}}{B(\varphi_F)^{\sigma}} \tag{95}$$

By definition, $A = \tau\left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}}$. Thus, $\left(\frac{f_x}{f}A^{1-\sigma}\right)^2 = \left(\tau^{1-\sigma}\right)^2 < 1$. Note that at any intersection of two curves, i.e., when $B(\varphi_F) = D(\varphi_F)$, the right-hand side of inequality (95) equals to $Q_H Q_F > 1$. Thus, at this point, the curve corresponding to equation (23) is flatter than the curve corresponding to equation (24). This property implies the uniqueness of the intersection point, since both curves are decreasing in φ_F. (If there is another intersection, at this point, the curve corresponding to equation (23) should be steeper than the curve corresponding to equation (24), which violates the property proved above.) Note that this result does not depend on the relationship between the productivity distributions in two countries.

Second, if countries have the same productivity distribution, i.e., if they are symmetric, the intersection of two curves lies on the 45^0 line as shown in Figure 4(a) and in the equilibrium $\varphi_H^* = \varphi_F^*$. Then, if the home country faces the productivity improvement, i.e., $G_{H,A}(\cdot) \succ_{hr} G_{H,B}(\cdot)$, then from Lemma 1, $j(\varphi, G_{H,A}(\cdot)) > j(\varphi, G_{H,B}(\cdot))$ for any φ. Using this result and recalling that $j(\varphi, G_{H,n}(\cdot))$, $n = A, B$, is decreasing in φ, it can be shown that the curve corresponding to equation (23) shifts up and in the equilibrium, $\varphi_F^* < \varphi_H^* < \varphi_{xH}^* < \varphi_{xF}^*$.[104] (See Figure 4(b).) The similar result can be proved in the case when the foreign country faces the productivity improvement, i.e., $G_{F,A}(\cdot) \succ_{hr} G_{F,B}(\cdot)$.

Finally, we discuss the restrictions imposed on parameters to ensure the existence of the

[104] Note that at the new intersection, the new curve is also flatter than that corresponding to equation (24).

equilibrium. We start with Assumption 2, which means that in the equilibrium with no specialization, both countries produce the differentiated goods, thus, both (21) and (22) should hold. Therefore, from (21), we derive $\varphi_F^* \equiv s(\varphi_H^*) = \frac{1}{A} j_H^{-1}\left(\frac{\delta f_e - f j_H(\varphi_H^*)}{f_x}\right)$ and substitute it in (22) to obtain an equation just for φ_H^* :

$$\psi(\varphi_H^*) \equiv \frac{f}{\delta} j_F(s(\varphi_H^*)) + \frac{f_x}{\delta} j_F(A\varphi_H^*) = f_e. \tag{96}$$

Note that $\psi'(\varphi_H^*) > 0$. (We can use the same technique as we used to compare the slopes of curves corresponding to (23) and (24) to prove it.) From Assumption 1, $\varphi_H^* < \varphi_{xH}^* = A\varphi_F^*$. Moreover, from (23), $\varphi_H^* < j_H^{-1}\left(\frac{\delta f_e}{f_x+f}\right)$. Therefore, we can derive the necessary condition for Assumption 2: the solution of (96) exists only if $f_e < \psi\left(j_H^{-1}\left(\frac{\delta f_e}{f_x+f}\right)\right)$ or $f_e < \frac{f}{\delta} j_F\left(\frac{1}{A} j_H^{-1}\left(\frac{\delta f_e}{f_x+f}\right)\right) + \frac{f_x}{\delta} j_F\left(A j_H^{-1}\left(\frac{\delta f_e}{f_x+f}\right)\right)$.

Assumption 1 implies that for any i and j, $i \neq j$, $\frac{\varphi_i^*}{\varphi_j^*} < A$. We proved that in the equilibrium, $\varphi_H^* > \varphi_F^*$. Thus, Assumption 1 requires $\frac{\varphi_H^*}{\varphi_F^*} < A$. ($\frac{\varphi_F^*}{\varphi_H^*} < A$ follows from it.) From (96), $\varphi_H^* = \psi^{-1}(f_e)$. Recalling that $\varphi_F^* = s(\varphi_H^*)$, we derive the necessary condition for Assumption 1: $\frac{\psi^{-1}(f_e)}{s(\psi^{-1}(f_e))} < A$. ∎

The price index in country i. By definition, $M_{ti} = \beta L / r_i(\tilde{\varphi}_{ti})$, where $r_i(\tilde{\varphi}_{ti}) = r_i(\varphi_i^*)\left(\frac{\tilde{\varphi}_{ti}}{\varphi_i^*}\right)^{\sigma-1} = \sigma f\left(\frac{\tilde{\varphi}_{ti}}{\varphi_i^*}\right)^{\sigma-1}$. As a result, formula (16) can be written as

$$P_i = \left(\frac{\beta L}{\sigma f}\right)^{\frac{1}{1-\sigma}} \frac{1}{\rho\varphi_i^*}. \tag{97}$$

∎

Proof of Lemma 4. We need to show that $\gamma_H > \beta > \gamma_F$. Given φ_H^* and φ_F^*, the trade balance equation can be written as

$$p_{xH} M_H r_F\left(\tau^{-1}\tilde{\varphi}_{xH}\right) + (1-\gamma_H) L - (1-\beta) L = p_{xF} M_F r_H\left(\tau^{-1}\tilde{\varphi}_{xF}\right). \tag{98}$$

By using $M_i = \frac{R_i^C}{\bar{r}_i} = \gamma_i L / \bar{r}_i$, $i = H, F$, in the trade balance equation (98) and denoting $\frac{r_i(\tilde{\varphi}_i)}{p_{xi} r_j(\tau^{-1}\tilde{\varphi}_{xi})}$ by b_i, the following expression for γ_H is obtained:

$$\gamma_H = \beta\frac{(b_F - 1)(b_H + 1)}{b_H b_F - 1} = \beta\left(1 + \frac{b_F - b_H}{b_H b_F - 1}\right). \tag{99}$$

By construction, $\gamma_F = 2\beta - \gamma_H$. To prove that $\gamma_H > \beta$ (home country exports the differentiated goods), we need to show that $b_H b_F > 1$ and $b_F > b_H$. Given that $r_i(\varphi) = E_i^C (P_i \rho \varphi)^{\sigma-1}$, formula (97) leads to:

$$b_i = \tau^{\sigma-1} \frac{1}{p_{xi}} \left(\frac{\tilde{\varphi}_i}{\varphi_i^*} * \frac{\varphi_j^*}{\tilde{\varphi}_{xi}} \right)^{\sigma-1} = \tau^{\sigma-1} \frac{(\varphi_i^*)^{1-\sigma} \int_{\varphi_i^*}^{\infty} x^{\sigma-1} g_i(x)\, dx}{\left(\varphi_j^*\right)^{1-\sigma} \int_{A\varphi_j^*}^{\infty} x^{\sigma-1} g_i(x)\, dx}.$$

Thus, $b_F b_H > \tau^{2\sigma-2} > 1$. To prove that $b_F > b_H$, rewrite b_i as $b_i = \tau^{\sigma-1} A^{1-\sigma} \frac{a_i(\varphi_i^*)}{a_i\left(A\varphi_j^*\right)} = \frac{f}{f_x} \frac{a_i(\varphi_i^*)}{a_i\left(A\varphi_j^*\right)}$, $i \neq j$, where $a_i(\varphi) \equiv \varphi^{1-\sigma} \int_{\varphi}^{\infty} x^{\sigma-1} g_i(x)\, dx$ is decreasing in φ.[105] From Lemma 2, $b_F = \frac{f}{f_x} \frac{a_F(\varphi_F^*)}{a_F\left(A\varphi_H^*\right)} > \frac{f}{f_x} \frac{a_F(\varphi_H^*)}{a_F\left(A\varphi_F^*\right)}$. We want to show that $\frac{f}{f_x} \frac{a_F(\varphi_H^*)}{a_F\left(A\varphi_F^*\right)} > b_H = \frac{f}{f_x} \frac{a_H(\varphi_H^*)}{a_H\left(A\varphi_F^*\right)}$. To do this, it is enough to compare the elasticities of the decreasing functions $a_F(\cdot)$ and $a_H(\cdot)$, or, respectively, ε_F and ε_H, and prove that $\varepsilon_F > \varepsilon_H$.

$$a_i'(\varphi) = \frac{1-\sigma}{\varphi} a_i(\varphi) - g_i(\varphi) \Longrightarrow \varepsilon_i(\varphi) = -\frac{a_i'(\varphi)}{a_i(\varphi)}\varphi = (\sigma-1) + \varphi \frac{g_i(\varphi)}{a_i(\varphi)}.$$

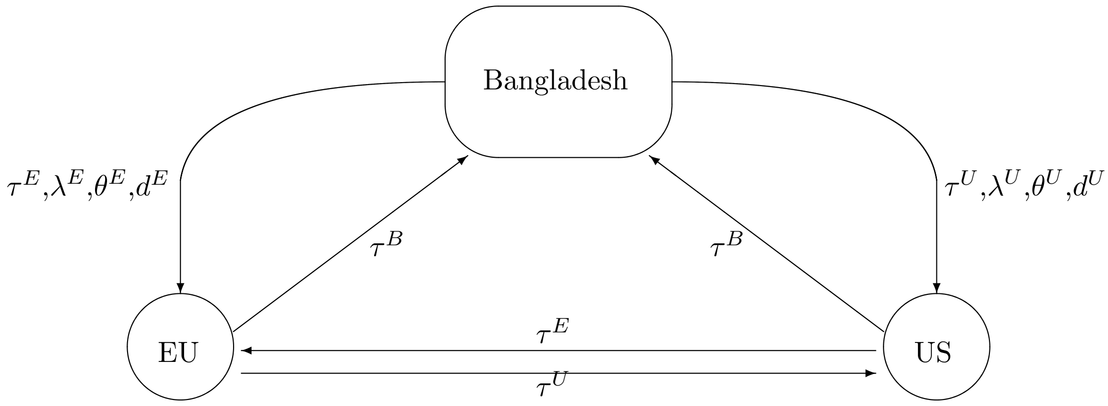
$$\frac{g_i(\varphi)}{a_i(\varphi)} = \frac{g_i(\varphi)}{1-G_i(\varphi)} \left(\frac{\varphi^{1-\sigma}}{1-G_i(\varphi)} \int_{\varphi}^{\infty} x^{\sigma-1} g_i(x)\, dx \right)^{-1}.$$

HRSD implies that $\frac{1}{1-G_H(\varphi)} \int_{\varphi}^{\infty} x^{\sigma-1} g_H(x)\, dx > \frac{1}{1-G_F(\varphi)} \int_{\varphi}^{\infty} x^{\sigma-1} g_F(x)\, dx$ and $\frac{g_F(\varphi)}{1-G_F(\varphi)} > \frac{g_H(\varphi)}{1-G_H(\varphi)}$. Thus, $g_F(\varphi)/a_F(\varphi) > g_H(\varphi)/a_H(\varphi)$, $\varepsilon_F > \varepsilon_H$, $b_F > b_H$, and $\gamma_H > \beta$. Thus, $\gamma_F < \beta$. This proves Lemma 4. ■

Productivity improvements and the volume of trade. The homogenous and differentiated good exports from the foreign country are, respectively, $[\gamma_H - \beta] L = \beta L \frac{b_F - b_H}{b_H b_F - 1}$ and $(2\beta - \gamma_H) L \frac{1}{1+b_F} = \beta L \frac{b_H - 1}{b_H b_F - 1}$. The export of differentiated goods from the home country and the volume of trade are $\gamma_H L \frac{1}{1+b_H} = \beta L \frac{b_F - 1}{b_H b_F - 1}$. By construction, $b_H(\cdot)$ is decreasing in φ_H^*, whereas b_F is increasing in φ_H^*. The trade comparison is straightforward, taking the derivatives of γ_H and export functions with respect to φ_H^* and recalling that $b_F > b_H > 1$, $b_H b_F > 1$, and φ_H^* falls when the foreign country faces the productivity improvement. Thus, productivity improvement in the foreign country leads to the fall in the volume of trade ■

[105] $a_i'(\varphi) = (1-\sigma)\varphi^{-\sigma} \int_{\varphi}^{\infty} x^{\sigma-1} g_i(x)\, dx - g_i(\varphi) < 0.$

Figure 23: The Structure of Economy



Appendix B

Proofs to Chapter 2[106]

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, Bangladesh (B) is smaller in that it has fewer units of effective labor. 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. Note that as labor is measured in effective units, factor price equalization says nothing about wages per worker which can be lower in Bangladesh if their labor is less productive. There are L consumers in the US and EU, and L^B consumers in Bangladesh. A consumer in country i, $i = E, U, B$, supplies one unit of labor.

B.1 Production and Firm Behavior

We assume that there is no specialization in equilibrium. Hence, we can normalize the wage rate and the price of the homogenous good to unity.[107] 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 23. The per unit trade costs of the US and EU

[106] An appendix with more details is available upon request.
[107] Even if unit labor requirements differ, factor price equalization in efficiency units is achieved.

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 exporting to the US and EU are, respectively, τ^U and τ^E reflecting the MFN tariffs set by two countries. 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 with productivity level ϕ is $\tau^B p(\phi)$, while the export prices set by US firms exporting to the EU and EU firms exporting to the US are, respectively, $\tau^E p(\phi)$ and $\tau^U p(\phi)$. Exporters from Bangladesh with productivity level ϕ set the following prices[108]:

$$p_x(\phi) = \begin{cases} \tau^E p(\phi), \text{ if the firm exports to the EU without meeting } ROOs; \\ \lambda^E \theta^E \tau^E p(\phi), \text{ if the firm meets } ROOs \text{ while exporting into the EU;} \\ \left(\theta^U + t\right) \tau^U p(\phi), \text{ if the firm exports into the US.} \end{cases} \tag{100}$$

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

$$r_d^k(\phi) = E^k \left(P^k \rho\phi\right)^{\sigma-1}, \; k = E, U, B \tag{101}$$

$$r_x^{EU}(\phi) = E^U \left(P^U \rho \left(\tau^U\right)^{-1} \phi\right)^{\sigma-1}, \tag{102}$$

$$r_x^{UE}(\phi) = E^E \left(P^E \rho \left(\tau^E\right)^{-1} \phi\right)^{\sigma-1}, \tag{103}$$

$$r_x^{kB}(\phi) = E^B \left(P^B \rho \left(\tau^B\right)^{-1} \phi\right)^{\sigma-1}, \; k = E, U. \tag{104}$$

A firm from Bangladesh gets:

$$r_x^{BE}(\phi) = E^E \left(P^E \rho \left(\tau^E\right)^{-1} \phi\right)^{\sigma-1}, \tag{105}$$

$$r_{xr}^{BE}(\phi) = E^E \left(P^E \rho \left(\lambda^E \theta^E \tau^E\right)^{-1} \phi\right)^{\sigma-1}, \tag{106}$$

$$r_{xr}^{BU}(\phi) = E^U \left(P^U \rho \left(\left(\theta^U + t\right) \tau^U\right)^{-1} \phi\right)^{\sigma-1}, \tag{107}$$

[108] Note that $\lambda^U = 1$, since the US does not give tariff preferences to Bangladeshi garments. (See Section 2.2.3.)

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, $r_{R}^{BE}(\phi)$, which is positive as $\sigma > 1$ (needed for bounded profits) and $\lambda\theta < 1$ (needed for preferences to ever be worth invoking), reflects the additional revenue gains of firms in Bangladesh from meeting $ROOs$ in the EU. Firms in Bangladesh use $ROOs$ only if the additional variable profit, $\frac{r_{R}^{BE}(\phi)}{\sigma}$, 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, $R^{k} = \gamma^{k}L^{k}$, where γ^{k} is the fraction of labor employed in the differentiated good sector in country k[109], 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.). However, 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 ($\frac{r_{d}\left(\phi^{*i}\right)}{\boldsymbol{\sigma}} = f$) or to export into country j without meeting $ROOs$ ($\frac{r_{x}^{ij}\left(\phi_{x}^{*ij}\right)}{\sigma} = f_{x}$). 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., $\frac{r_{R}^{BE}\left(\phi_{xr}^{*BE}\right)}{\sigma} = d^{E}$ and $\frac{r_{xr}^{BU}\left(\phi_{xr}^{*BU}\right)}{\sigma} = f_{x} + d^{U}$. Now, there are a number of relations between these cutoffs. For example, the export cutoff for a Bangladeshi firm exporting to the EU without meeting $ROOs$ must be related to the entry cutoff for a EU firm. Since

$$r\left(\phi^{*E}, P^{E}, E^{E}\right) = \sigma f, \quad r\left(\frac{\phi_{x}^{*BE}}{\tau^{E}}, P^{E}, E^{E}\right) = \sigma f_{x},$$

[109] The value of output or revenue earned in the differentiated good sector equals the total factor payment or the earnings of labor employed in the sector. The value of output in country k includes revenue earned in the differentiated good sector and in the homogenous good sector and equals factor payments or L. National income in addition includes net government revenue, in this case, tariff revenue.

using the explicit functional form for revenue, yields

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

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

$$\phi_x^{*EU} = A^{US}\phi^{*U}, \quad \phi_x^{*UE} = \phi_x^{*BE} = A^{EU}\phi^{*E}, \tag{108}$$

$$\phi_x^{*EB} = \phi_x^{*UB} = A^B\phi^{*B}, \tag{109}$$

$$\phi_{xr}^{*BE} = A_{ROO}^{BE}\phi_x^{*BE} = A_{ROO}^{BE}A^{EU}\phi^{*E} \tag{110}$$

$$\phi_{xr}^{*BU} = A_{ROO}^{BU}\phi^{*U}, \tag{111}$$

where

$$A^{US} = \tau^U \left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}} > 1,\ A^{EU} = \tau^E \left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}} > 1,\ A^B = \tau^B \left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}} > 1, \tag{112}$$

$$A_{ROO}^{BE} = \left(\frac{d^E}{f_x}\frac{1}{\left(\lambda^E\theta^E\right)^{1-\sigma} - 1}\right)^{\frac{1}{\sigma-1}} > 1, \tag{113}$$

$$A_{ROO}^{BU} = \tau^U\left(\theta^U + t\right)\left(\frac{f_x + d^U}{f}\right)^{\frac{1}{\sigma-1}} > 1. \tag{114}$$

We assume that d^E, λ^E, and θ^E are such that $A_{ROO}^{BE} > 1$, i.e., not all Bangladeshi firms exporting to the EU invoke *ROOs*. In addition, as $\tau^U > \tau^E$ and tariffs are MFN, we have $A^{US} > A^{EU}$. Moreover, we will assume that $A^B > A_{ROO}^{BU}$. This is motivated by Bangladeshi tariffs on imports being quite high. We assume that they are higher than the implicit effect of US *ROOs* and quotas, i.e., $\tau^B > \tau^U(\theta^U + t)$. As a result, the relationship between the parameters is:

$$A^B > A_{ROO}^{BU} > A^{US} > A^{EU}. \tag{115}$$

The free entry (FE) condition in country i leads to the following equation[110]:

$$\frac{\bar{\pi}_i}{\delta}\left(1 - G\left(\phi^{*i}\right)\right) = f_e,\ i = E, U, B, \tag{116}$$

[110] δ is the usual exogenous probability of death for a firm which allows the static model to be interpreted as a dynamic one in its steady state.

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 $\tilde{\phi}(\phi^*)$ as

$$\tilde{\phi}(\phi^*) \equiv \left[\int_0^\infty \phi^{\sigma-1}\mu(\phi)\,d\phi\right]^{\frac{1}{\sigma-1}} \tag{117}$$

$$= \left[\frac{1}{1-G(\phi^*)}\int_{\phi^*}^\infty \phi^{\sigma-1}g(\phi)\,d\phi\right]^{\frac{1}{\sigma-1}}. \tag{118}$$

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

$$\bar{\pi}^E = \pi_d^E\left(\tilde{\phi}^E\right) + p_x^{EU}\pi_x^{EU}\left(\tilde{\phi}_x^{EU}\right) + p_x^{EB}\pi_x^{EB}\left(\tilde{\phi}_x^{EB}\right), \tag{119}$$

$$\bar{\pi}^U = \pi_d^U\left(\tilde{\phi}^U\right) + p_x^{UE}\pi_x^{UE}\left(\tilde{\phi}_x^{UE}\right) + p_x^{UB}\pi_x^{UB}\left(\tilde{\phi}_x^{UB}\right), \tag{120}$$

$$\begin{aligned}\bar{\pi}^B &= \pi_d^B\left(\tilde{\phi}^B\right) + p_x^{BE}\pi_x^{BE}\left(\tilde{\phi}_x^{BE}\right)\\ &\quad + p_{xr}^{BE}\pi_R^{BE}\left(\tilde{\phi}_{xr}^{BE}\right) + p_{xr}^{BU}\pi_{xr}^{BU}\left(\tilde{\phi}_{xr}^{BU}\right),\end{aligned} \tag{121}$$

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 successful entry,

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

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

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

Note that

$$\pi_d^i\left(\tilde{\phi}^i\right) = \frac{r_d^i\left(\tilde{\phi}^i\right)}{\sigma} - f \;\text{ and }\; r_d^i\left(\tilde{\phi}^i\right) = r_d^i\left(\phi^{*i}\right)\left(\frac{\tilde{\phi}^i}{\phi^{*i}}\right)^{\sigma-1} = \sigma f\left(\frac{\tilde{\phi}^i}{\phi^{*i}}\right)^{\sigma-1}. \tag{122}$$

Thus,

$$\pi_d^i\left(\tilde{\phi}^i\right) = fk\left(\phi^{*i}\right), \quad \text{where } k\left(\phi\right) = \left(\frac{\tilde{\phi}\left(\phi\right)}{\phi}\right)^{\sigma-1} - 1. \tag{123}$$

Similarly,

$$\begin{aligned} \pi_x^{ij}\left(\tilde{\phi}_x^{ij}\right) &= f_x k\left(\phi_x^{*ij}\right), &(124)\\ \pi_R^{BE}\left(\tilde{\phi}_x^{BE}\right) &= d^E k\left(\phi_{xr}^{*BE}\right), &(125)\\ \pi_{xr}^{BU}\left(\tilde{\phi}_{xr}^{BU}\right) &= \left(f_x + d^U\right) k\left(\phi_{xr}^{*BU}\right). &(126) \end{aligned}$$

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 (116) and using relationships (108)-(111), we receive three equations for the productivity cutoffs corresponding to, respectively, the EU, the US, and Bangladesh**:**

$$fJ(\phi^{*E}) + f_x J(A^{US}\phi^{*U}) + f_x J\left(A^B\phi^{*B}\right) = \delta f_e, \tag{127}$$

$$fJ(\phi^{*U}) + f_x J(A^{EU}\phi^{*E}) + f_x J\left(A^B\phi^{*B}\right) = \delta f_e, \tag{128}$$

$$\begin{aligned} &fJ(\phi^{*B}) + f_x J(A^{EU}\phi^{*E}) + d^E J\left(A_{ROO}^{BE} A^{EU}\phi^{*E}\right) \\ &\qquad + \left(f_x + d^U\right) J\left(A_{ROO}^{BU}\phi^{*U}\right) = \delta f_e. \end{aligned} \tag{129}$$

Solving the above system gives ϕ^{*E}, ϕ^{*U}, and ϕ^{*B}, which, in turn, allows to solve for all the other variables in the economy.[111]

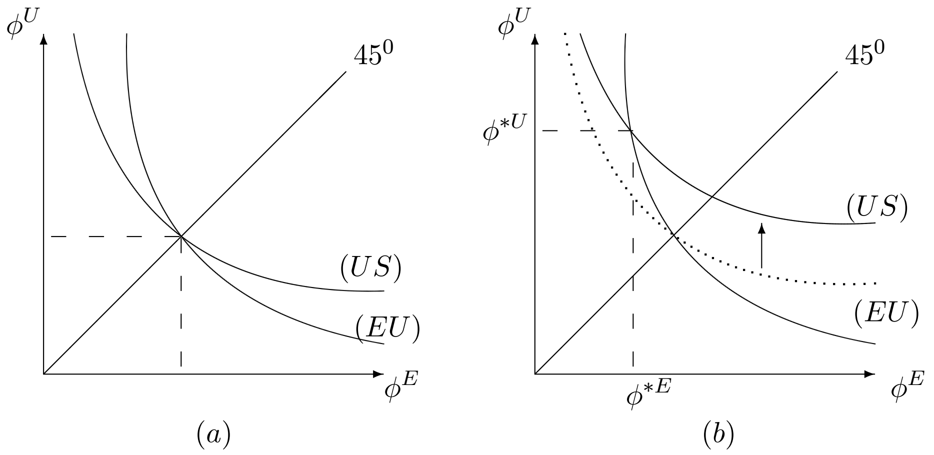
B.2 Ranking Domestic Cutoffs

To compare ϕ^{*U}, ϕ^{*E}, and ϕ^{*B}, we will first discuss the solution of the following system of equations:

$$\begin{aligned} fJ(\phi^{*E}) + f_x J(A^{US}\phi^{*U}) + f_x J\left(A^B\phi^{*B}\right) &= \delta f_e, &(130)\\ fJ(\phi^{*U}) + f_x J(A^{EU}\phi^{*E}) + f_x J\left(A^B\phi^{*B}\right) &= \delta f_e, &(131)\\ fJ(\phi^{*B}) + f_x J(A^{EU}\phi^{*E}) + f_x J\left(A_{ROO}^{BU}\phi^{*U}\right) &= \delta f_e, &(132) \end{aligned}$$

[111] 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.

Figure 24: Proof of Lemma 6



where equation (130) corresponds to the EU, equation (131) corresponds to the US, and equation (132) corresponds to Bangladesh. Using the same technique as in Demidova (2005), we will show that the solution of (130)-(132) must satisfy $\phi^{*B} > \phi^{*U} > \phi^{*E}$ and adding $d^E J\left(A^{BE}_{ROO} A^{EU} \phi^{*E}\right) + d^U J\left(A^{BU}_{ROO} \phi^{*U}\right)$ to equation (132) does not change this result.

Lemma 6 *In the equilibrium defined by (130)-(132),* $\phi^{*B} > \phi^{*U} > \phi^{*E}$.

Proof. First, let us prove that for any ϕ^{*B}, from (130) and (131) $\phi^{*U} > \phi^{*E}$. Then we will show that for any ϕ^{*E}, from (131) and (132) $\phi^{*B} > \phi^{*U}$, and the lemma will be proved.

Consider equations (130) and (131). Move $f_x J\left(A^B \phi^{*B}\right)$ to the RHS of these equations. This gives two equations in ϕ^{*E} and ϕ^{*U} which are equal to the same value on the RHS, namely $\delta f_e - f_x J\left(A^B \phi^{*B}\right)$. Clearly, if $A^{US} = A^{EU}$, then then the intersection of two curves is on the 45^0 line as shown in Figure $24(a)$. What if $A^{US} > A^{EU}$?

Well, ϕ^{*U} can be written as a function of ϕ^{*E} (ϕ^{*B} is fixed):

$$(130) \quad \Rightarrow \quad \phi^{*U} = \frac{1}{A^{US}} J^{-1}\left(\frac{\delta f_e}{f_x} - \frac{f}{f_x} J\left(\phi^{*E}\right) - J(A^B \phi^{*B})\right), \tag{133}$$

$$(131) \quad \Rightarrow \quad \phi^{*U} = J^{-1}\left(\frac{\delta f_e}{f} - \frac{f_x}{f} J(A^{EU}\phi^{*E}) - \frac{f_x}{f} J\left(A^B \phi^{*B}\right)\right). \tag{134}$$

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

$$J'\left(\phi^*\right) = -\left(\sigma - 1\right)\left(\phi^*\right)^{-\sigma} \int\limits_{\phi^*}^{\infty} \phi^{\sigma-1} g\left(\phi\right) d\phi < 0. \tag{135}$$

Since $J(\phi)$ is a decreasing function of ϕ, ϕ^{*U} is decreasing function of ϕ^{*E} in both equations (133) and (134). Moreover, at any intersection point, the curve for the US corresponding to equation (134) is flatter than the curve for the EU corresponding to equation (133)[112] as depicted in Figure 24(a). Suppose A^{EU} falls to $\tau^{EU}\left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}}$. Then, it is obvious that the curve for the US corresponding to equation (134) shifts up as shown in Figure 24(b). Hence, we know that for any ϕ^{*B}, $\phi^{*U} > \phi^{*E}$.

The proof that for any ϕ^{*E}, $\phi^{*B} > \phi^{*U}$ in the equilibrium defined by (130)-(132), is analogous to the previous one, but now we use equations (131) and (132) and the fact that $A^B > A^{BU}_{ROO}$. ■

Next, we add $d^E J\left(A^{BE}_{ROO}A^{EU}\phi^{*E}\right) + d^U J\left(A^{BU}_{ROO}\phi^{*U}\right)$ to equation (132).[113] Thus, instead of equation (132), we have

$$fJ(\phi^{*B}) + f_x J(A^{EU}\phi^{*E}) + f_x J\left(A^{BU}_{ROO}\phi^{*U}\right) + d^E J\left(A^{BE}_{ROO}A^{EU}\phi^{*E}\right) + d^U J\left(A^{BU}_{ROO}\phi^{*U}\right) = \delta f_e, \tag{136}$$

which is equivalent to equation (129). Note that this change does not affect equations (130) and (131). Thus, ϕ^{*U} remains above ϕ^{*E}, whatever be the value of ϕ^{*B}.

We can think of what happens when we add these two terms in three steps. First, as shown in Lemma 7, raising ϕ^{*B} raises $\delta f_e - f_x J(A^B\phi^{*B})$, and shifts out both the curves determining the values of ϕ^{*U} and ϕ^{*E}. If one curve shifts out more than the other, it is possible that ϕ^{*U} and ϕ^{*E} do not move in the same direction. However, we show below that this is not so. Both their equilibrium values rise. Second, using this relation between ϕ^{*U} and ϕ^{*E}, denoted by $\phi^{*E}(\phi^{*U})$, we can make the equations corresponding to (132) and (131) a function only of ϕ^{*B} and ϕ^{*U}. We show, in Lemma 8, that these two curves have similar properties as they do when ϕ^{*E} is fixed: in other words, that indirect effects do not swamp direct ones. In Lemma 9, we show that adding these terms thus shifts up only the augmented curve corresponding to (132) and so raises ϕ^{*B} from its value in the more symmetric system.

[112] The expressions for the slopes can be derived from (130) and (131) using the implicit function theorem.

[113] In the detailed appendix (available upon request) we consider an additional possible variation: that Bangladesh draws from a better productivity in terms of hazard rate stochastic dominance. This leads to the same result: ϕ^{*B} rises, while ϕ^{*U} and ϕ^{*E} fall with $\phi^{*B} > \phi^{*U} > \phi^{*E}$.

Lemma 7 *Any change in ϕ^{*B} moves ϕ^{*U} and ϕ^{*E} in the same direction.*

Proof. A change in ϕ^{*B} will raise the RHS of (130) and (131) equally so that it will remain true that

$$fJ(\phi^{*E}) + f_x J(A^{US}\phi^{*U}) = fJ(\phi^{*U}) + f_x J(A^{EU}\phi^{*E}). \tag{137}$$

Thus, equation (137) gives the relationship between ϕ^{*E} and ϕ^{*U} in the equilibrium. Using the implicit function theorem and differentiating (137) gives

$$\begin{aligned} \frac{d\phi^{*E}}{d\phi^{*U}} &= -\frac{-fJ'\left(\phi^{*U}\right) + f_x A^{US} J'\left(A^{US}\phi^{*U}\right)}{fJ'\left(\phi^{*E}\right) - f_x A^{EU} J'\left(A^{EU}\phi^{*E}\right)} \\ &= \frac{f\left|J'\left(\phi^{*U}\right)\right| - f_x A^{US}\left|J'\left(A^{US}\phi^{*U}\right)\right|}{f\left|J'\left(\phi^{*E}\right)\right| - f_x A^{EU}\left|J'\left(A^{EU}\phi^{*E}\right)\right|} > 0, \end{aligned}$$

since $J'(\phi^*) < 0$ and $f\left|J'(\phi^*)\right| > f_x A^j \left|J'\left(A^j\phi^*\right)\right|$.

From (135),

$$\frac{f\left|J'(\phi^*)\right|}{f_x A^j \left|J'\left(A^j\phi^*\right)\right|} = \frac{f\displaystyle\int_{\phi^*}^{\infty} \phi^{\sigma-1} g(\phi)\, d\phi}{f_x \left(A^j\right)^{1-\sigma} \displaystyle\int_{A^j\phi^*}^{\infty} \phi^{\sigma-1} g(\phi)\, \phi} = \left(\tau^j\right)^{\sigma-1} \frac{\displaystyle\int_{\phi^*}^{\infty} \phi^{\sigma-1} g(\phi)\, d\phi}{\displaystyle\int_{A^j\phi^*}^{\infty} \phi^{\sigma-1} g(\phi)\, \phi} > 1, \tag{138}$$

since $\tau^j > 1,\ A^j > 1,\ j = EU, US, B$. Thus, in the equilibrium, $\phi^{*E}\left(\phi^{*U}\right)$ is an increasing function of ϕ^{*U}. ■

Lemma 8 *The addition of $d^E J\left(A^{BE}_{ROO}A^{EU}\phi^{*E}\right) + d^U J\left(A^{BU}_{ROO}\phi^{*U}\right)$ to equation (132) must move ϕ^{*B} in the opposite direction to ϕ^{*E} and ϕ^{*U}.*

Proof. Note that

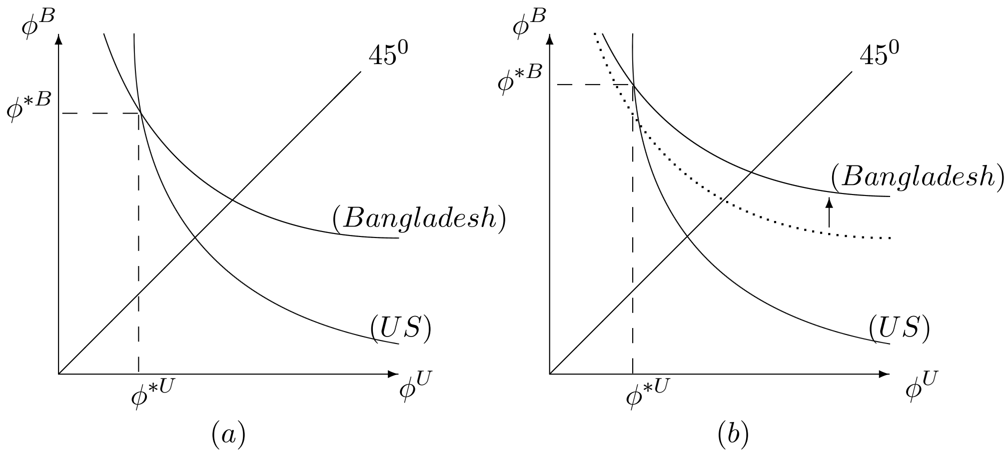
$$f_x J\left(A^B\phi^{*B}\right) = \delta f_e - fJ(\phi^{*E}) - f_x J(A^{US}\phi^{*U}).$$

As ϕ^{*E} and ϕ^{*U} move in the same direction, the RHS either rises (if ϕ^{*E} rises) or falls (if ϕ^{*E} falls). As $J(\cdot)$ is a decreasing function, for the above equation to hold, ϕ^{*B} has to move in the opposite direction from ϕ^{*E} and ϕ^{*U}. ■

Now we move to the third step.

Lemma 9 *The addition of $d^E J\left(A^{BE}_{ROO}A^{EU}\phi^{*E}\right) + d^U J\left(A^{BU}_{ROO}\phi^{*U}\right)$ to equation (132) must raise ϕ^{*B}.*

Figure 25: The Domestic Cutoffs in the US and Bangladesh



Proof. Using Lemma 7, we can rewrite equations (131) and (132) as

$$fJ(\phi^{*U}) + f_x J(A^{EU}\phi^{*E}\left(\phi^{*U}\right)) + f_x J\left(A^B\phi^{*B}\right) = \delta f_e, \tag{139}$$

$$fJ(\phi^{*B}) + f_x J(A^{EU}\phi^{*E}\left(\phi^{*U}\right)) + f_x J\left(A^{BU}_{ROO}\phi^{*U}\right) = \delta f_e, \tag{140}$$

where $\phi^{*E}\left(\phi^{*U}\right)$ is defined by (137). We can rewrite (139) and (140) as

$$\phi^{*B} = \frac{1}{A^B}J^{-1}\left(\frac{\delta f_e}{f_x} - \frac{f}{f_x}J(\phi^{*U}) - J(A^{EU}\phi^{*E}\left(\phi^{*U}\right))\right), \tag{141}$$

$$\phi^{*B} = J^{-1}\left(\frac{\delta f_e}{f} - \frac{f_x}{f}J(A^{EU}\phi^{*E}\left(\phi^{*U}\right)) - \frac{f_x}{f}J\left(A^{BU}_{ROO}\phi^{*U}\right)\right). \tag{142}$$

Note that the curve corresponding to equation (141) is steeper than the curve corresponding to equation (142) as shown in Figure 25(a). Moreover, the intersection of these curves is above the 45^0 line since from Lemma 6, $\phi^{*U} < \phi^{*B}$.

Adding $d^E J\left(A^{BE}_{ROO}A^{EU}\phi^{*E}\left(\phi^{*U}\right)\right) + d^U J\left(A^{BU}_{ROO}\phi^{*U}\right)$ to equation (132) shifts the curve corresponding to equation (142) up as shown in Figure 25(b). Moreover, the property of the slopes of two curves at the intersection point remains the same, if d^E and d^U are small enough. Hence, this change leads to an increase in ϕ^{*B} and a fall in ϕ^{*U}, which, in turn, leads to the fall in ϕ^{*E}. (The latter follows from Lemma 7.) ■

Thus, we have proved our main result.

Proposition 7 *In the equilibrium defined by (127)-(129),* $\phi^{*B} > \phi^{*U} > \phi^{*E}$.

It is easy to see that various cutoffs can now be ranked. For example, the productivity cutoff levels for firms exporting from Bangladesh to the EU and US can be ranked as in Result 2. Since $A^{BU}_{ROO} > A^{EU}$, using the relations in equations (108) and (111), namely that $\phi_x^{*BE} = A^{EU}\phi^{*E}$ and $\phi_{xr}^{*BU} = A^{BU}_{ROO}\phi^{*U}$, we see that $\phi_x^{*BE} < \phi_{xr}^{*BU}$. This shows that a more restrictive trade policy in the US results in only more productive Bangladeshi firms being able to compete there. Other cutoff comparisons follow from using these relations along with the assumptions and results so far.

That 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 (3(a)) needs a little explanation. The definition of mass of firms exporting to the US and EU:

$$M_x^{BE} = p_x^{BE} M^B = \frac{1 - G\left(\phi_x^{*BE}\right)}{1 - G\left(\phi^{*B}\right)} M^B, \tag{143}$$

$$M_{xr}^{BE} = p_{xr}^{BE} M^B = \frac{1 - G\left(\phi_{xr}^{*BE}\right)}{1 - G\left(\phi^{*B}\right)} M_B, \tag{144}$$

$$M_{xr}^{BU} = p_{xr}^{BU} M^B = \frac{1 - G\left(\phi_{xr}^{*BU}\right)}{1 - G\left(\phi^{*B}\right)} M^B. \tag{145}$$

From Result 1, it follows that $M_{xr}^{BU} < M_x^{BE}$.

B.3 Ranking Price Indices

By definition, the price index in country i can be written as

$$P_t^i = \left(M_t^i\right)^{\frac{1}{1-\sigma}} p\left(\tilde{\phi}_t^i\right), \tag{146}$$

where M_t^i is the total mass of variety available to consumers in country i, and $\tilde{\phi}_t^i$ is the average productivity level of firms, who sell in country i. For example, in country E (that represents the EU in our model)[114]

$$
\begin{aligned}
M_t^E &= M^E + M_x^{UE} + M_x^{BE} + M_{xr}^{BE}, \text{ and} && (147) \\
\tilde{\phi}_t^E &\equiv \left\{ \frac{1}{M_t^E} \left[M^E \left(\tilde{\phi}^E\right)^{\sigma-1} + M_x^{UE} \left(\tau^{-1}\tilde{\phi}_x^{UE}\right)^{\sigma-1} + M_x^{BE} \left(\left(\tau^E\right)^{-1}\tilde{\phi}_x^{BE}\right)^{\sigma-1} \right.\right. \\
&\qquad \left.\left. + M_{xr}^{BE} \left((\lambda^E\theta^E\tau^E)^{-1}\tilde{\phi}_{xr}^{BE}\right)^{\sigma-1} \right] \right\}^{1/(\sigma-1)}. && (148)
\end{aligned}
$$

M_t^i and $\tilde{\phi}_t^i$ can be defined similarly for $i = U$, B.

By definition, $M_t^i = \frac{E^i}{r^i\left(\tilde{\phi}_t^i\right)}$, where E^i is the expenditure on the differentiated goods in country i,

$$E^i = \beta I^i = \beta\left(L^i + TR^i\right),$$

and $r_i\left(\tilde{\phi}_{ti}\right)$ is the average revenues earned by firms, who sell in country i. Note that

$$r^i\left(\tilde{\phi}_t^i\right) = r^i\left(\phi^{*i}\right)\left(\frac{\tilde{\phi}_t^i}{\phi^{*i}}\right)^{\sigma-1} = \sigma f\left(\frac{\tilde{\phi}_t^i}{\phi^{*i}}\right)^{\sigma-1}.$$

Since $p\left(\tilde{\phi}_t^i\right) = \frac{1}{\rho\tilde{\phi}_t^i}$, equation (146) can be written as

$$P^i = \left(\frac{E^i}{\sigma f}\right)^{\frac{1}{1-\sigma}} \frac{1}{\rho\phi^{*i}}. \tag{149}$$

Note that if countries have the same income (for instance, if tariff revenues are not included into the country's income, so that $E^i = \beta L$ for any i), then the country with the highest cutoff level for domestic firms has the lowest price index and, as a result, the highest level of welfare. Also, to the extent that tariff revenues are a small share of national income, their effect can be outweighed by the price index effect. We use these results on cutoff and price index rankings to derive our results in the body of the paper. We can also derive some further results.

[114]Note that in the formulas below $M_x^{BE} = \frac{G\left(\phi_{xr}^{*BE}\right)-G\left(\phi_x^{*BE}\right)}{1-G\left(\phi^{*B}\right)}$ and $\tilde{\phi}_x^{BE} = \left[\frac{1}{G\left(\phi_{xr}^{*BE}\right)-G\left(\phi_x^{*BE}\right)}\int_{\phi_x^{*BE}}^{\phi_{xr}^{*BE}} \phi^{\sigma-1}g\left(\phi\right)d\phi\right]^{\frac{1}{\sigma-1}}$. These formulas differ from the original definitions used before, and we choose to redefine them to simplify the interpretation. For instance, now M_x^{BE} is the mass of Bangladeshi exporters to the EU, who do not invoke *ROOs*, while previously M_x^{BE} included both exporters who invoked *ROOs* and those who did not.

B.4 Some Further Implications

There is an interesting implication of our results so far. Namely, that preferences given by developed countries might not be in their own interests.

Proposition 8: Relaxing *ROOs* on Bangladeshi exports can reduce welfare in the US and EU if tariff revenues effects are small.

Proof: The proof of the last result is the following: trade policy, which makes *ROOs* for Bangladeshi firms less restrictive, is equivalent to a fall in A^{BE}_{ROO} and A^{BU}_{ROO}. This leaves unaffected the argument that $\phi^{*U} > \phi^{*E}$. However, the fall in A^{BE}_{ROO} and A^{BU}_{ROO} will at any ϕ^{*U} raise

$$\phi^{*B} = J^{-1}\left(\begin{array}{c} \frac{\delta f_e}{f} - \frac{f_x}{f}J(A^{EU}\phi^{*E}\left(\phi^{*U}\right)) - \frac{d^E}{f}J\left(A^{BE}_{ROO}A^{EU}\phi^{*E}\left(\phi^{*U}\right)\right) \\ -\frac{\left(f_x+d^U\right)}{f}J\left(A^{BU}_{ROO}\phi^{*U}\right) \end{array}\right) \tag{150}$$

and shift the flatter curve in Figure 25 upwards. This will increase ϕ^{*B} and reduce ϕ^{*U} and ϕ^{*E}. But, as shown below, this will tend to raise the aggregate price index in the US and EU and reduce US and EU welfare for a given level of tariff revenues! Relaxing *ROOs* makes the average Bangladeshi exporter less productive, and the average firms selling in Bangladesh more productive, thus, raising the price index in export markets and lowering it in Bangladesh. This is consistent with the harmful unilateral liberalization results of Melitz and Ottaviano (2005).

Appendix C

Proofs to Chapter 3

Proof of Proposition 1. The proof is available upon request. ■

Proof of Proposition 2. First, we prove that when s rises, y must fall and x must rise. Then we will show that wage is increasing in s.

Step 1. Let us rewrite the (EXP) and (TB) conditions and then use the result to show that y falls and x rises as the export subsidy s increases. Note that

$$\text{(EXP):} \quad \frac{w^\sigma}{y^{\sigma-1}} = \frac{A\rho^{\sigma-1}}{\sigma f_x} s^\sigma, \tag{151}$$

so that if the export subsidy increases, $w^\sigma / y^{\sigma-1}$ must increase.

$$\begin{aligned} \text{(TB)} + \text{(M)} \quad \Rightarrow \qquad L &= \frac{L}{(f + m_x f_x)} \left[f_x m_x \left(1 + \frac{1}{s} \theta M \left(\frac{x}{w} \right)^{\sigma-1} \right) + (1 - \rho) f \right] \\ &= \frac{L}{(f + m_x f_x)} \left[f + f_x m_x + \frac{1}{s} \frac{L f_x m_x}{\sigma (f + m_x f_x)} \left(\frac{x}{w} \right)^{\sigma-1} - \rho f \right], \end{aligned}$$

or

$$1 = 1 + \frac{1}{(f + m_x f_x)} \left[\frac{1}{s} \frac{L f_x m_x}{\sigma (f + m_x f_x)} \left(\frac{x}{w} \right)^{\sigma-1} - \rho f \right],$$

which is equivalent to

$$\frac{1}{s} \frac{L f_x m_x}{\sigma (f + m_x f_x)} \left(\frac{x}{w} \right)^{\sigma-1} = \rho f. \tag{152}$$

Finally,

$$\left(\frac{w}{x} \right)^{\sigma-1} \left(1 + \frac{f}{f_x} \left(\frac{y}{x} \right)^\beta \right) = \frac{1}{s} \frac{L}{\sigma \rho f}, \tag{153}$$

i.e., if s rises, the left-hand side of equation above should fall. Now, assume that if s rises, then y rises and x falls. Then

$$\begin{aligned} &\text{from (151):} \qquad w = \left(\frac{A\rho^{\sigma-1}}{\sigma f_x} s^\sigma y^{\sigma-1} \right)^{1/\sigma} \quad \text{must rise;} \\ &\text{from (153):} \qquad w = \left(\frac{1}{s} \frac{L}{\sigma \rho f} \frac{x^{\sigma-1}}{\left(1 + \frac{f}{f_x} \left(\frac{y}{x} \right)^\beta \right)} \right)^{1/(\sigma-1)} \quad \text{must fall.} \end{aligned}$$

Our assumption led to the contradiction, thus, as s rises, y must fall and x must increase.

Step 2. We will use the fact that x rises as s rises, and prove that the wage is an increasing function of x, and as a result, it increases with s as well. First, let us express s as a function of x and y. Note that from (151),

$$\frac{w}{s} = \left(\frac{A\rho^{\sigma-1}}{\sigma f_x}\right)^{1/\sigma} y^{\rho}. \tag{154}$$

Then, from (153) and the (FE) condition,

$$\left(\frac{w}{x}\right)^{\sigma-1}\left(\frac{\delta f_e}{(\theta-1)\, b^{\beta}}\right)\frac{y^{\beta}}{f_x} = \frac{1}{s}\frac{L}{\sigma\rho f},$$

or

$$\frac{w}{x} = \left(\frac{L\,(\theta-1)\, b^{\beta} f_x}{\sigma\rho f\delta f_e}\right)^{\frac{1}{\sigma-1}} s^{\frac{1}{1-\sigma}} y^{\frac{\beta}{1-\sigma}}. \tag{155}$$

Dividing (155) by (154), we get

$$\frac{s}{x} = \Delta\left[s^{\frac{1}{1-\sigma}} y^{\frac{\beta}{1-\sigma}-\rho}\right],$$

where $\Delta = \left(\frac{L(\theta-1)b^{\beta} f_x}{\sigma\rho f\delta f_e}\right)^{\frac{1}{\sigma-1}} / \left(\frac{A\rho^{\sigma-1}}{\sigma f_x}\right)^{1/\sigma}$ is a constant. Therefore,

$$s^{1+\frac{1}{\sigma-1}} = s^{\frac{1}{\rho}} = \Delta x y^{\frac{\beta}{1-\sigma}-\rho}$$

and

$$s = \Delta^{\rho} x^{\rho} y^{-\frac{\beta}{\sigma}-\rho^2}.$$

If we plug the expression above into (154), we get

$$w = \left(\frac{A\rho^{\sigma-1}}{\sigma f_x}\right)^{1/\sigma} \Delta^{\rho} x^{\rho} y^{\rho-\frac{\beta}{\sigma}-\rho^2},$$

where $\left(\frac{A\rho^{\sigma-1}}{\sigma f_x}\right)^{1/\sigma}\Delta^{\rho}$ is defined exogenously. Note that $\beta > \sigma$ and $\rho < 1$, so that $\rho - \frac{\beta}{\sigma} - \rho^2 < 0$. Thus, since x rises and y falls as s rises, then wage w must rise with s. ■

Proof of Proposition 3. Recall that the utility function is given by

$$U = \left(z^{\rho} + \int_{x}^{\infty} q(\varphi)^{\rho} M\mu(\varphi)d\varphi\right)^{1/\rho},$$

where from the (TB) condition,

$$z = RP^{\sigma-1} = \frac{1}{s}\sigma f_x w\theta M_x,$$

and

$$
\begin{aligned}
\int_x^\infty q(\varphi)^\rho M\mu(\varphi)d\varphi &= M\left[f(\sigma-1)\right]^\rho x^{\beta-\rho(\sigma-1)}\beta\int_x^\infty \varphi^{\rho\sigma-\beta-1}d\varphi \\
&= M\theta\left[f(\sigma-1)x\right]^\rho x^\rho,
\end{aligned}
$$

so that

$$
U^\rho = \left(\frac{1}{s}\sigma f_x w\theta M_x\right)^\rho + M\theta\left[f(\sigma-1)x\right]^\rho .
$$

We want to show that

$$
U^\rho = Mx^\rho\left[\left(\frac{w}{sx}\sigma f_x\theta\left(\frac{x}{y}\right)^\beta\right)^\rho M^{\rho-1} + \theta\left[f(\sigma-1)\right]^\rho\right] \tag{156}
$$

is decreasing as s increases from 1 to infinity. To do this, we will show that

$$
U^\rho = d(s)\,h(s),
$$

where $d(s) \equiv Mx^\rho$ falls faster than $h(s) \equiv \left(\frac{w}{sx}\sigma f_x\theta\left(\frac{x}{y}\right)^\beta\right)^\rho M^{\rho-1} + \theta\left[f(\sigma-1)\right]^\rho$ rises, as s increases.

In order to conduct the analysis, first, we will use the fact that x rises as s rises to rewrite both functions in terms of x and $y(x)$, where $y(x)$ is a decreasing function of x, and look at the behavior of $d(s)$ and $h(s)$ as functions of x. Then we will compare the elasticities of these two functions and show that $\varepsilon_d < 0 < \varepsilon_h$ and in absolute terms $|\varepsilon_d| > |\varepsilon_h|$, so that $d(x)$ falls faster than $h(x)$ rises, and $U = d(x)\,h(x)$ falls as a result.

Step 1.

$$
d(x) = Mx^\rho = \left[\frac{(\theta-1)\,b^\beta L}{\sigma\theta\delta f_e}\right](x)^{\rho-\beta} .
$$

Since $\rho < 1 < \beta$, $d(x)$ is decreasing in x and

$$
\varepsilon_d = \rho - \beta < 0. \tag{157}
$$

Step 2.

$$
\begin{aligned}
h(x) &= \left(\frac{w}{sx}\right)^\rho (\sigma f_x\theta)^\rho \left(\frac{x}{y}\right)^{\beta\rho} M^{\rho-1} + \theta\left[f(\sigma-1)\right]^\rho \\
&= \left(\frac{w}{sy}\right)^\rho (\sigma f_x\theta)^\rho \left(\frac{x}{y}\right)^{(\beta-1)\rho} M^{\rho-1} + \theta\left[f(\sigma-1)\right]^\rho
\end{aligned}
$$

Note that from the (EXP) condition,

$$\frac{w}{sy} = \left(\frac{A\rho^{\sigma-1}}{\sigma f_x}\right)^{1/\sigma} \frac{1}{y^{1/\sigma}},$$

and from the (M) condition,

$$M = \frac{(\theta-1)\, b^{\beta} L}{\sigma\theta\delta f_e} x^{-\beta}.$$

Thus,

$$h(x) = \gamma + \kappa(x),$$

where

$$\begin{aligned}
\gamma &= \theta\left[f(\sigma-1)\right]^{\rho} \text{ is exogenously defined constant,} \\
\kappa(x) &= \left(\frac{w}{sy}\right)^{\rho} (\sigma f_x \theta)^{\rho} \left(\frac{x}{y}\right)^{(\beta-1)\rho} M^{\rho-1} \\
&= \left(\left(\frac{A\rho^{\sigma-1}}{\sigma f_x}\right)^{1/\sigma} \frac{1}{y^{1/\sigma}}\right)^{\rho} (\sigma f_x \theta)^{\rho} \left(\frac{x}{y}\right)^{(\beta-1)\rho} \left(\frac{(\theta-1)\, b^{\beta} L}{\sigma\theta\delta f_e} x^{-\beta}\right)^{\rho-1} \\
&= (\text{exogenously defined constant})[x^{\beta-\rho} y^{-(\beta-\rho)\rho}].
\end{aligned}$$

Since $\beta > 1 > \rho$ and y falls as x rises, then $\kappa(x)$, and in turn $h(x)$, is increasing with x. Moreover,

$$\varepsilon_h = \frac{h'(x)}{h(x)} x = \frac{\kappa'(x)}{\gamma + \kappa(x)} x = \frac{\kappa'(x)}{\kappa(x)} x \frac{\kappa(x)}{\gamma + \kappa(x)} = \varepsilon_{\kappa} \frac{\kappa(x)}{\gamma + \kappa(x)}.$$

To calculate ε_{κ}, we use two properties:

$$\varepsilon_{a(x)b(x)} = \varepsilon_{a(x)} + \varepsilon_{b(x)} \text{ and } \varepsilon_{a(b(x))} = \varepsilon_{a(b)} \varepsilon_{b(x)}.$$

Then,

$$\varepsilon_{\kappa(x)} = \varepsilon_{x^{\beta-\rho}} + \varepsilon_{y^{-\frac{\rho}{\sigma}-(\beta-\rho)\rho}} = (\beta-\rho) - \rho(\beta-\rho)\, \varepsilon_{y(x)}.$$

From the (FE) condition,

$$\varepsilon_{y(x)} = -\frac{f}{f_x}\left(\frac{y}{x}\right)^{\beta},$$

so that

$$\varepsilon_{\kappa(x)} = (\beta-\rho)\left(1 + \rho\frac{f}{f_x}\left(\frac{y}{x}\right)^{\beta}\right),$$

and

$$\varepsilon_h = (\beta - \rho)\left(1 + \rho\frac{f}{f_x}\left(\frac{y}{x}\right)^{\beta}\right)\frac{\kappa(x)}{\gamma + \kappa(x)} > 0. \tag{158}$$

Step 3. Now we can compare the absolute values of elasticities from (157) and (158):

$$|\varepsilon_d| = \beta - \rho \quad \text{versus} \quad |\varepsilon_h| = (\beta - \rho)\left(1 + \rho\frac{f}{f_x}\left(\frac{y}{x}\right)^{\beta}\right)\frac{\kappa(x)}{\gamma + \kappa(x)},$$

or

$$1 \text{ versus } \left(1 + \rho\frac{f}{f_x}\left(\frac{y}{x}\right)^{\beta}\right)\frac{\kappa(x)}{\gamma + \kappa(x)},$$

or

$$\frac{\gamma}{\kappa(x)} \quad \text{versus} \quad \rho\frac{f}{f_x}\left(\frac{y}{x}\right)^{\beta},$$

or

$$\frac{1}{\rho}\frac{f_x}{f}\left(\frac{x}{y}\right)^{\beta}\frac{\gamma}{\kappa(x)} \quad \text{versus} \quad 1. \tag{159}$$

To compare the left-hand side with 1, we plug the expressions for $\kappa(x)$ and γ :

$$\begin{aligned}
\frac{1}{\rho}\frac{f_x}{f}\left(\frac{x}{y}\right)^{\beta}\frac{\gamma}{\kappa(x)} &= \frac{1}{\rho}\frac{f_x}{f}\left(\frac{x}{y}\right)^{\beta}\frac{\theta\left[f(\sigma-1)\right]^{\rho}}{\left(\frac{w}{sy}\right)^{\rho}(\sigma f_x\theta)^{\rho}\left(\frac{x}{y}\right)^{(\beta-1)\rho}M^{\rho-1}} \\
&= \rho^{\rho-1}\left(\frac{f_x}{f}\right)^{1-\rho}\left(\frac{x}{y}\right)^{\beta}\theta^{1-\rho}\frac{1}{\left(\frac{w}{sx}\left(\frac{x}{y}\right)^{\beta}\right)^{\rho}M^{\rho-1}} \\
&= \rho^{\rho-1}\left(\frac{f_x}{f}\right)^{1-\rho}\left(\frac{x}{y}\right)^{\beta(1-\rho)}\theta^{1-\rho}\left(\frac{sx}{w}\right)^{\rho}M^{1-\rho}.
\end{aligned} \tag{160}$$

Note that from (152) and (61),

$$\frac{1}{s}\frac{Lf_x m_x}{\sigma(f + m_x f_x)}\left(\frac{x}{w}\right)^{\sigma-1} = \rho f \quad \text{and } M = \frac{L}{\sigma\theta(f + m_x f_x)},$$

Therefore,

$$M = \frac{\rho f\left(\frac{w}{x}\right)^{\sigma-1}s}{\theta f_x m_x},$$

and (160) can be rewritten as

$$
\begin{aligned}
& \rho^{\rho-1}\left(\frac{f_x}{f}\right)^{1-\rho}\left(\frac{x}{y}\right)^{\beta(1-\rho)}\theta^{1-\rho}\left(\frac{sx}{w}\right)^{\rho}M^{1-\rho} \\
= \; & \rho^{\rho-1}\left(\frac{f_x}{f}\right)^{1-\rho}\left(\frac{x}{y}\right)^{\beta(1-\rho)}\theta^{1-\rho}\left(\frac{sx}{w}\right)^{\rho}\left(\frac{\rho f\left(\frac{w}{x}\right)^{\sigma-1}}{\theta f_x m_x}s\right)^{1-\rho} \\
= \; & \left(\frac{x}{y}\right)^{\beta(1-\rho)}\left(\frac{sx}{w}\right)^{\rho}\left(\frac{\left(\frac{w}{x}\right)^{\sigma-1}}{\left(\frac{x}{y}\right)^{\beta}}s\right)^{1-\rho} = \left(\frac{sx}{w}\right)^{\rho}\left(\left(\frac{w}{x}\right)^{\sigma-1}s\right)^{1-\rho} \\
= \; & s\left(\frac{x}{w}\right)^{\rho-(1-\rho)(\sigma-1)} = s.
\end{aligned}
$$

Thus, the comparison in (159) results in

$$\frac{1}{\rho}\frac{f_x}{f}\left(\frac{x}{y}\right)^{\beta}\frac{\gamma}{\kappa(x)} = s > 1.$$

Now we proved that for any $s > 1$, $\varepsilon_d < 0$, $\varepsilon_h > 0$, and $|\varepsilon_d| > |\varepsilon_h|$. In other words, if x (or s) rises, $d(x)$ falls faster than $h(x)$ increases. Thus, $U^{\rho}(x) = d(x)\,h(x)$ falls as s increases from 1 to infinity. ■

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