UCD CENTRE FOR ECONOMIC RESEARCH

WORKING PAPER SERIES

2017

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WP17/05

February 2017

UCD SCHOOL OF ECONOMICS
UNIVERSITY COLLEGE DUBLIN
BELFIELD DUBLIN 4

The Impact of Protection on Observed Productivity Distributions*

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February 25, 2017

Abstract

As is well established, one prediction of the heterogenous firms literature spear-headed by Melitz (2003) is that trade liberalization, by increasing import competition, drives less productive domestic firms from the market. This increases average productivity of the domestic economy via the "selection effect". In addition, it has the potential to affect the skewness of the observed productivity distribution, i.e. the gap between the productivity of the median firm and average productivity. We examine these predictions empirically using data on 28 sectors across 99 countries. On the whole, we find that higher protection levels lower average productivity and drive a larger wedge between mean and median productivity. This latter suggests that policy decisions based on mean outcomes may arrive at different conclusions than those based on median voters.

JEL classification: F12, F13

Keywords: Non-tariff measures; Productivity distribution; heterogeneous firms.

*We thank Madhi Ghodsi, Oliver Rieter, and Robert Stehrer for kindly providing the NTM data. The authors acknowledge that this paper is produced as part of the project "Globalization, Investment and Services Trade (GIST) Marie Curie Initial Training Network (ITN)" funded by the European Commission under its Seventh Framework Programme - Contract No. FP7-PEOPLE-ITN-2008-211429. All remaining errors are our own.

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1 Introduction

Models of international trade predict several benefits from globalization with different models highlighting different gains.[1] The seminal technology-based Ricardian and Hecksher-Ohlin models highlighted the gains from exchange and specialization (see Feenstra, 2004). Krugman (1979, 1981), by bringing in intra-industry monopolistic competition, shows that because exporting firms can spread fixed costs across a broader consumer base that trade can increase the number of varieties available to a country's consumers. When variety is valued, this then creates an additional gain from trade. Melitz (2003) takes this idea and incorporates firms with heterogenous productivities. Here, when a country opens its borders to foreign competition, this places additional pressure on domestic firms and drives low-productivity ones from the domestic market. Trade therefore creates a productivity gain as it reallocates resources towards high productivity firms, a result known as the "selection effect".[2]

This latter idea has been the focus of a rapidly-growing literature on the endogenous choice of exporting at the firm level with Ranjan and Raychaudhuri (2016) providing a recent review. Here, the focus has been on what affects a given firm's choice of whether or not to export with the consensus being that, across countries and industries, more productive firms are more likely to export. Expanding on this basic question, the literature has begun to focus on more nuanced questions including how this productivity-exporting relationship hinges on, for example, special economic zones (Davies and Mazhikeyev, 2015b), firm ownership (Davies and Mazhikeyev, 2015a), or a country's exporting costs (Davies and Jeppesen, 2015).[3] However, less attention has been paid to what factors influence the distribution of active domestic firms, an issue tied directly to the Melitz (2003) productivity gain from

[1]We acknowledge that here we only discuss a small number of the gains from globalization, other aspects of which can include the benefits of technology transfer, efficiency gains from foreign direct investment, the welfare-boost from migration, and more.

[2]Nevertheless, the results of Arkolakis, Costinot, and Rodriguez-Clare (2012) suggest such gains are modest.

[3]There is a concurrent literature on productivity and foreign direct investment, e.g. Helpman, Melitz, and Yeaple (2004).

opening to trade. This is the gap the current analysis seeks to fill.

We do so by using World Bank firm-level data on productivity for 59,099 firms across 28 sectors and 99 countries.[4] We begin by fitting the observed distribution of sector-country information to the Gamma distribution. From this, we obtain two estimates of the data's moments: the mean productivity and the skewness of productivity. In addition, we calculate the Pearson median skewness. The Melitz (2003) model predicts that the mean should rise as protection barriers are lowered; the change in the skewness, however, depends on the productivity of the least productive active firm relative to the mean of the underlying productivity distribution. We then ask how this is correlated with a country's use of non-tariff measures (NTMs) and tariffs. Our results indicate that, consistent with the theory, NTMs are negatively correlated with mean productivity, i.e. liberalization would increase average productivity. We find a comparable result for tariffs, although the estimates are less precise. Skewness, on the other hand, appears to be increasing in protection (especially tariffs). This suggests that as protection levels rise, the productivity gap between mean and median firm would rise. As such, policy makers making decisions based on average outcomes may take a different direction than those seeking to appease the median voter.

Beyond the literature on what determines whether or not a firm participates in globalization, our results are linked to those which directly consider the distribution of productivity.[5] Here, the literature has two main branches: those examining what influences the distribution and those looking for the distribution that best fits the observed data. In addition, within each of these are studies that directly examine some measure of productivity and those that instead consider some other outcome, such as exports, which is presumed to be a function of productivity.[6] The first, which is the tradition our work follows, uses a measure of productivity to construct distribution statistics by fitting the data to an assumed distribution.

[4]Note that this includes both exporting and non-exporting firms, i.e. we are examining the distribution of active domestic firms, not only those that export.

[5]Nigai (2017) provides a recent overview of the literature.

[6]Particularly in the Melitz (2003) framework with constant marginal production costs, constant elasticities of substitution preferences, and monopolistic competition, there is a clearcut mapping between productivity, employment, total sales, and exports.

The estimated variation in these statistics is then compared to the variation in observables. For example, using the gamma distribution for value added per worker, Okubo and Tomiura (2014) estimate the parameters for a gamma distribution and examine how this varies with factors such as agglomeration. Similarly, Cabral and Mata (2003) and Barrios, Barrios, and Georg (2004) fit firm size to the gamma distribution and compare it to, for example, ownership patterns.

The second strand of the literature seeks to determine which distribution function is most appropriate for the data. While the bulk of the theory assumes a Pareto distribution for productivity, the empirical work is less convinced with several papers examining the fit of the data to different distributions. Here, in addition to the gamma distribution used in the above studies, there are two main contenders: the Pareto distribution (and variants of it), the gamma distribution and the log-normal distribution. Using export data, di Giovanni, Levchenko, and Ranciere (2011) find that exports fit the Pareto distribution which, under the standard modeling assumptions implies that productivity does as well. Head, Mayer, and Thoenig (2014) on the other hand, using trade data between France and Belgium and between China and Japan, find that exports follow a log normal distribution. The log normal distribution can be reconciled with the theory by modifying the baseline model. For example, Arkolakis (2010) adds in market penetration costs that are increasing in firm size. Nigai (2017) constructs a productivity measure from sales data and demonstrates that it is best described as a mixture of the log-normal and Pareto distributions. Alternatively, Helpman, Melitz, and Rubinstein (2008) and Feenstra (2014) (who also uses an alternative demand structure), are better able to match the data on exports by using a bounded Pareto distribution. Amand and Pelgrin (2016) further counter the Pareto-rejecting results by exploring how alternative heterogeneity and uncertainty assumptions can result in a log-normal export distribution even if the underlying productivity distribution is Pareto. Thus, the literature has yet to reach a consensus for whether a “true” productivity distribution exists and, if so, what it is.

The paper proceeds as follows. In Section 2, we present a simplified model in the Melitz (2003) tradition to highlight how trade protection affects the distribution of active firms in a country. Section 3 discusses our data and empirical methodology. Section 4 contains the results. Section 5 concludes.

2 The Model

To consider how import barriers affects the productivity distribution within a country, consider a two-country model of a small open economy (the home country) and a large rest of the world (the foreign country, whose variables are denoted by an asterisk). Our analysis focuses on the effect import policy has on the set of active firms in the home country. Changes in this set will then drive changes in the productivity distribution of active (observed) firms. The two countries produce and trade two goods, a homogeneous numéraire good Y and a differentiated good X. Following Melitz (2003), firms in the X sector have heterogenous production costs. Consumers in the home country have an exogenous labour endowment L which is the only factor of production.

2.1 Consumers

Consumers are homogeneous and maximize the quasi-linear utility function

$$U \equiv \mu \ln X + Y^D, \qquad X \equiv \left[\int_{j \in \Omega} q(j)^{\alpha} \, dj \right]^{\frac{1}{\alpha}}. \tag{1}$$

In this, Y^D is consumption of the numéraire and X is the CES aggregation of the X varieties available to home consumers. The set of these varieties, Ω, can include both home- and foreign-produced varieties. Consumption of the variety produced by firm j is $q(j)$. The elasticity of substitution between any two varieties is $\varepsilon \equiv 1/(1-\alpha) > 1$, where $\alpha \in (0,1)$.

Maximizing (1) implies that $\mu/X = P$ and expenditures for the differentiated good X

are fixed at μ.[7] This yields isoelastic demand functions for each variety:

$$q(j) = \left[\frac{P}{p(j)} \right]^{\varepsilon} \frac{\mu}{P} \,, \tag{2}$$

where the price index for good X is

$$P = \left[\int_{j \in \Omega} p(j)^{-(\varepsilon - 1)} \, dj \right]^{-\frac{1}{\varepsilon - 1}} \,. \tag{3}$$

Finally, with μ spent on the differentiated good, the remainder of income I is spent on good Y. Income in home is derived from wages, domestic profits, and revenue-generating trade barriers (e.g. tariffs) that are redistributed to consumers as a lump sum.

2.2 Producers

The numéraire sector is constant returns to scale and operates under perfect competition. Fixing the price to unity and scaling it so that the unit-labour requirement is one, the equilibrium wage will be 1.[8]

In the X sector, firms are monopolistically competitive. Each country has an exogenous mass of potential entrants, N^e in home (which we normalize to 1) and N^{e*} in foreign where each firm is capable of producing a single variety. Because home is small, its policy does not affect the mass of active firms in foreign (see Flam and Helpman, 1987).[9] Each firm j's production technology is described by an exogenously determined unit labour requirement $a(j)$, the distribution of which is given by $G(.)$.[10] When necessary, we will assume that this

[7] This simplifying aspect of the quasi-linear preference structure has been exploited by several applications of heterogeneous goods to questions of policy; see Chor (2009), Cole and Davies (2011), Pflüger and Südekum (2013), and Bauer, Davies, and Haufler (2014). Because changes in trade costs only affect consumption of the numéraire, this setup allows us to avoid complications caused by changes in income driven by trade costs.

[8] Note that our model does not determine where the numéraire is produced. This is not important for our results.

[9] This definition of 'small' has been applied to the heterogenous firms literature by Demidova and Rodriguez-Clare (2009), Bauer, Davies, and Haufler (2014), and others.

[10] Some heterogeneous firm models, including Melitz (2003), assume instead that entrepreneurs draw from this distribution at a cost. As discussed by Cole (2009) and Jørgensen and Schröder (2008), this approach and ours yield generally comparable results. The biggest difference is that in those models, this drives

distribution is Pareto, i.e. $g(a) = G'(a) = \frac{\theta a^{\theta-1}}{a_0^{\theta}}$.[11] The Pareto distribution is characterized by the maximum cost level a_0 and the shape parameter θ, with a higher θ implying lower productivity heterogeneity across firms. We follow Helpman et al. (2004) and Chor (2009) and assume that $\theta > \varepsilon - 1$. Regardless of the distribution of unit-labour requirements, given that the wage equals to 1, per-unit costs for j are $a(j)$.

If a firm decides to produce, it must pay a fixed cost F_d. In addition, if it chooses to service the export market, it incurs a further fixed cost $F_x \geq F_d$ as well as iceberg transportation costs τ. Note that these fixed costs imply that a firm that exports pays a total fixed cost of $F_d + F_x$ regardless of whether it sells domestically. As such, all firms that export will also sell domestically. With these costs and the demand (2), if firm j serves the domestic market, its price and quantity there will be:

$$p_d\left(a\right) = \frac{a}{\alpha}, \qquad q_d\left(a\right) = \left[\frac{\alpha}{a}\right]^{\varepsilon} P^{\varepsilon-1}\mu. \tag{4}$$

Likewise, if it exports, its prices and quantities will be:

$$p_x\left(a\right) = \frac{\left(1+\tau\right)a}{\alpha}, \qquad q_x\left(a\right) = \left[\frac{\alpha}{\left(1+\tau\right)a}\right]^{\varepsilon} \left(P^{*}\right)^{\varepsilon-1}\mu^{*}\,. \tag{5}$$

Note that, for the small home country, P^* and μ^* are fixed.

With these, we can now obtain equilibrium profits domestically:

$$\pi_d(j)\left(a\right) = \left(1-\alpha\right)\left(\frac{\alpha P}{a(j)}\right)^{\varepsilon-1}\mu - F_d, \tag{6}$$

and overseas:

$$\pi_x\left(a\right) = \left(1-\alpha\right)\left[\frac{\alpha P^{*}}{\left(1+\tau\right)a(j)}\right]^{\varepsilon-1}\mu^{*} - F_x. \tag{7}$$

aggregate X profits to zero whereas in ours, they will be positive in equilibrium. However, since these profits are funneled into Y consumption due to our utility function, this is unimportant.

[11] This distribution is frequently used (e.g. Baldwin and Okubo (2009) or Krautheim and Schmidt-Eisenlohr (2011)), as the Pareto distribution is analytically convenient and, as discussed above, has some support in the data.

Note that due to the higher cost of exporting, any firm earning non-positive profits from domestic sales will earn negative profits overseas.

2.3 Equilibrium

Firm j is active in a market only when it earns non-negative payoffs. This allows us to define key cutoffs denoting the lowest productivity firm (highest a) from a particular country active in a particular market. Setting $\pi_d(a_d) = 0$, we can derive the unit labour requirement (i.e. the inverse of productivity) for the least-productive home firm selling domestically as:

$$a_d \equiv \alpha P \left(\frac{\mu}{\varepsilon F_d} \right)^{\frac{1}{\varepsilon - 1}}. \tag{8}$$

All firms with unit costs $a \leq a_d$ will choose to be active in the domestic market. Note that home's trade policy only affects this via its impact on the price index.

Similarly, home firms export if $\pi_x(a) \geq 0$. This yields a maximum cost threshold a_x for exporting:

$$a_x \equiv \frac{\alpha P^*}{1+\tau} \left(\frac{\mu^*}{\varepsilon F_x} \right)^{\frac{1}{\varepsilon - 1}}. \tag{9}$$

In the following we assume that the parameters are such that $a_d > a_x$, i.e. there is sorting so that more productive firms produce for domestic and overseas markets, moderately productive firms produce for the local market, and very low productivity firms do not produce. Sufficient conditions for this are that $P = P^*$, $\mu = \mu^*$, $\tau > 0$ and $F_x > F_d$.

Finally, foreign firms choose to export if $\pi_x^*(a) > 0$. This yields a cutoff cost level for foreign exporters a_x^* equal to

$$a_x^* \equiv \frac{\alpha P}{1+\tau^*} \left(\frac{\mu^*}{\varepsilon F_x^*} \right)^{\frac{1}{\varepsilon - 1}}. \tag{10}$$

Thus the effect of home trade policy, i.e. τ^* and/or F_x^*, affects foreign producers and therefore the set of active domestic producers via the home price index.[12] Therefore to

[12] In contrast, by virtue of the small country assumption P^* is fixed and is therefore not impacted by home policy, meaning that the set of home exporters is not affected by home policy.

understand what happens to the set of active home firms, we need to derive the change in P from a change in τ or F_x^*.

2.4 NTMs and Observed Productivity Distributions

Imposing the Pareto distribution on the unit-labour requirements, we are able to rewrite the price index so that:

$$(\alpha P)^{\theta} = \frac{\left(1 - \frac{\varepsilon-1}{\theta}\right) a_0^{\theta} \left(\frac{\varepsilon}{\mu}\right)^{\frac{\theta}{\varepsilon-1}-1}}{{F_d}^{1-\frac{\theta}{\varepsilon-1}} + (1+\tau^*)^{-\theta} {F_X}^{*1-\frac{\theta}{\varepsilon-1}}} \tag{11}$$

from which we obtain:

$$\frac{dP}{d\tau^*} = \frac{P(1+\tau^*)^{-\theta-1} {F_X}^{*1-\frac{\theta}{\varepsilon-1}}}{\left({F_d}^{1-\frac{\theta}{\varepsilon-1}} + (1+\tau^*)^{-\theta} {F_X}^{*1-\frac{\theta}{\varepsilon-1}}\right)} > 0 \tag{12}$$

and

$$\frac{dP}{dF_X^*} = \frac{P\left(\frac{\theta}{\varepsilon-1} - 1\right)(1+\tau^*)^{-\theta} {F_X}^{*-\frac{\theta}{\varepsilon-1}}}{\theta\left({F_d}^{1-\frac{\theta}{\varepsilon-1}} + (1+\tau^*)^{-\theta} {F_X}^{*1-\frac{\theta}{\varepsilon-1}}\right)} > 0. \tag{13}$$

Intuitively, as barriers to foreign competition rise, imports fall and the home price index increases. By inspection of (8), this means that the unit-labour requirement of the lowest active home firm rises, i.e. lower productivity firms are able to survive as trade barriers rise. Therefore if a tariff or NTM increases either the fixed entry cost (such as when it requires certification) or variable trade costs (e.g. a per-unit inspection fee or tariff), lower productivity firms are able to enter the home market so that a_d rises. This is the selection effect.

In our empirical analysis, we consider two moments of a country's observed productivity (i.e. the inverse of the unit labour requirement) distribution: the mean and the skewness. The mean of observed productivity is:

$$Mean(a_d) = \int_{a_d}^{0} a^{-1} \frac{g\left(a\right)}{G(a_d)} da. \tag{14}$$

Note that the use of the last active firm in the limits of the integral is what determines the "observed" productivity distribution. Taking the derivative with respect to $z = \{\tau^*, F_X^*\}$, i.e. some trade barrier, we see that:

$$\frac{dMean}{dz} = \left(-{a_d}^{-1} g\left(a_d\right) \frac{da_d}{dz} - \frac{g(a_d)}{G(a_d)} Mean(a_d) \right) \frac{da_d}{dz} < 0. \tag{15}$$

Intuitively, since the NTM allows more costly (less productive) home firms to survive, the average productivity of a protected industry should be smaller.

The observed skewness of productivity is:

$$Skew(a_d) = \int_{0}^{a_d} \left(\frac{a^{-1} - \rho}{\sigma} \right)^3 \frac{g\left(a\right)}{G(a_d)} da \tag{16}$$

where ρ is the mean of the entire productivity distribution (including both active and inactive firms, so that $\rho = \int_0^{\infty} a^{-}1 g(a) da$) and σ is the standard deviation of the entire productivity distribution. This then gives us:

$$\frac{dSkew}{dz} = \left(-\left(\frac{{a_d}^{-1} - \rho}{\sigma} \right)^3 g\left(a_d\right) - \frac{g(a_d)}{G(a_d)} Skew(a_d) \right) \frac{da_d}{dz} \tag{17}$$

the sign of which is ambiguous with $a_d > \rho$ being a sufficient condition for it to be negative. By definition $a_d^{-1} < Mean$ for any non-degenerate distribution and, because productivity for a non-entrant is less than a_d^{-1}, we know that $\rho < Mean$. However, neither of these *a priori* gives us an expectation of the sign of this comparative static and we must turn to the data.

While understanding these changes is academically interesting, it also has implications for policy. In particular, the bulk of the evidence finds that productivity is positively skewed, i.e. there are many lower productivity firms in operation and a long tail of high productivity firms.[13] Since, the greater the skewness the larger the gap between the mean and the median (with the median less than the mean when the distribution is positively skewed), how one interprets the impact of an NTM on productivity can be quite different depending on whether one considers the average or the median firm. When there is a political element to the policy decision process (such as in a median voter model), it may be crucial to recognize these differential effects to understand policy formation.

3 Data and Empirical Methodology

In our empirical analysis, we require data on firm productivity and trade barriers. We therefore obtain firm-level data from the World Enterprise Surveys (World Bank, 2015). These stratified surveys cover firms in a range of countries, most of which are developing. There are multiple surveys per country in most cases, however, individual firms are not tracked across them. Therefore they should be considered as repeated cross-sections. For a list of countries and the years of their surveys, see Table 1. Stratification is done by sector and firm size, therefore we take these as a random sample of firms within a country-sector-year triad.[14] From these, we have information on a firm's sales and employment. Comparable to Okubo and Tomiura (2014) we then construct sales per employee (which are converted to constant 2010 US dollars) and use this as our productivity measure.[15] The survey also provides each firm's two-digit ISIC sector classification. Thus, for each country-year-sector, we have a set of observations on productivity. We drop those country-sector-years where we have fewer than 50 observations leaving us with the sectors in Table 2. We make this restriction so that we have some degree of confidence that we have enough data to estimate the distribution. In robustness checks, we consider only those country-sector-years where we

[13]See Nigai (2017).

[14]Note that, since this means that populations which are a small share of the universe of firms will have fewer data points, this has a potential impact on the accuracy of the fit of the data to the distribution for these groups. For example, less than 2% of our sample has more than 1000 employees, i.e. very large firms have few data points to fit to the distribution.

[15]The exchange rate and GDP deflators were taken from the World Development Indicators (World Bank, 2016a).

have at least 100 observations.

With this information, we construct the mean and skewness in two ways. First, we use a non-parametric approach and calculate the sample mean and Pearson median skewness statistic.[16] Second, following Okubo and Tomiura (2014), Barrios, Barrios, and Georg (2004), and Cabral and Mata (2003), we assume a gamma distribution and fit the data to that. We then use the estimated parameters of the distribution to construct an estimated mean and skewness based on this assumption. Note that this estimation methodology produces a mean under the gamma distribution proportional to the sample (non-parametric) mean.

Since our goal is to examine how this varies with the sector's import protection, we construct two protection measures. The first is the average log tariff across six-digit products in the sector code.[17] These data come from the World Bank's WITS database (World Bank, 2016b). Second, we use the average NTM. This begins with data at the HS six-digit product level which indicates whether or not the importer has notified the WTO about the use of an NTM. These were obtained from Ghodsi, Reiter, and Stehrer (2015).[18] At the six digit level, we therefore know whether a country has notified the WTO about its use of an NTM and the number of such NTMs. We acknowledge that this measure is imperfect for two reasons: it relies on self-notification and these are measures that apply to imports of the product from all sources (i.e. is a worldwide NTM and excludes those that apply only to some trade partners, e.g. antidumping duties). Therefore we proceed acknowledging these caveats.[19] It should be noted because we utilize those that apply on a worldwide basis, most of these notifications would fall under either sanitary and phytosanitary measures or technical barriers to trade (Chapter B). Comparable to the tariff data, we then average this

[16] Pearson's median skewness is $\frac{3(mean-median)}{std.dev}$.

[17] As we have no zero tariffs in our sample (recall that a sector is at the two-digit level), there are no concerns with losing observations due to taking logs.

[18] See Ghodsi, M., J. Gruebler, and R. Stehrer (2016a), Ghodsi, M., J. Gruebler, and R. Stehrer (2016b), or Disdier, Fontagne, and Mimouni (2008) for examples working with such data.

[19] The self-reporting issue can be mitigated somewhat by including trade concerns from the WTO, i.e. an exporter raising concerns with the WTO about the use of an NTM by a given importer. We do not make use of these in our data for two reasons. First, there are very few in our set of countries. Second, just as not all NTMs will be notified by the importer, not all concerns by exporters are valid.

across the six-digit products in a two-digit ISIC category.

We then estimate the statistic (S which is mean or skewness) for country i's sector s in year t as:

$$S_{ist} = \beta_i + \beta_s + \beta_t + Tariff_{ist} + NTM_{ist} + \varepsilon_{ist} \tag{18}$$

where ε_{ist} is the error term. We cluster errors by sector. To help with interpretation, Figure 1 presents the gamma distributions for different shape parameters. As the shape parameter falls, the skewness of the distribution rises and becomes more pronounced.

In additional explorations of the data, we modify this by adding in, for a relevant country-sector-year, the percentage of exporting firms, the percentage of importers, the percentage of foreign-owned firms, the average age of firms, and the share of firms in the country's capital, a city of at least 250,000 people, or in a city with more than 1 million people. These are all constructed from the World Enterprise Survey data.

4 Results

4.1 Baseline Estimates

Table 4 presents our baseline estimates for the distribution's mean. Given the above, we expect that both NTMs and tariffs will lower the sample mean. Columns (1)-(3) use the estimated Gamma distribution mean; (4)-(6) use the non-parametric mean (which should be the same). As found in column (1), the greater the NTM average in a country-sector-year, the lower the average productivity. At the sample average, an increase in NTM by 1 (a 23.6% rise) lowers average productivity by approximately 3.4%. When instead using tariffs in column (2), we see two changes. First, although we again find the anticipated negative coefficient, it is no longer significant. Second, there is a marked rise in the fit of the estimation, with the adjusted R^2 more than doubling. In column (3), we find the expected coefficient for tariffs, however neither protection measure's coefficient is significant. Since the sample mean equals the predicted Gamma distribution mean, the estimates in (4)-(6) are exactly the same (and we include them here only for verification purposes).

In Table 5 we use the estimated Gamma distribution skewness in columns (1)-(3) and the Pearson median skewness in (4)-(6). Across these, we find no impact of NTMs on skewness, although the coefficient is positive three out of four times. For the tariff, we find positive coefficients in all cases and significance when using the estimated skewness from the Gamma distribution. Using column (2)'s estimates, at the sample mean a 1% rise in the tariff would imply a .36% increase in the estimated Gamma distribution skewness. This suggests that as protection, and particularly tariffs, rises, the distribution is pushed away from the zero skewness of the normal distribution (i.e. the shape parameter falls in Figure 1). This then increases difference between the mean and median productivity.

While the estimated coefficients are imprecisely estimated, the results are indicative of two things. First, protection (especially NTMs) tends to lower the productivity mean, a result consistent with the selection effect. Second, protection (especially tariffs) seems to be positively correlated with skewness. Taken together, these suggest that increasing protection lowers average productivity and drives a greater wedge between the productivity of the average firm and that of the median firm.

Such interpretations are, however, subject to the somewhat low statistical significance of our coefficients. This could be arising from three issues. The first issue is that we have a fairly small number of country-sector-years and, as noted above, some firm size groups may not have enough data points to provide a good fit to the distribution for high-productivity firms. The second issue is that our NTM and tariff measures are averages within a two-digit sector. This second has two impacts. First, because these are averages, they do not reflect the relative importance of different sub-sectors within the broader category. Second, our measure of productivity is sales over employment. Here, two issues arise. One is that a change in import competition, which affects the price level, should affect the sales and employment of non-marginal domestic firms. The other is that, if import protection is correlated with export barriers (such as when domestic liberalization is matched with foreign liberalization), sales and employment would change for exporting firms as protection changes. If these changes are not proportional, then this would cause a change in our measure productivity for non-marginal domestic firms, clouding the relatively simple distribution changes found in the theory.[20] Third, since the link between protection and the selection effect is likely more clear-cut within a narrowly defined sector, it may be necessary to use further disaggregation to find more significant results. However, given our data's small number of observations in each country-sector-year this is not possible for us.

To further explore this last point, we now change the data point cutoff for inclusion in our sample. Since our estimated moments are constructed from observed data, we are reliant on the assumption that we have enough productivity observations for a country-sector-year to accurately estimate the mean and skewness. In Tables 6 and 7, rather than using country-sector-years with at least 50 observations, we restrict ourselves to those with at least 100 observations. As can be seen, this cuts our sample size nearly in half. Somewhat unexpectedly, in Table 6 we now find that NTMs increase the mean productivity (although this is just barely significant at the 10% level). For skewness in Table 7, we find no significant estimates. Whether this drop in significance is due to fewer observations or a better fit to the true underlying productivity distribution is unclear.

4.2 Robustness Checks

In Tables 8 through 10, we consider other factors that may influence the distribution. For the mean (Table 8), estimated Gamma distribution skewness (Table 9), and Pearson skewness (Table 10), column (1) introduces the share of exporters in the country-sector-year. In a similar fashion, column (2) includes the share of importers, (3) the share of foreign-owned firms (defined as those where foreigners own at least 10% of the equity), (4) the average age of firms, (5) three measures of the size of firms' locations, and (6) all of these.

[20]This motivates our inclusion of exporter shares in the robustness checks.

Beginning with Table 8 we find little more than we did in the baseline results. When using the estimated Gamma distribution skewness in Table 9 we find that our positive tariff coefficient is reasonably robust to including these other variables. In addition, we find that when a country-sector-year has a greater share of importers and/or a greater share of foreign owned firms, the wedge between the median and mean productivity increases. This does not, however, seem to hold for the Pearson skewness. Note that the insignificance of the exporter share in these results provides some reassurance that changes in our productivity measure for non-marginal domestic firms due to reciprocal trade liberalization is driving the results.

Finally, in Table 11, we omit European Union countries because their trade policies are jointly set. Here, columns (1) and (2) are for the mean, (3) and (4) for the estimated Gamma distribution skewness, and (5) and (6) for the Pearson skewness. Although the exclusion of these countries lowers our sample size somewhat, it does not largely affect our results compared to those for the full sample. One notable exception is we find relatively strong evidence that a higher share of foreign-owned firms increases mean productivity.

5 Conclusion

Among the many gains from trade, the Melitz (2003) highlights the role of selection in which trade liberalization drives low productivity firms from the market and shifts resources to more productive ones. This implies that protection should be negatively correlated with the average productivity of active firms. In addition, it has the ability to affect the median productivity relative to the mean, i.e. the skewness of the productivity distribution. We examine the possibility of such effects using firm-level data on 28 sectors across 99 countries to examine how non-tariff measures and tariffs affect the estimated moments of the distribution.

On the whole, we find that greater protection may be correlated with a decline in average productivity as Melitz (2003) predicts. In addition, we find that protection increases the wedge between mean and median productivity. This also seems to be true when a greater share of firms import inputs and are foreign-owned. This impact on the mean versus median firm suggests that the policy implemented to benefit a country "on average" may be quite different from one done to secure votes (as in a median voter model). While our estimates suggest that it may be beneficial to acquire more observations on firms in order disaggregate the data into more refined sectors and protection measures, we hope our results nevertheless serve to spark debate on the link between selection and trade policy.

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Figure 1: Shape Parameter and the Gamma Distribution

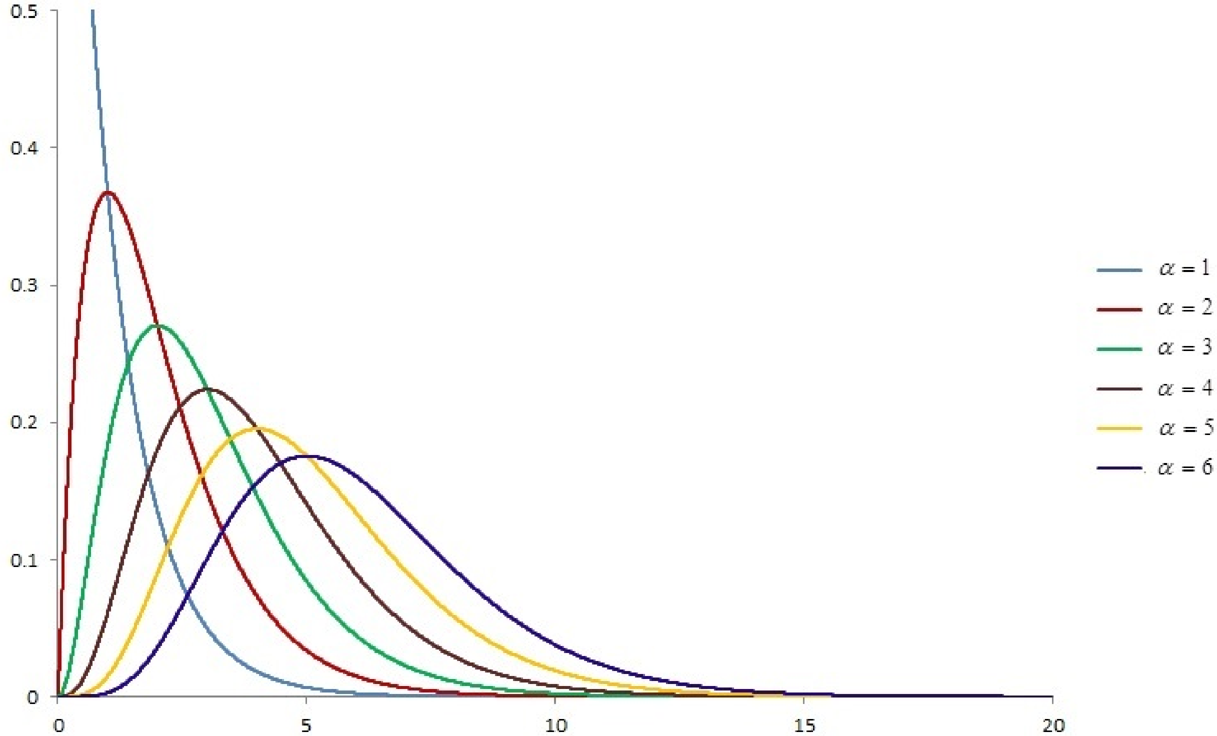

Table 1: Countries in the Sample

Afghanistan	2008	Guatemala	2006, 2010	Panama	2006, 2010
Albania	2007, 2013	Honduras	2006	Paraguay	2006
Angola	2006, 2010	Hungary	2009, 2013	Peru	2006, 2010
Argentina	2006, 2010	India	2014	Philippines	2009, 2015
Armenia	2009, 2013	Indonesia	2009, 2015	Poland	2009, 2013
Azerbaijan	2009, 2013	Iraq	2011	Romania	2009, 2013
Bangladesh	2007, 2013	Israel	2013	Russian Federation	2009, 2012
Belarus	2008, 2013	Jamaica	2010	Senegal	2007, 2014
Bhutan	2009	Jordan	2013	Serbia	2009, 2013
Bolivia	2006	Kazakhstan	2009, 2013	Slovenia	2009, 2013
Bosnia and Herzegovina	2009, 2013	Kenya	2007, 2013	Solomon Islands	2015
Botswana	2010	Kosovo	2009	South Africa	2007, 2014
Brazil	2009	Lao PDR	2009, 2012, 2016	South Sudan	2014
Bulgaria	2007, 2009, 2013	Latvia	2009, 2013	Sri Lanka	2011
Burkina Faso	2009	Lebanon	2013	Sudan	2014
Cambodia	2016	Lithuania	2009, 2013	Sweden	2014
Cameroon	2009	Macedonia, FYR	2009, 2013	Tajikistan	2008, 2013
Chile	2006, 2010	Madagascar	2009, 2013	Tanzania	2006, 2013
China	2012	Malawi	204	Thailand	2016
Colombia	2006, 2010	Malaysia	2015	Tonga	2009
Congo, Dem. Rep.	2006, 2010, 2013	Mali	2007	Trinidad and Tobago	2010
Costa Rica	2010	Mauritius	2009	Tunisia	2013
Cote d'Ivoire	2009	Mexico	2006, 2010	Turkey	2008, 2013
Croatia	2007, 2013	Moldova	2009, 2013	Uganda	2006, 2013
Djibouti	2013	Mongolia	2009, 2013	Ukraine	2008, 2013
Dominican Republic	2010	Morocco	2013	Uruguay	2006, 2010
Ecuador	2006, 2010	Mozambique	2007	Uzbekistan	2013
Egypt, Arab Rep.	2013	Myanmar	2014	Venezuela, RB	2010
El Salvador	2006, 2010, 2016	Namibia	2014	Vietnam	2009, 2015
Estonia	2009, 2013	Nepal	2009, 2013	West Bank and Gaza	2013
Ethiopia	2011, 2015	Nicaragua	2006, 2010	Yemen, Rep.	2010, 2013
Georgia	2008, 2013	Nigeria	2007, 2014	Zambia	2007, 2013
Ghana	2007, 2013	Pakistan	2007, 2013	Zimbabwe	2011

Notes: Year is the year in which surveys took place.

Table 2: Sectors in the Sample

Sector	Code	Observations	% of Sample
Food & Beverages	15	77	14.98
Tobacco	16	1	0.19
Textiles	17	23	4.47
Apparel	18	50	9.73
Leather	19	6	1.17
Wood	20	3	0.58
Paper	21	2	0.39
Publishing	22	4	0.78
Chemicals	24	30	5.84
Rubber	25	13	2.53
Non-metallic Minerals	26	19	3.7
Basic Metals	27	4	0.78
Fabricated Metals	28	27	5.25
Machinery	29	13	2.53
Electrical Machinery	31	8	1.56
Communication Equipment	32	1	0.19
Medical Instruments	33	2	0.39
Motor Vehicles	34	3	0.58
Furniture	36	15	2.92
Construction	45	16	3.11
Vehicle Sales & Repair	50	8	1.56
Wholesale	51	28	5.45
Retail	52	124	24.12
Hotels & Restaurants	55	23	4.47
Land Transport	60	3	0.58
Support Transport	63	3	0.58
Post & Telecom	64	2	0.39
Computer Activities	72	6	1.17

Table 3: Summary Statistics

	Obs	Mean	Std. Dev.	Min	Max
Mean	288	1314553	1.25E+07	4255.3	2.01E+08
Skew (Gamma)	288	2.493752	0.8215205	1.067124	5.911659
Skew (Pearson)	288	1314553	1.25E+07	4255.3	2.01E+08
NTM	288	4.2236	11.85092	0	117.3256
Tariff	250	2.700335	0.8899781	-1.771957	5.010635
Exporter Share	288	0.303626	0.1885329	0	0.9357798
Importer Share	283	0.468953	0.2290338	0	1
Foreign Share	288	0.1009952	0.0937807	0	0.5959596
Mean Age	288	37.86658	33.7749	7.895833	263.0637
Share in Capital	226	0.1463616	0.2317233	0	0.9607843
Share in Million+	226	0.3517937	0.2990783	0	1
Share in 250K-Million	226	0.2654036	0.2056452	0	1

Table 4: Protection and Mean of Productivity

	(1)	(2)	(3)	(4)	(5)	(6)
		Gamma			Non-param.	
NTM	-45,332**		161.9	-45,245**		291.5
	(20,443)		(3,741)	(20,398)		(3,747)
Tariff		-25,029	-2,589		-28,383	-6,543
		(113,383)	(120,313)		(116,017)	(123,481)
Constant	3.249e+06***	78,541	205,049	3.245e+06***	87,017	213,868
	(1.020e+06)	(286,556)	(267,687)	(1.020e+06)	(293,213)	(277,955)
Observations	288	262	250	288	262	250
Adjusted R-squared	0.390	0.910	0.915	0.390	0.910	0.915

Notes: Columns (1) through (3) use estimated Gamma distribution mean; (4) through (6) use the sample mean. ***, **, and * on coefficients denote significance at the 1%, 5%, and 10% levels respectively. Robust standard errors clustered by sector in parentheses. All specifications include country, year, and 2-digit sector dummies.

Table 5: Protection and Skewness of Productivity

	(1)	(2)	(3)	(4)	(5)	(6)
		Gamma			Non-param.	
NTM	0.000906		-0.00190	0.0141		0.00551
	(0.00211)		(0.00204)	(0.0115)		(0.0148)
Tariff		0.0986*	0.0916*		0.154	0.204
		(0.0493)	(0.0470)		(0.443)	(0.451)
Constant	2.038***	0.976***	1.737***	4.771***	1.641	4.129**
	(0.0924)	(0.125)	(0.228)	(0.786)	(1.119)	(1.867)
Observations	288	262	250	288	262	250
Adjusted R-squared	0.556	0.498	0.490	0.108	0.080	0.070

Notes: Columns (1) through (3) use estimated Gamma distribution skew; (4) through (6) use the Pearson median skew. ***, **, and * on coefficients denote significance at the 1%, 5%, and 10% levels respectively. Robust standard errors clustered by sector in parentheses. All specifications include country, year, and 2-digit sector dummies..

Table 6: Protection and Mean of Productivity: Only Country-Sector-Years with 100+ firms

	(1)	(2)	(3)	(4)	(5)	(6)
		Gamma			Non-param.	
NTM	-2,264		1,733*	-2,176		1,854*
	(4,010)		(986.4)	(4,031)		(963.2)
Tariff		8,535	17,421		4,753	12,989
		(65,110)	(79,755)		(67,640)	(82,186)
Constant	196,922	130,166	85,900	190,959	139,366	93,667
	(163,394)	(111,410)	(161,175)	(161,441)	(118,373)	(167,837)
Observations	163	154	145	163	154	145
Adjusted R-squared	0.989	0.962	0.961	0.989	0.962	0.961

Notes: Columns (1) through (3) use estimated Gamma distribution mean; (4) through (6) use the sample mean. ***, **, and * on coefficients denote significance at the 1%, 5%, and 10% levels respectively. Robust standard errors clustered by sector in parentheses. All specifications include country, year, and 2-digit sector dummies.

Table 7: Protection and Skewness of Productivity: Only Country-Sector-Years with 100+ firms

	(1)	(2)	(3)	(4)	(5)	(6)
		Gamma			Non-param.	
NTM	-0.00258		-0.00223	0.0114		0.0117
	(0.00288)		(0.00320)	(0.0204)		(0.0260)
Tariff		0.131	0.121		0.0350	-0.0486
		(0.0909)	(0.110)		(0.646)	(0.773)
Constant	2.170***	1.669***	1.762***	5.105***	4.902*	5.035
	(0.113)	(0.283)	(0.359)	(1.422)	(2.786)	(3.293)
Observations	163	154	145	163	154	145
Adjusted R-squared	0.607	0.519	0.502	0.084	0.059	0.038

Notes: Columns (1) through (3) use estimated Gamma distribution skew; (4) through (6) use the Pearson median skew. ***, **, and * on coefficients denote significance at the 1%, 5%, and 10% levels respectively. Robust standard errors clustered by sector in parentheses. All specifications include country, year, and 2-digit sector dummies..

Table 8: Protection and Mean of Productivity: Extended results

	(1)	(2)	(3)	(4)	(5)	(6)
NTM	52.89	-57.17	55.79	57.94	-369.1	-329.4
	(3,831)	(3,936)	(3,730)	(3,760)	(2,190)	(1,972)
Tariff	-2,350	-4,652	-7,161	-2,096	74,888	67,812
	(122,437)	(123,137)	(119,832)	(119,935)	(70,645)	(72,903)
Exporter Share	335,681					-366,593
	(372,323)					(482,275)
Importer Share		-646,516				21,179
		(653,196)				(526,591)
Foreign Share			485,320			881,003*
			(576,694)			(446,149)
Mean Age				-813.1		1,480
				(1,470)		(2,925)
Share in Capital					307,763	205,592
					(205,413)	(284,600)
Share in Million+					-206,013	-113,701
					(700,856)	(637,625)
Share in 250K-Million					477,205	595,098
					(728,411)	(940,462)
Constant	84,900	497,155	180,868	251,486	-97,945	-123,988
	(313,770)	(495,403)	(268,430)	(239,499)	(239,417)	(299,417)
Observations	250	250	250	250	192	192
Adjusted R-squared	0.915	0.916	0.915	0.915	0.963	0.962

Notes: All columns use the estimated Gamma distribution mean. ***, **, and * on coefficients denote significance at the 1%, 5%, and 10% levels respectively. Robust standard errors clustered by sector in parentheses. All specifications include country, year, and 2-digit sector dummies.

Table 9: Protection and Skewness of Productivity: Extended Results (Gamma)

	(1)	(2)	(3)	(4)	(5)	(6)
NTM	-0.00207	-0.00172	-0.00216	-0.00190	-0.00160	-0.00154
	(0.00198)	(0.00214)	(0.00197)	(0.00199)	(0.00266)	(0.00248)
Tariff	0.0920*	0.0934*	0.0806	0.0916*	0.0688	0.0637
	(0.0488)	(0.0460)	(0.0466)	(0.0476)	(0.0865)	(0.0853)
Exporter Share	0.499					-0.518
	(0.410)					(0.693)
Importer Share		0.556***				0.712**
		(0.193)				(0.291)
Foreign Share			1.170***			1.299**
			(0.216)			(0.554)
Mean Age				6.60e-05		-0.00105
				(0.00116)		(0.00216)
Share in Capital					0.120	-0.0389
					(0.404)	(0.483)
Share in Million+					0.176	-0.0518
					(0.942)	(0.898)
Share in 250K-Million					0.618	0.449
					(0.868)	(0.955)
Constant	1.559***	1.486***	1.679***	1.734***	1.583***	1.446***
	(0.333)	(0.252)	(0.213)	(0.185)	(0.247)	(0.438)
Observations	250	250	250	250	192	192
Adjusted R-squared	0.492	0.495	0.496	0.487	0.543	0.550

Notes: All columns use estimated Gamma distribution skew. ***, **, and * on coefficients denote significance at the 1%, 5%, and 10% levels respectively. Robust standard errors clustered by sector in parentheses. All specifications include country, year, and 2-digit sector dummies..

Table 10: Protection and Skewness of Productivity (Pearson)

	(1)	(2)	(3)	(4)	(5)	(6)
NTM	0.00480	0.00585	0.00499	0.00520	0.00778	0.00588
	(0.0147)	(0.0151)	(0.0148)	(0.0148)	(0.0154)	(0.0165)
Tariff	0.205	0.207	0.181	0.205	0.205	0.170
	(0.458)	(0.453)	(0.440)	(0.447)	(0.469)	(0.432)
Exporter Share	2.199*					-0.383
	(1.240)					(2.643)
Importer Share		0.984				0.820
		(0.682)				(1.715)
Foreign Share			2.372			2.436
			(1.951)			(2.826)
Mean Age				-0.00247		-0.0138
				(0.00675)		(0.0122)
Share in Capital					-0.955	-1.284
					(5.700)	(6.082)
Share in Million+					-1.625	-2.120
					(3.788)	(4.060)
Share in 250K-Million					5.108	4.023
					(3.353)	(3.741)
Constant	3.342*	3.685*	4.011**	4.271**	2.874	3.565
	(1.901)	(1.784)	(1.894)	(1.634)	(2.113)	(2.926)
Observations	250	250	250	250	192	192
Adjusted R-squared	0.072	0.067	0.068	0.066	0.094	0.074

Notes: All columns use the Pearson median skew. ***, **, and * on coefficients denote significance at the 1%, 5%, and 10% levels respectively. Robust standard errors clustered by sector in parentheses. All specifications include country, year, and 2-digit sector dummies..

Table 11: No European Union Sample

	(1)	(2)	(3)	(4)	(5)	(6)
	Mean		Skew (Gamma)		Skew (Pearson)	
NTM	221.5	-253.4	-0.00244	-0.00133	0.00856	0.00761
	(3,780)	(1,970)	(0.00219)	(0.00252)	(0.0146)	(0.0151)
Tariff	6,961	76,322	0.106**	0.0730	0.189	0.141
	(125,614)	(80,274)	(0.0461)	(0.0904)	(0.450)	(0.421)
Exporter Share		-361,232		-0.533		-1.491
		(512,697)		(0.671)		(2.796)
Importer Share		29,284		0.872**		1.474
		(618,519)		(0.351)		(1.865)
Foreign Share		909,762**		1.585**		4.623
		(363,599)		(0.555)		(3.504)
Mean Age		1,428		-0.00176		-0.0196*
		(3,165)		(0.00240)		(0.0108)
Share in Capital		74,239		-0.0642		-2.148
		(303,561)		(0.517)		(6.954)
Share in Million+		-199,733		-0.174		-3.481
		(623,752)		(0.926)		(4.503)
Share in 205K-Million		496,506		0.282		2.893
		(1.031e+06)		(1.056)		(4.239)
Constant	182,902	-92,641	1.710***	1.375***	4.068**	4.444
	(274,171)	(353,567)	(0.217)	(0.467)	(1.902)	(2.922)
Observations	236	183	236	183	236	183
Adjusted R-squared	0.915	0.962	0.478	0.534	0.068	0.084

Notes: Columns (1) and (2) use the estimated Gamma distribution mean, (3) and (4) the estimated Gamma distribution skew, and (5) and (6) the Pearson median skew. ***, **, and * on coefficients denote significance at the 1%, 5%, and 10% levels respectively. Robust standard errors clustered by sector in parentheses. All specifications include country, year, and 2-digit sector dummies..

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