

Specialization Across Goods and Export Quality

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Abstract

This paper explores the link between international specialization across goods and within goods along the quality dimension. The analysis is performed in a multi-country model with an integer number of efficiency heterogeneous firms producing each good and under reasonably general assumptions on the shape of firm efficiency distributions and market structure. In equilibrium, each country exports a range of qualities for each good that overlaps with the ranges of other countries following patterns that relate to differences in wages, trade frictions and absolute advantage. If firm efficiency is *quality biased* (i.e., the relative productivity of more-efficient firms is higher when producing higher quality) then, conditional on wages, the average quality of the exports within an industry increases with the country's international specialization in that industry.

Keywords: comparative advantage; absolute advantage; quality; vertical differentiation; Cournot. *JEL classification:* F10.

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1 Introduction

Empirical research has shown that accounting for both specialization across goods and specialization within goods along the quality dimension is indispensable for interpreting the current patterns of international trade.¹ Although existing models of trade tend to focus on either one or the other of these dimensions, the two are likely to be connected. Figure 1 is suggestive of the potential relationship. For several products, this figure shows a positive correlation between the unit value of US imports from different countries (where unit value is interpreted as a proxy for quality) and the exporting country's revealed comparative advantage in the corresponding product (see Section 5 for details). In these examples, a positive relationship between the two variables is apparent and holds regardless of whether or not the sample of exporting countries is split into different groups according to their income level.

This paper analyzes the potential link between specialization across goods and specialization within goods along the quality dimension. The main result is that the countries that are specialized in a given good tend to export a higher average quality of that good (conditional on wages and other variables). The analysis is performed in a multi-country model with an integer number of industries, each of which is composed by an integer number of heterogeneous producers, and under reasonably general assumptions on the distribution of firm efficiencies and market structure.

The heterogeneity of producers in terms of efficiency and export status, within each industry and country, is large and has fundamental implications for understanding the consequences of trade, as shown by a recent and growing literature.² In turn, working with models that have an integer number of firms is important because, as stated by Eaton, Kortum and Sotelo (2012), it is difficult to reconcile the small number of firms engaged in selling from one country to another and the many country bilateral trade flows that are zero, with a continuum of firms. As a result of these features, in this model's equilibrium, each good tends to be exported to each market by multiple firms (but not by an infinite number of firms) and from more than one country (but not necessarily from all of the countries). Moreover, countries tend to export a wide but finite range of qualities for every product. In this regard, the model provides simple but intuitive predictions on how the ranges in the quality for each good exported by different countries overlap according to differences in wages, trade frictions, and absolute advantage.

¹On the importance of the quality dimension, see Schott (2004), Hummels and Klenow (2005), Khandelwal (2010) and Hallak and Schott (2011) among a rapidly expanding literature. Throughout the paper, we refer to specialization across goods as *horizontal* specialization and to specialization within goods along the quality dimension as *vertical* specialization.

²On the empirics of trade and firm heterogeneity, see Bernard and Jensen (1995) for pioneering work and Eaton, Kortum and Kramarz (2011) for recent influential research. See Bernard et al. (2003) and Melitz (2003) for path-breaking general equilibrium models. Redding (2011) and Bernard et al. (2012) review this literature.

At the firm level, the key assumption of the model is *quality-biased efficiency*. Quality-biased efficiency means that the relative productivity of two firms increases in favor of the most efficient firm as production shifts toward higher quality.³ Formally, quality-biased efficiency means that firm productivity is log-supermodular in firm efficiency and product quality. Costinot (2009) has shown that log-supermodularity provides a unifying principle that underlies numerous results in international trade. The quality bias of productivity is a common (often implicit) hypothesis in models with heterogeneous firms and quality differentiation and has received empirical support using data from the US and other countries.⁴

In this model, quality-biased efficiency at the firm level translates into a connection at the country level between specialization across goods and the average export quality of each good. The argument can be outlined as follows. Firms from a country that has an absolute advantage (*AA*; to be precisely defined below) in a given industry j will, on average, be more efficient than the firms from other countries. Thus, if efficiency is quality biased, then the firms from this country and industry will, on average, produce higher quality than their competitors. Moreover, if the country has an *AA* in j over another country and a *lower* wage, then it will tend to be relatively specialized in industry j . Thus, conversely, a higher specialization in industry j with respect to another country and a *higher* wage, implies that the country has as an *AA* in j . Therefore, noting that there is also a direct link between wages and quality, countries with higher specialization in j and higher wages should export higher average quality of j .

Developing this argument under reasonably general assumptions on the distribution of firm efficiencies and market structure involves dealing with three primary aggregation issues. First, absolute advantage must be defined. First-order stochastic dominance (FOSD) may appear to be the natural concept to be used to order country distributions of firm efficiencies within each industry. However, we show with a numerical example that FOSD is not sufficient to guarantee a basic property for *AA* orders whenever we depart from the particularly *well-behaved* Dixit-Stiglitz monopolistic competition (DSMC) model. This property is that if country i' has an *AA* over country i'' in industry j , then the exporters of j from i' have greater average productivity than those from i'' . Rather, the monotone likelihood ratio property (MLRP), which is satisfied by continuous distributions commonly used in the trade literature such as Pareto and Fréchet and can also be used in models with a discrete distribution of firms, guarantees this property. Thus, we define a country to have an *AA* over another country in a given industry if for any two categories

³Firm efficiency is an exogenous, one-dimensional index that allows the ordering of firms according to their available technology. Conversely, firm productivity is endogenous as it depends on the quality that the firm chooses to produce.

⁴For models assuming a quality bias of firm efficiency, see Verhoogen (2008), Alcalá and Hernández (2010), Baldwin and Harrigan (2011) and Johnson (2012), among others. For the empirical evidence, see Gervais (2011), Hallak and Sivadasan (2013), Kugler and Verhoogen (2012) and Manova and Zhang (2012).

of firm efficiency, the ratio of the number of firms in the high-efficiency category to the number in the low-efficiency category is larger in the first country. Using this definition, we can demonstrate that, conditional on wages, firms from a country that has an *AA* on a given good will produce it with higher average quality.

Second, the effect of wages and trade frictions on the countries' average export quality depend on how wages and trade frictions affect the relative market shares of firms that produce different qualities. However, the sign of this effect can be uncertain. For instance, we know that the market shares of firms from countries with higher wages and trade frictions will be smaller (for any given efficiency). However, as wages and trade frictions increase, it is possible that the less-efficient firms' market shares are reduced relatively less than the more-efficient firms' market shares.⁵ This would imply that the exporters from countries that have higher wages and trade frictions feature lower average efficiency and export quality (at least for a certain range of these variables). We show that the condition guaranteeing that countries with higher wages and trade frictions (conditional on *AA*) export higher average quality is that the cross derivative of the log of market share with respect to wages and efficiency is positive. Third, country specialization across goods is not only the result of the average output per firm in each industry but also of the relative number of firms in each industry. Thus, to analyze horizontal specialization we need to endogenize the number of firms. We use a static zero-profit condition to endogenize firms and show that the country's relative exports in a given industry are larger in the economies with a stronger *AA* and a lower wage. The key assumption to reach this latter result is that the cross derivative of the operating profits with respect to trade frictions and the industry's price index is negative.

DSMC and Cournot competition⁶ are two prominent cases of market structures that meet the two aforementioned key assumptions on the cross derivative of the log of market shares with respect to wages and efficiency, and the cross derivative of the operating profits with respect to trade frictions and the industry's price index. Note that these two models represent opposing

⁵This cannot happen under DSMC because market shares are power functions of marginal costs and, therefore, the relative market shares within the set of active exporters from a given source country stay constant as the country's wage or trade frictions change. This is a very useful but rather unique property of the DSMC market structure.

⁶In Section 2, we discuss the Cournot case in some detail and use it as the primary example of a market structure that satisfies our assumptions for several reasons. First, Cournot allows building the numerical example showing that FOSD may not be sufficient to define *AA* in a helpful way. Second, in contrast to the constant markups in the DSMC model, Cournot implies that markups are heterogeneous across firms and increasing with trade barriers, which is consistent with the pro-competitive effects emphasized by the empirical literature on trade liberalizations (e.g., Tybout, 2003, and Feenstra and Weinstein, 2010). These patterns of markups appear to be very important in assessing the gains from trade (Edmond, Midrigan and Xu, 2013). Additional interesting features of the Cournot's equilibrium are that, in contrast to the DSMC's equilibrium, *measured* marginal labor productivity differs across producers that are heterogeneous in efficiency, only the most efficient firms export even if there is not a fixed cost of exporting and the relative market shares of the more-efficient firms strictly increase within the set of active firms as wages or trade frictions rise. Atkeson and Burstein (2008) and Edmond, Midrigan and Xu (2013) are other trade models using Cournot competition.

market structures from the point of view of the response of prices and markups to differences in firm efficiency. The combination of the MLRP on the firm efficiency distributions and the two cited cross-derivative assumptions appear to provide a fruitful and fairly general basis for the analysis of aggregates (such as average productivity and quality) in models with heterogeneous producers. It might be conjectured that some qualitative results in the trade literature that have been developed in the context of particular firm efficiency distributions such as Pareto or Fréchet and particular market structures such as DSMC could be generalized to this framework.

The contribution of this paper is theoretical. However, it is appropriate to provide an empirical illustration of the model's main prediction. Thus, we explore the correlation between horizontal specialization and export average quality for a particular sector, apparel and clothing accessories, using unit values as a proxy for quality and data on US imports. The apparel and clothing accessories sector has the largest number of exporting countries to the US and includes many products with large variations in unit values. We run regressions pooling together the data for all of the 233 6-digit goods in chapters 61 and 62 of the HS-1996 classification, and independent regressions for the 113 goods of these two chapters that have at least 50 exporting countries. Overall, the results of this limited exercise appear to be consistent with the main implication of the model: conditional on wages, horizontal specialization tends to be positively correlated with export unit values. However, conducting a proper test of the theory is beyond the scope of this paper and is left for future research. Although there are sometimes direct measures of quality (e.g., Crozet, Head and Mayer, 2012), empirical work on quality typically involves using unit values as proxies, as we do in our exercise. However, unit values may not be a good proxy for quality. In monopolistic competition markets, the more-efficient firms may sell larger quantities at lower prices even if they produce higher quality. This is especially problematic for the use of prices as a proxy for quality when, as in this paper, we are interested in the link between relatively high sales (horizontal specialization), which may tend to lower prices, and high quality. Hence, conducting a proper test of the theory will require a more sophisticated empirical approach to capture export quality than the unit-value approach followed in our empirical exercise.⁷

This paper is related to several strands of the trade literature. Early models of specialization along the quality dimension assume either only one vertically differentiated good in the economy (together with a non-differentiated good) or only one quality level per good at each point in time.⁸

⁷See Khandelwal (2010), Hallak and Schott (2011) and Feenstra and Romalis (2012) for different approaches that go beyond prices to capture export quality. At any rate, while low unit values may not be indicative of low quality if sales are high, high unit values together with high relative sales (high horizontal specialization) are difficult to explain without referring to high quality.

⁸This includes Flam and Helpman (1987), Falvey and Kierzkowski (1987), Grossman and Helpman (1991), Stokey (1991), Copeland and Kotwal (1996) and Murphy and Shleifer (1997).

Therefore, there is no room for interaction between horizontal and vertical specializations. Most of the recent general equilibrium trade models with heterogeneous producers are set in terms of homogeneous quality goods but can often be reinterpreted as models with quality differentiation. However, this reinterpretation may involve a trivial distinction between quantity and quality that leaves undetermined the product of the quantity times quality being produced. The distinction between quantity and quality becomes relevant from the point of view of the supply when different firms have different comparative advantage for producing quality. In this paper, this variation in comparative advantage arises from the assumption of quality-biased efficiency.

The model also introduces an industry-country component of firm efficiency (this is done by assuming an *AA* order of countries in each industry, according to the definition of *AA* given above). The concept of *industry* is central to the literature on comparative advantage and to our analysis of specialization across goods but is absent from many of the recent general equilibrium models with heterogeneous producers. Notable heterogeneous-firm trade models in which this concept does play an important role are Bernard, Redding, and Schott (2007) who analyze comparative advantage in a two-country two-factor two-industry model, and Chor (2010) and Costinot, Donaldson and Komunjeer (2012) who build on Eaton and Kortum (2002) and consider a multi-good multi-country economy. As we discuss later, Costinot, Donaldson and Komunjeer (2012) is the closest to the present paper, although they do not consider the quality dimension of specialization and, in contrast to our market structure and firm distribution framework, they assume perfect competition and Fréchet distributions.

The link here between the exporters' technology and specialization along the quality dimension has a Ricardian flavor, in contrast to other approaches to export quality that emphasize differences in factor-proportions (Schott, 2004) and home-market effects (Fajgelbaum, Grossman and Helpman, 2011). In turn, the approach in this paper to deal with a finite number of firms also differs from Eaton, Kortum, and Sotelo (2012), who assume specific firm efficiency distributions in order to parameterize the model and assess its quantitative implications.

One important simplification of this model lies in the structure of demand. The model assumes the same homothetic demand with perfect quantity and quality substitutability in all countries. To be sure, non-homotheticities are important in shaping the patterns of trade along the quality dimension (see Hallak 2006 and 2010, Choi, Hummels and Xiang 2009, Fielor 2011, Hallak and Schott 2011, Fajgelbaum, Grossman, and Helpman 2011, and Feenstra and Romalis 2012). However, demand homotheticity proves to be a very useful simplification to derive new relevant predictions, whereas there is no reason to expect that non-homotheticities would reverse these predictions.

This paper is organized as follows. Section 2 sets the model. Section 3 analyzes specialization

within goods along the quality dimension. Section 4 extends the model to endogenize the number of firms in order to analyze specialization across goods and to link it with the average export quality. Section 5 presents the empirical illustration. Section 6 concludes.

2 The Model

We consider a static model. There are J goods or industries indexed by j (the terms good and industry are used interchangeably throughout this paper) and I countries indexed by i when we refer to them as production sources and by n when as destinations. Every good can be produced along a continuum of qualities $q \in (0, \infty)$. Labor is the only factor of production. It is perfectly mobile across industries and immobile across countries. Country i has an inelastic labor supply of $L_i > 0$ units, which is equal to its population. In each country and industry, there is a finite set of potential producers, which are heterogeneous in terms of their productive efficiency. Each firm's efficiency is parameterized by an index $z \in Z$, where $Z \equiv \{z_0, z_1, \dots, \bar{z}\}$ is a set with an integer number of potential efficiencies in ascending order (i.e., $z_t < z_{t+1} < \bar{z}$ for $t \in \mathbb{N}$) with $z_0 \geq 0$. The number of firms in country i and industry j that have efficiency z is $m_i^j(z) \in \mathbb{N}$. In this and the following sections, we analyze the model's equilibrium for any exogenous vector of firms $(m_i^j(z)) \in \mathbb{N}^{J \times I \times Z}$ such that there is more than one potential producer of each good; i.e., $m^j \equiv \sum_{i=1}^I \sum_{z \in Z} m_i^j(z) > 1$ for each j . In Section 4, we endogenize this vector of firms by imposing a zero-profit condition.

2.1 Setting

Consumers

We consider a two-level (across goods and within goods) utility function. Utility across goods is Cobb-Douglas. For each good j , each of the m^j potential firms produces a different variety, which may or may not be a perfect substitute of the other firms' varieties. At this point, we assume a generic functional form $V(\cdot)$ for the utility within goods although, later in this section, we introduce further assumptions and consider the particular cases of CES preferences and of no horizontal differentiation. The key assumption maintained throughout the paper is the perfect substitutability from the point of view of consumption between the quantity and quality of each good. Formally, we assume that in every country $n = 1, \dots, I$, there is a representative consumer that maximizes the following utility function:

$$U_n = \prod_{j=1}^J (V^j [(g_n^j(k) \cdot q_n^j(k))])^{\alpha^j}, \quad (1)$$

where for each good j , $\alpha^j > 0$ is the expenditure share in the good (i.e., $\sum_{i=I}^J \alpha^i = 1$); $(y_n^j(k) \cdot q_n^j(k))$ is a vector in $\mathbb{R}_+^{m^j}$,⁹ where $y_n^j(k)$ is the number of units of firm k 's output being consumed and $q_n^j(k)$ is this firm's output quality; and the lower tier utility function $V^j(\cdot) : \mathbb{R}_+^{m^j} \rightarrow \mathbb{R}$ is symmetric with respect to all of its arguments, strictly increasing and concave.

Let $p_n^j(k, q)$ be the price of firm k 's output of good j in destination n , which depends on the quality q that the firm produces, and let Y_n be country n 's aggregate income. Thus, the consumer budget constraint is $Y_n/L_n = \sum_{j=1}^J \sum_{k=1}^{m^j} y_n^j(k) p_n^j(k, q)$. Now, let $\tilde{y}_n^j(k)$ be the consumption of firm k 's output in quality-adjusted units ($\tilde{y}_n^j(k) \equiv y_n^j(k) q_n^j(k)$) and $\tilde{p}_n^j(k)$ be the price of firm k 's output in destination n if the quality it produces were equal to one ($\tilde{p}_n^j(k) \equiv p_n^j(k, 1)$). Because, for each firm, consumers only care about the total number of quality-adjusted units per firm, utility maximization yields

$$p_n^j(k, q) = \tilde{p}_n^j(k) \cdot q, \quad (2)$$

for any q . Moreover, utility maximization and Cobb-Douglas utility implies that the expenditure of country n in good j is $\alpha^j Y_n$ for each n and j . Thus, the demand for firm k 's output ($k = 1, \dots, m^j$) in industry j and market n , in terms of quality-adjusted units, can be expressed as

$$\tilde{y}_n^j(k) L_n = D^j(\alpha^j Y_n, \tilde{p}_n^j(k), (\tilde{p}_n^j(-k))), \quad (3)$$

where $(\tilde{p}_n^j(-k)) \in \mathbb{R}_+^{m^j-1}$ is the vector of prices of good j in destination n for all the potential producers of j excluding firm k .

Throughout the paper we use the DSMC and Cournot market structures as two prominent particular cases that fit our model. In the first case, the lower tier utility function in (1) takes the form $V^j((y_n^j(k) q_n^j(k))) = \left[\sum_{k=1}^{m^j} (\tilde{y}_n^j(k))^{\frac{(\gamma^j-1)}{\gamma^j}} \right]^{\gamma^j/(\gamma^j-1)}$, where $\gamma^j > 1$ is the elasticity of substitution between two varieties of good j . In the Cournot model without horizontal differentiation, the second tier utility function becomes $V^j((y_n^j(k) q_n^j(k))) = \sum_{k=1}^{m^j} y_n^j(k) q_n^j(k) \equiv \tilde{y}_n^j$.

Producers and quality-biased efficiency

Firms choose which quality and how many units to produce. The output (in physical units) of a firm in industry j with efficiency z producing quality q and employing l units of labor is given by the following production function:

$$x(z, q, l) = z \cdot \exp\left(1 - \frac{q}{z\sigma^j}\right) l. \quad (4)$$

⁹We employ the following standard notation: \mathbb{R}_+^n is the set of strictly positive vectors in \mathbb{R}^n , whereas \mathbb{R}_+^n is the set of all nonnegative vectors in \mathbb{R}^n .

Thus, there are constant returns to scale to produce any good and quality. However, increasing output quality comes at the cost of fewer units of output per worker. For each quality, higher efficiency z allows the production of more units with the same amount of labor. In turn, as we discuss below, the parameter σ^j (which is restricted to $\sigma^j > -1$) captures the *quality bias of efficiency* in industry j .

We assume iceberg trade frictions: to deliver one unit of good j from source country i to destination country n , the producer must ship $d_{ni}^j \geq 1$ units of the good, with $d_{ii}^j = 1$. Moreover, we assume that for each i there is a parameter $d_i > 0.5$ such that if $i' \neq i''$, then $d_{i''i'}^j = d_{i'i''}^j = d_{i''}^j + d_{i'}^j$. The world economy can thus be interpreted as having a central hub through which all international trade travels and such that d_i is the distance from country i to the hub. It then follows that if $d_{i'}^j \geq d_{i''}^j$, then $d_{ni'}^j \geq d_{ni''}^j$ for every destination $n \neq i', i''$. The parameter d_i^j can also be interpreted as an inverse measure of the country's *market access*, which can be specific for each good.

Now, the constant marginal cost for a firm from country i and efficiency z to produce good j with quality q and deliver it to destination n is

$$c_{ni}^j(z, q) = d_{ni}^j \frac{w_i}{z} \exp\left(\frac{q}{z^{\sigma^j}} - 1\right),$$

whereas its marginal cost of producing and delivering one quality-adjusted unit is $\tilde{c}_{ni}^j(z) = c_{ni}^j(z, q)/q$. Note that the more-efficient firms have a comparative advantage to produce higher quality if and only if $\sigma^j > 0$. To see this point, consider two firms with efficiencies $z_1, z_2 \in \mathcal{Z}$ such that $z_1 > z_2$, and a pair of qualities $q_1 > q_2 > 0$. Then, it is immediately apparent that $\frac{c(z_1, q_1)}{c(z_1, q_2)} < \frac{c(z_2, q_1)}{c(z_2, q_2)}$ if and only if $z_1^{\sigma^j} > z_2^{\sigma^j}$.

2.2 Equilibrium

Cost minimization and quality

Firms from the same country and industry that have the same efficiency face a symmetric demand and identical cost parameters and will take identical quality and quantity or price choices. Thus, from now on we index firm variables by the source country i and the firm's efficiency z rather than by the index k . Hence, $x_{ni}^j(z)$ is the sales of good j in destination n by a firm from country i that has efficiency z , and $\tilde{x}_{ni}^j(z)$ is its sales in terms of quality-adjusted units; i.e., $\tilde{x}_{ni}^j(z) = x_{ni}^j(z)q_{ni}^j(z)$. For each destination country n , the firm maximizes its profit $\pi_{ni}^j(z) = x_{ni}^j(z) \left[p_{ni}^j(z, q) - c_{ni}^j(z, q) \right] = \tilde{x}_{ni}^j(z) \left[\tilde{p}_{ni}^j(z) - \tilde{c}_{ni}^j(z) \right]$ with respect to its output quality and price or quantity, taking as given the demand function (3), the destination market income, the home country wage, and the other firms' choices.

The firm's maximization program can be separated into two parts. The first part of the program is to choose the optimal quality to minimize the marginal cost of delivering each quality-adjusted unit of output, $\tilde{c}_{ni}^j(z)$, which is independent of the decision on the number of units to be delivered or its quality-adjusted price. From cost minimization with respect to q , we find that

$$q_{ni}^j(z) = z^{\sigma^j}. \quad (5)$$

Hence, more-efficient firms in industry j produce higher quality goods if and only if $\sigma^j > 0$. Thus, if $\sigma^j > 0$, then we say that efficiency in industry j is *quality biased*, whereas if $\sigma^j = 0$ or $\sigma^j < 0$ then efficiency is *quality neutral* or has a *negative quality bias*, respectively. The empirical evidence cited in the Introduction identifies a positive link between firm efficiency and output quality and is, therefore, supportive of the case of quality-biased efficiency.

It can be shown that the general condition for the positive link between efficiency and quality at the firm level is that marginal costs $c(z, q)$ are log-submodular in efficiency and quality (i.e., $\partial^2 \ln c(z, q) / \partial z \partial q < 0$). However, using the particular production function in (4) leads to a simple expression for the marginal cost that is directly related to its standard expression in Ricardian trade models. Under optimal quality choices, the labor required by a firm with efficiency z to produce and ship one quality unit from i to n is $d_{ni}^j / z^{1+\sigma^j}$ and the corresponding marginal cost is $\tilde{c}_{ni}^j(z) = d_{ni}^j w_i / z^{1+\sigma^j}$.

Market shares

Next, we consider the (partial) equilibrium of the market for good j in destination n . The parameters of the market are the vector of firms producing j , $(m_i^j(z)) \in \mathbb{R}_+^{I \times Z}$, trade frictions $(d_i^j) \in \mathbb{R}_{++}^I$, country incomes $(Y) = (Y_1, \dots, Y_I) \in \mathbb{R}_{++}^I$, wages $(w) = (w_1, \dots, w_I) \in \mathbb{R}_{++}^I$ and the demand function for each firm's output, which is given by eq. (3). Given the market structure and the corresponding conditions for market equilibrium and firm profit maximization, we can determine the equilibrium prices $\tilde{p}_{ni}^j(z)$ and quantities $\tilde{x}_{ni}^j(z)$, as well as firm market shares $s_{ni}^j(z) \equiv \tilde{p}_{ni}^j(z) \tilde{x}_{ni}^j(z) / (\alpha^j Y_n)$ for each $z \in Z$ and $i = 1, \dots, I$.

For the purpose of this Section, which describes the model and shows that it has an equilibrium, it is sufficient to consider the following assumption. In Sections 3 and 4, which characterize the equilibrium, we require and discuss several additional assumptions on the market share and profit functions.

A.1 In each market n of each good j :

- (a) The price $\tilde{p}_{ni}^j(z)$ for each i and z is a continuous and positive-valued function of the

vector of wages $(w) = (w_1, \dots, w_I) \in \mathbb{R}_{++}^I$ with $\lim_{w_i \rightarrow 0} \tilde{p}_{ni}^j(z) = 0$.

- (b) We can define a continuous index \tilde{p}_n^j of the prices $\tilde{p}_{ni}^j(z)$, $i = 1, \dots, I$ and $z \in Z$, such that the market share $s_{ni}^j(z) \geq 0$ is a continuous and positive-valued function of the ratio $\tilde{c}_{ni}^j(z)/\tilde{p}_n^j$. This function is denoted as $s_{ni}^j(z) = s^j(\tilde{c}_{ni}^j(z)/\tilde{p}_n^j)$.

It is straightforward to verify that the DSMC market structure with no fixed cost of exporting to each market satisfies this assumption by recalling that for this market structure (and suppressing the superscript j) we have $\tilde{p}_{ni}(z) = (\gamma/[\gamma - 1])\tilde{c}_{ni}(z)$ and $s_{ni}(z) = [(\gamma/[\gamma - 1])(\tilde{c}_{ni}(z)/\tilde{p}_n)]^{1-\gamma}$, where $\tilde{p}_n = \left[\sum_{i=1}^I \sum_{z \in Z} m_i(z) (\tilde{p}_{ni}(z))^{1-\gamma} \right]^{1/(1-\gamma)}$.¹⁰ Next, we consider the Cournot equilibrium and show that it also satisfies this assumption.

The Cournot case

We now discuss in some detail the equilibrium under Cournot competition without horizontal differentiation, which leads to several interesting predictions that stand in contrast to the DSMC model. In the following section, we also use the Cournot market structure to build a numerical example showing that certain arguments on average efficiency and quality that can be made within the theoretical framework of the DSMC model and FOSD may not generalize to other market structures. This numerical example motivates the definition of *AA* that follows in that section.

In the Cournot equilibrium for each good j and destination market n , utility maximization yields $\tilde{p}_{ni}^j(z) = \tilde{p}_n^j$ for every i and z , and the firms' demand functions (3) collapse into the following single aggregate demand in quality-adjusted units:

$$\tilde{y}_n^j L_n = \frac{\alpha^j Y_n}{\tilde{p}_n^j}. \quad (6)$$

In turn, the market equilibrium condition is

$$\tilde{y}_n^j L_n = \sum_{i=1}^I \sum_{z \in Z} \tilde{x}_{ni}^j(z) m_i^j(z), \quad (7)$$

Firms' profit maximization with respect to $\tilde{x}_{ni}^j(z)$ taking as given the other firms' output, yields the following expressions for the equilibrium market shares and the single price in the market:

¹⁰An important caveat is that we assume that the number of sellers of j in n is sufficiently large for the firms to ignore strategic interactions. Additionally, we do not consider fixed costs of entering each market to avoid discontinuities in market shares (these discontinuities are usually avoided by assuming a continuum of firms with infinitely small fixed costs). The continuity of market shares is used in our proof of the existence of a general equilibrium of the model. However, all of the partial equilibrium results that follow in Sections 3 and 4 hold regardless of the existence or lack thereof of such fixed costs.

$$s_{ni}^j(z) = \begin{cases} 1 - \frac{\tilde{c}_{ni}^j(z)}{\tilde{p}_n^j} & \text{if } z \geq \left(\frac{d_{ni}^j w_i}{\tilde{p}_n^j} \right)^{1/1+\sigma^j} \equiv \underline{z}_{ni}^j; \\ 0 & \text{otherwise.} \end{cases} \quad (8)$$

$$\tilde{p}_n^j = \frac{1}{\sum_{i=1}^I \sum_{z \geq \underline{z}_{ni}^j} m_i^j(z) - 1} \sum_{i=1}^I \sum_{z \geq \underline{z}_{ni}^j} \tilde{c}_{ni}^j(z) m_i^j(z) \quad (9)$$

Note that the last expression is implied by (8) and the equilibrium condition $1 = \sum_{i=1}^I \sum_{z \in Z} s_{ni}^j(z) m_i^j(z)$, which is equivalent to (7). Using these two expressions, it can be verified that the Cournot equilibrium satisfies Assumption A.1 (see Appendix B, where we start by noting that if the vector (w) of wages is strictly positive, so is the vector of marginal costs $(\tilde{c}_n^j) \in \mathbb{R}^{I \times Z}$, which in turn implies $\sum_{z \geq \underline{z}_{ni}^j} m_i^j(z) > 1$). This Cournot equilibrium is characterized by the following features: (1) only a subset of the firms selling in the domestic market (i.e., the most efficient firms) also export and only an even more select group export to the more distant destinations; (2) consequently, only the higher qualities are shipped to the more distant destinations; (3) firms with lower marginal costs of exporting to n have both larger market shares and greater markups $\mu_{ni}^j(z) \equiv \tilde{p}_n^j / \tilde{c}_{ni}^j(z)$; (4) the price \tilde{p}_n^j and, therefore, markups decrease with the *intensity of competition*, which can be defined in terms of the number and average marginal cost of the active competitors in the market (i.e., the right-hand side of expression (9));¹¹ and (5) more-efficient firms have higher *measured marginal productivity* $\varrho_{ni}^j(z) \equiv \tilde{p}_n^j \cdot z^{1+\sigma^j} / d_{ni}^j = \mu_{ni}^j(z) \cdot w_i$.

Point 1 is a common key prediction of trade models with heterogeneous producers. Here, it is implied by the expression that determines the cutoff \underline{z}_{ni}^j for firms from source i to be active in destination n .¹² Note that in the Cournot model, this result does not require the existence of fixed costs of selling to each destination. Point 2 is also common to heterogenous-firm trade models with quality differentiation (e.g., Baldwin and Harrigan, 2011). The predictions in points 3 and 4 on the markups are different from the implications of the DSMC model (in which markups are identical across all of the firms and do not depend on the competition intensity) and consistent with the empirical evidence, which shows substantial heterogeneity and variability in markups across firms and time. Point 5 is also in contrast to the DSMC model, in which *measured marginal productivity* is constant across the firms from the same source country regardless of differences in efficiency.

¹¹Other models that generate endogenous variable markups include Bernard et al. (2003), who consider Bertrand competition, and Melitz and Ottaviano (2008), who consider non-CES utility and monopolistic competition.

¹²To see this, note that arbitrage implies that the efficiency cutoffs are higher for exporting than for selling in the domestic market. That is, the no arbitrage condition $d_{ni}^j \tilde{p}_{ii}^j \geq \tilde{p}_{ni}^j$ and expression (8) imply that $\underline{z}_{ni}^j \geq \underline{z}_{ii}^j$ for any $n \neq i$. The firms with z in the interval $(\underline{z}_{ii}^j, \min_{n \neq i} \{\underline{z}_{ni}^j\})$ only sell in the domestic market.

Under Cournot, trade liberalizations also have a pro-competitive effect on markups that is absent in the models based on DSMC such as Melitz (2003). This effect can easily be seen by considering a trade liberalization in a market n for good j sufficiently small such that we can take the destination country's income Y_n and the vector of wages (w_1, \dots, w_I) as constant. A reduction in trade frictions d_{ni}^j increases the markups of the exporters to n from each source country $i \neq n$ and reduces those of country- n firms in their home market (besides increasing the number and market shares of exporters and reducing those of the domestic producers).¹³ As pointed out in the Introduction, empirical studies find that greater exposure to international competition has a significant impact on markups and that this impact can be quantitatively important for the gains from trade (e.g., Tybout, 2003, Feenstra and Weinstein, 2010, Edmond, Midrigan and Xu, 2013).

General equilibrium

The model is closed with the following two equations stating that each country's income is equal to the sum of its firms' revenues and that the labor market clears for each country:

$$Y_i = \sum_{j=1}^J \sum_{z \in Z} \sum_{n=1}^I \alpha^j Y_n s_{ni}^j(z) m_i^j(z); \quad i = 1, \dots, I. \quad (10)$$

$$L_i = \sum_{j=1}^J \sum_{z \in Z} \sum_{n=1}^I \frac{d_{ni}^j}{z^{1+\sigma^j}} \frac{1}{\tilde{p}_{ni}^j(z)} \alpha^j Y_n s_{ni}^j(z) m_i^j(z); \quad i = 1, \dots, I. \quad (11)$$

Summarizing, the primitives of the model that characterize the different economies are the labor supplies $(L_i) \in \mathbb{R}_+^I$, the trade frictions $(d_{ni}) \in \mathbb{R}_+^{I \times I}$ and the potential producers across industries and efficiencies $(m_i^j(z)) \in \mathbb{N}^{J \times I \times Z}$. The distribution of producers across industries and efficiencies embody the available technology in each country. Given these primitives and for any vector of country aggregate incomes and wages $(Y, w) \in \mathbb{R}_{++}^{2I}$, the prices $\tilde{p}_{ni}^j(z)$ and market shares $s_{ni}^j(z)$ that appear in expressions (10) and (11) are determined according to our previous discussion of the partial equilibrium in each market n of each good j (e.g., in the particular case of Cournot competition, they are determined by eq. (8)–(9)). The following proposition, which is proven in Appendix A, establishes the existence of a general equilibrium of the economy:

¹³A reduction in d_{ni}^j decreases the marginal cost $\tilde{c}_{ni}^j(z)$ of exporters to destination n , thereby reducing \tilde{p}_n^j (eq. 9). If the number of active domestic producers is positive, then the reduction in \tilde{p}_n^j is relatively smaller than the reduction in d_{ni}^j and, therefore: (a) the efficiency cutoffs for exporters decrease, whereas the cutoff for domestic firms increases (see \underline{z}_{ni}^j in eq. 8); (b) within the set of active firms, exporters' markups $\tilde{p}_n^j/\tilde{c}_{ni}^j(z)$ and market shares increase, whereas domestic firms' decrease. Under Cournot, relative market shares also change within the original set of exporters. These latter changes are potentially very relevant and are discussed in the next section with regard to Assumption A.2 and the sign of $\partial^2 \ln s_{ni}^j(z) / \partial (d_{ni}^j w_i / \tilde{p}_n^j) \partial z$.

Proposition 1 *Let Assumption A.1 hold. For any triplet of vectors of population $((L_i) \in \mathbb{R}_+^I)$, trade frictions $((d_{ni}) \in \mathbb{R}_+^{I \times I})$, and potential producers $((m_i^j(z)) \in \mathbb{N}^{J \times I \times Z})$, there exist a vector of incomes and wages $(Y^*, w^*) \in \mathbb{R}_+^{2I}$ that satisfies the equilibrium conditions (10) and (11).*

3 Absolute Advantage and Quality

This section characterizes the countries' specialization within each good along the quality dimension. First, we introduce our concept of *AA*. Subsequently, we relate *AA* to the average quality of exports and also provide a simple characterization of how the ranges of qualities exported by different countries overlap.

3.1 Absolute Advantage

For each industry, how can we order countries according to the efficiency of their firms? That is, how can we define *Absolute Advantage*? With heterogeneous producers whose efficiencies overlap across countries, the answer is not unique. A natural candidate to order country distributions of firm efficiencies is FOSD. However, if we depart from the DSMC model, FOSD is insufficient to guarantee a basic aggregation property and it is then insufficient to serve as the basis for our analysis. Specifically, we show by means of a numerical example that a country whose distribution of firm efficiencies FOSD another country's does not necessarily have higher average productivity (even if both countries feature identical wage and trade frictions).¹⁴ Thus, predictions involving aggregates such as average productivity, exports and quality appear to require a condition stronger than FOSD to be valid beyond the DSMC model.

Define the average productivity of the firms from country i 's that sell good j in market n as

$$v_{ni}^j \equiv \frac{\sum_{z \in Z} \tilde{x}_{ni}^j(z) m_i^j(z)}{\sum_{z \in Z} l_{ni}^j(z) m_i^j(z)} = \sum_{z \in Z} \frac{z^{1+\sigma^j}}{d_{ni}^j} \frac{l_{ni}^j(z) m_i^j(z)}{\sum_{z \in Z} l_{ni}^j(z) m_i^j(z)},$$

where $l_{ni}^j(z)$ is the amount of labor used by a firm from country i with efficiency z to produce and export j to n . Consider an economy in which $Z = \{9.75, 10, 12\}$ and the vectors of firms (across efficiency categories) from countries 1 and 2 producing good j are $(m_1^j(z)) = (1, 4, 1)$ and $(m_2^j(z)) = (4, 1, 1)$, respectively. Clearly, the efficiency distribution of firms in country 1 FOSD the distribution in country 2. Suppose that $\sigma^j = d_{ni}^j = \tilde{p}_n^j = 1$ and $w_i = 95$ for both countries $i = 1, 2$ and a certain destination market n . In the Cournot equilibrium, we find $v_{n1}^j = 123.8$ and

¹⁴A similar example could be built in terms of average efficiency defined as $\sum_{z \in Z} z \cdot l_{ni}^j(z) m_i^j(z) / \sum_{z \in Z} l_{ni}^j(z) m_i^j(z)$.

$v_{n2}^j = 135.9$.¹⁵ Hence, although the firm efficiency distribution of country 1 FOSD the distribution of country 2, the average productivity of the exporters from country 2 is greater. To grasp some intuition about the source of the limitations of FOSD for ordering firm efficiency distributions note that although country 1's firm distribution FOSD country 2's, the converse is true if we truncate from below the distributions by excluding the lowest efficiency category (as it would happen if \tilde{p}_n^j were slightly lower, so that the least efficient firms exit the market). If we perform this truncation, then the new distributions of firms are (4,1) for country 1 and (1,1) for country 2. Also note that in our example, which is built using Cournot, the market shares of the firms with the lowest efficiency have *disproportionally* small market shares, so that average productivities are almost the same as those that would correspond to the truncated distributions of firms.

The definition of *AA* in this paper is based on the MLRP. In short, we say that a country has an *AA* over another country in a given industry if for any two categories of firm efficiency, the ratio of the number of firms in the high-efficiency category to the number in the low-efficiency category is larger in the first country.¹⁶ This property is sufficient to ensure some important aggregation properties. Note that the MLRP implies FOSD but the reverse is not true and that, unlike FOSD, the MLRP keeps the same order within a collection of distributions for any truncation of the distributions. For mathematical convenience, we assume that in each country there is a potential firm with the minimal efficiency in each industry¹⁷ and that if a country has any firm in a given efficiency category of an industry, then it also has firms (possibly inactive) in each of the categories corresponding to lower efficiencies. That is, for each i and j , we have $m_i^j(z_0) > 0$, and for each $z \in Z$ such that $z \leq \bar{z}_i^j$, we have $m_i^j(z) > 0$, where $\bar{z}_i^j \equiv \max \{z \in Z : m_i^j(z) > 0\}$. Formally, we define *AA* as follows:

Definition Consider two countries i' and i'' . Country i' has an *AA* over country i'' in industry j , denoted as $i' \succ_{AA}^j i''$, if $\bar{z}_{i'}^j \geq \bar{z}_{i''}^j$ and for every pair of efficiencies z_s and z_t such that $z_s > z_t$ and $z_t \leq \bar{z}_{i''}^j$, we have $m_{i'}^j(z_s)/m_{i'}^j(z_t) \geq m_{i''}^j(z_s)/m_{i''}^j(z_t)$. The *AA* is strict, denoted as $i' \succ_{AA}^j i''$, if $i' \succ_{AA}^j i''$ and $\bar{z}_{i'}^j > \bar{z}_{i''}^j$.

The case $i' \succ_{AA}^j i''$ and $i'' \succ_{AA}^j i'$ is denoted as $i' \sim_{AA}^j i''$. How strong is the MLRP ordering assumption? An important portion of the trade literature with heterogeneous producers assumes that firm efficiencies are distributed Pareto. Note that any family of Pareto distributions $\Pr(Z \leq$

¹⁵Firm and country market shares are $s_{ni}^j(9.75) = 0.0007$, $s_{ni}^j(10) = 0.05$, $s_{ni}^j(12) = 0.34$, $s_{n1}^j = 0.54$ and $s_{n2}^j = 0.39$. There would be a third country that would complete the market equilibrium.

¹⁶In a somewhat similar context with many skill levels, Costinot and Vogel (2010) also use the MLRP to compare skill abundance across countries.

¹⁷Note that because we can consider this minimum efficiency z_0 to be arbitrarily small, this assumption does not have any relevance for the equilibrium of the economy.

$z) = 1 - (z_0/z)^\theta$ indexed by the parameter θ and with common support (z_0, ∞) satisfies the MLRP. Hence, if we assume that firm efficiencies are distributed Pareto and allow the parameter θ to differ within industries across countries, then countries can be ordered within each industry in a non-trivial way according to (a continuous version of) the AA relation. Specifically, $i' \succ_{AA}^j i''$ if and only if $\theta_{i'}^j \leq \theta_{i''}^j$.¹⁸ Notwithstanding, Pareto (as well as Fréchet) is only a particular case of a distribution that bears the MLRP.¹⁹

3.2 Average Quality

We define the average quality of country i 's exports of good j to market n as²⁰

$$Q_{ni}^j \equiv \sum_{z \in Z} q^j(z) \frac{x_{ni}^j(z) m_i^j(z)}{\sum_{z \in Z} x_{ni}^j(z) m_i^j(z)}.$$

Given our definition of AA, quality-biased efficiency is sufficient to link AA to average efficiency and quality. However, to link wages and trade frictions to average quality we must impose some additional structure on the patterns of market shares. Higher trade frictions and wages affect average quality through two mechanisms. The first mechanism works through changes in the set of active firms: if the efficiency cutoff satisfies $\partial \underline{z}_{ni}^j / \partial (d_{ni}^j w_i) > 0$, then the least efficient producers leave the market at higher levels of the product $d_{ni}^j w_i$, thereby raising average quality. This is the type of mechanism emphasized in different contexts, following Melitz (2003) (e.g., Baldwin and Harrigan, 2011, on the impact of distance on export quality at the firm level). The second mechanism works through changes in the relative market shares within the set of active firms.

¹⁸Although it is often assumed in the literature that the parameter θ is identical across industries and countries, there does not appear to be any empirical basis for this assumption. In fact, if the parameter θ is close to 1 (as it has sometimes been found in connection to Zipf's law; see Axtell, 2001), small differences in this parameter can imply large differences in expected productivity. For example, recalling that $E[Z] = z_0 \theta / (\theta - 1)$, we find that a shift from $\theta' = 1.01$ to $\theta'' = 1.1$ implies a nine-fold difference in the expected firm productivity.

¹⁹Costinot, Donaldson and Komunjer (2012) assume that firm productivities are distributed Fréchet $F_i^j(z) = \exp[-([z - z_0] / \hat{z}_i^j)^{-\theta}]$, with $\hat{z}_i^j > 0$, $\theta > 1$, $z_0 = 0$, and support $[0, \infty)$, where \hat{z}_i^j is a county-industry specific parameter. These authors call this parameter the country's *fundamental productivity* in the industry. Differences in \hat{z}_i^j lead to different expected productivities across countries in industry j . Fréchet distributions indexed by the parameter \hat{z}_i^j is another particular case of a family of distributions that satisfies the MLRP. The approach in Costinot, Donaldson and Komunjer (2012) to ordering country productivities in a setting with heterogeneous producers is the closest to the approach used in this paper. It is worth noting that taking the scale parameter \hat{z}_i^j in Fréchet distributions as an analog of the location parameter z_0 in Pareto distributions could be misleading. Unlike differences in z_0 in Pareto distributions, differences in \hat{z}_i^j do not affect the support of the distribution (which may be difficult to justify from an economic point of view). Moreover, any truncation from below (as given by cutoffs \underline{z}) of two Pareto distributions with an identical parameter θ results in an identical distribution of efficiencies (thereby resulting in identical expected productivity and quality). This is not the case for two Fréchet distributions with an identical parameter θ but different \hat{z}_i^j .

²⁰In our previous numerical example, we find $Q_{n1}^j = 11.2$ and $Q_{n2}^j = 11.7$. Thus, although country 1's firm efficiency distribution FOSD the distribution of country 2, country 2's average quality is higher. Note that the MLRP does not hold in this example.

This mechanism is ignored in the models based on DSMC because the equilibrium of this market structure implies $\partial^2 \ln s_{ni}^j(z) / \partial z \partial (d_{ni}^j w_i) = 0$. However, as noted in the Introduction, as wages and trade frictions increase, the less-efficient firms' market shares could be reduced relatively less than the more-efficient firms' market shares (at least for some range), thereby reducing average exported quality. Contrarily, if $\partial^2 \ln s_{ni}^j(z) / \partial z \partial (d_{ni}^j w_i) > 0$, then the more-efficient producers have larger relative market shares at higher levels of frictions and wages. In this paper, we consider the following assumption:

A.2 For each j , n , and i there exists an efficiency cutoff $\underline{z}_{ni}^j \geq 0$ such that if $z \leq \underline{z}_{ni}^j$ then $s_{ni}^j(z) = 0$, whereas if $z > \underline{z}_{ni}^j$, then $s_{ni}^j(z) > 0$. This cutoff is a function of the ratio $d_{ni}^j w_i / \tilde{p}_n^j$, with $\frac{\partial \underline{z}_{ni}^j}{\partial (d_{ni}^j w_i / \tilde{p}_n^j)} \geq 0$. Moreover, for each z , the market share $s_{ni}^j(z) = s^j(\tilde{c}_{ni}^j(z) / \tilde{p}_n^j)$ satisfies that if $z > \underline{z}_{ni}^j$, then $\frac{\partial s_{ni}^j(z)}{\partial (\tilde{c}_{ni}^j(z) / \tilde{p}_n^j)} < 0$ and $\frac{\partial^2 \ln s_{ni}^j(z)}{\partial z \partial (d_{ni}^j w_i / \tilde{p}_n^j)} \geq 0$.

A.2b The condition on $\frac{\partial^2 \ln s_{ni}^j(z)}{\partial z \partial (d_{ni}^j w_i / \tilde{p}_n^j)} \geq 0$ holds with strict inequality.

It is straightforward to verify that the Cournot and DSMC equilibria satisfy Assumption A.2. Moreover, Cournot also satisfies A.2b, whereas in DSMC with a large number of producers we have $\frac{\partial^2 \ln s_{ni}^j(z)}{\partial (d_{ni}^j w_i / \tilde{p}_n^j) \partial z} = 0$.²¹

The condition on the cross derivative of $\ln s_{ni}^j(z)$ may be better understood with two applications. Consider the relative difference in the market shares in destination n of two firms that have an identical efficiency z but are from two different countries such that $d_{i'w} < d_{i''w}$. The condition implies that the relative differences in market shares are smaller when we compare firms with greater efficiency; i.e., $s^j\left(\frac{d_{i''w}}{z\tilde{p}}\right) / s^j\left(\frac{d_{i'w}}{z\tilde{p}}\right) < 1$ increases with z . Similarly, consider the ratio of a firm's market share in a foreign destination to its market share in the domestic market, $s^j\left(\frac{d_{ni} w_i}{z\tilde{p}_n}\right) / s^j\left(\frac{w_i}{z\tilde{p}_i}\right) < 1$ (where $d_{ni}^j / \tilde{p}_n^j \geq 1 / \tilde{p}_i^j$ because relative differences in prices cannot exceed trade frictions due to arbitrage). This ratio is greater for more efficient firms; i.e., trade frictions affect relatively less the market share of the more-efficient firms.²²

²¹However, in DSMC with a fixed cost of entering each destination market, the condition $\partial \underline{z}_{ni}^j / \partial (d_{ni}^j w_i / \tilde{p}_n^j) \geq 0$ in Assumption A.2 holds with strict inequality (as it always does in Cournot). In a model with a continuum of agents, the condition $\partial \underline{z}_{ni}^j / \partial (d_{ni}^j w_i / \tilde{p}_n^j) > 0$ has similar implications on the characterization of the equilibrium to those of Assumption A.2b. It is also interesting to note that the difference between DSMC and Cournot with respect to the strict inequality in the cross derivative of $\ln s_{ni}^j(z)$ is potentially important in certain contexts, as in the analysis of the efficiency gains that follow from trade liberalization.

²²The evidence in Eaton, Kortum and Kramarz (2011) on *normalized export intensities* can be interpreted as supportive of this condition. This index is a normalization of the ratio of a firm's sales in an export market with respect to its sales in the domestic market; i.e., $export\ intensity_{ni'}^j(k) = \frac{E_{ni'}^j(k) / \bar{E}_{ni'}^j}{E_{i'i'}^j(k) / \bar{E}_{i'i'}^j}$, where $E_{ni'}^j(k)$ denotes exports of j by firm k from i' to n and $\bar{E}_{ni'}^j$ denotes the average of this variable across the exporters from i' . Using data for French firms ($i' = \text{France}$) to 113 destinations, they show that $1 > \frac{E_{ni'}^j(j_{95}) / \bar{E}_{ni'}^j}{E_{i'i'}^j(j_{95}) / \bar{E}_{i'i'}^j} > \frac{E_{ni'}^j(j_{50}) / \bar{E}_{ni'}^j}{E_{i'i'}^j(j_{50}) / \bar{E}_{i'i'}^j}$, where j_{50} is the median and j_{95} is the 95th percentile exporter intensity. Furthermore, the latter ratio is about 2 orders of magnitude

Now, we can link export quality to AA , wages and trade frictions as follows:²³

Proposition 2 *Consider an equilibrium in which two countries i' and i'' export good j to market n ($n \neq i', i''$) and suppose that efficiency is quality-biased in industry j and Assumption A.2 holds. If $i' \succ_{AA}^j i''$ and $d_{ni'}^j w_{i'} \geq d_{ni''}^j w_{i''}$, then $Q_{ni'}^j \geq Q_{ni''}^j$. Moreover, if $i' \succ_{AA}^j i''$, or if $d_{ni'}^j w_{i'} > d_{ni''}^j w_{i''}$ and A.2b holds, then $Q_{ni'}^j > Q_{ni''}^j$.²⁴*

3.3 The Range of Exported Qualities

The model's equilibrium suggests a structure of international trade in which there is no complete specialization in any dimension: each good tends to be exported to each market by multiple firms from a variable number of countries; each country exports a wide range of qualities for each of its exported goods; and each country's range of exported qualities for each good is likely to overlap with other countries' ranges. We now examine some immediate predictions with regard to the overlap of the ranges of exported qualities for each good. We consider the particular characterization of the Cournot equilibrium although qualitatively similar arguments could be made invoking Assumption A.2 instead of equation (8).

From expressions (5) and (8), we have that if country i exports good j to destination n (i.e., if $\underline{z}_{ni}^j < \bar{z}_i^j$) then the interval of its exported qualities is $(\underline{q}_{ni}^j, \bar{q}_{ni}^j] = \left(\left(d_{ni}^j w_i / \tilde{p}_n \right)^{\sigma_j}, \left(\bar{z}_i^j \right)^{\sigma_j} \right]$. Therefore, for the set of countries that satisfy $\underline{z}_{ni}^j < \bar{z}_i^j$, the highest quality being exported to n is sourced from the country that has an AA in j over the other countries (i.e., it has the highest \bar{z}_i^j). In turn, the lowest qualities are exported from the countries with the lowest wages and trade frictions. If the differences in trade frictions d_{ni}^j across source countries are relatively small, then the lowest quality is exported by the country that has the lowest wage. Additionally, among exporters with similar wage levels, the closest country to the destination market is expected to export the lowest quality.

The first point, which is related to AA , is the most novel and implies that the highest qualities may not be exported by the richest countries. Although most rich countries are likely to have an AA over most poor countries in most industries, this technical supremacy cannot be taken

or more below 1 and the difference between this ratio and 1 appears to increase as the destination n becomes less popular (which can be interpreted as a signal of a greater trade friction d_{ni}). In terms of our variables, the previous inequalities are equivalent to $\frac{\bar{E}_{ni'}^j / Y_n}{\bar{E}_{i'i'}^j / Y_{i'}} > \frac{s_{ni'}^j(j95)}{s_{i'i'}^j(j95)} > \frac{s_{ni'}^j(j50)}{s_{i'i'}^j(j50)}$. This implies that the most export oriented firms have much larger relative market shares $s_{ni'}^j(k) / s_{i'i'}^j(k)$ than the remaining exporters. As long as the most export oriented firms are also the most efficient ones, this evidence is supportive of Assumption A.2.

²³Most propositions in this paper state the conditions in the hypothesis in terms of wages and incomes (in addition to AA and trade frictions). In Appendix C, we sketch a version of the model along the lines of the probabilistic trade models with a continuum of potential producers (Eaton and Kortum, 2002 and 2010) that could serve as the basis to restate the propositions in terms of exogenous general-state-of-technology parameters T_i and labor supplies L_i .

²⁴Similarly, we could also show that $v_{ni'}^j \geq v_{ni''}^j$.

for granted for all industries and all bilateral relationships. In combination with the other two predictions indicated in the paragraph above, this point implies that, for each good, the spectrums of qualities that are exported by the different countries can overlap in non-trivial ways. Figures 2a and 2b illustrate this point. The figures consider two countries R and P that export good j to destination n , such that $w_R > w_P$ and $d_{nR}^j = d_{nP}^j$. The interval of qualities exported by R and P are $[q(\underline{z}_{nR}^j), q(\bar{z}_R^j)]$ and $[q(\underline{z}_{nP}^j), q(\bar{z}_P^j)]$, respectively. Figure 2a considers the case in which $R \succ_{AA}^j P$, whereas Figure 2b considers the case $P \succ_{AA}^j R$. In the first case, country R exports the highest quality, whereas country P exports the lowest quality. In the second case, the poorer country P exports the highest as well as the lowest quality (and everything in between). Meanwhile, the richer country R only exports a proper subset of the qualities exported by P .²⁵

4 Specialization across Goods and Export Quality

In this Section, we link country horizontal specialization in a given good and wage to the average export quality of this good. This analysis requires extending the model to endogenize the number of firms. The reason is that the volume of exports of a given industry (and therefore, horizontal specialization) depends not only on the average exports per firm but also on the number of firms in the industry. This extension of the model is described in Subsection 4.1, in which we introduce a zero-profit entry condition. Then, in Subsection 4.2, we show that, conditional on having a *lower* wage, a country having an *AA* in good j over another country will have a greater international specialization in j , as measured by the ratio E_i^j/Y_i (where E_{ni}^j is country i ' exports of j to destination n and E_i^j is its total exports of j ; i.e., $E_i^j \equiv \sum_{n \neq i} E_{ni}^j$). Given Assumption A.5 below, a corollary of this latter result is that if a country shows higher specialization in good j and a *higher* wage, then it must have an *AA* in good j . Finally, combining these arguments with Proposition 2 we find that higher specialization in j and a higher wage lead to a greater average quality of the exports of j .

²⁵As an example, consider the exports of coffee by Guatemala, Ethiopia, and Mexico. Guatemala's and Ethiopia's per capita incomes are far below that of Mexico and their exports of unprocessed coffee have an average price that is slightly lower than Mexico's exports (as for 2006). This lower average price of exports from Guatemala and Ethiopia is likely to be the consequence of the export of some low quality coffees whose production is nonetheless profitable due to the low wages in these two countries. However, Guatemala and Ethiopia also produce some of the most expensive and appreciated coffee varieties in the world, which are unmatched in Mexico's production. This suggests that the richer country (Mexico) exports a proper subset of the qualities exported by the poorer countries (Guatemala and Ethiopia).

4.1 The Model Extended

We now introduce in the model a *zero-profit entry condition* that is motivated by the equilibrium that would result from a dynamic entry process à la Melitz (2003). However, this is a static model in which we do not specify the dynamics of entry but impose the zero-profit condition as an assumption. In Melitz's setting (amended here to consider differences across industries), there is an unbounded pool of prospective entrants into each country's industry who are identical prior to entry. To enter industry j , firms must first pay a sunk entry cost $\Phi^j > 0$, which is measured in labor units. Entrants in industry j of country i then draw their efficiency parameter z from a probability distribution with support Z and density $f_i^j(z)$, where $f_i^j(z) > 0$ for each $z \in Z$, and $\sum_{z \in Z} f_i^j(z) = 1$. In what follows, we assume that the vector $(m_i^j(z))$ of firms in the economy is such that the following condition holds:²⁶

A.3 For each $i = 1, \dots, I$ and $j = 1, \dots, J$ we have $\sum_{n=1}^I \sum_{z \in Z} \pi_{ni}^j(z) \cdot f_i^j(z) = \Phi^j w_i$.

Furthermore, we reinforce our definition of *AA* with an additional condition (A.4) and we explicitly impose the *AA* ordering across countries for each industry (A.5), as follows:

A.4 If $i' \succ_{AA}^j i''$, then for every pair of efficiencies z_t and z_s in Z such that $z_s \geq z_t$ we have $f_{i'}^j(z_s)/f_{i'}^j(z_t) \geq f_{i''}^j(z_s)/f_{i''}^j(z_t)$.

A.5 For each j and every pair of countries i' and i'' , either $i' \succ_{AA}^j i''$, $i'' \succ_{AA}^j i'$ or $i' \sim_{AA}^j i''$.

Note that the MLRP condition on the densities $f_i^j(z)$ (in Assumption A.4) is a condition on the *ex ante distribution* of firm efficiencies, whereas the MLRP condition on the $m_i^j(z)$ (used in the definition of *AA*) is a condition on the *actual distribution* of firm efficiencies. Certainly, if there were a continuum of firms per industry, the actual distribution of efficiencies would be the same as the distribution of the generating process of efficiencies $f_i^j(z)$. However, because the actual number of firms is a finite number, it is possible that MLRP holds for $f_i^j(z)$ but MLRP does not hold for $m_i^j(z)$. Hence, we impose the MLRP on both the generating process and the actual distribution of efficiencies.²⁷

²⁶This assumption is stronger than the conditions that would hold from free entry in a dynamic model with an integer number of firms. Those conditions would be given in terms of inequalities and would make the characterization of the equilibrium very intricate.

²⁷At any rate, imposing the MLRP on both the generating process and the actual distribution of efficiencies is not a stronger assumption than the standard assumption of a continuum of firms whose efficiency is exactly distributed according to a particular distribution such as Pareto.

4.2 Specialization across Goods and Quality

Conditional on size and trade frictions, a country that has an *AA* in j and a lower wage will appear to be relatively specialized in the good j . The argument can be outlined as follows. Clearly, individual firms that have higher efficiency and pay a lower wage export more and have higher profits. Then, at the country level, the MLRP used to define *AA* and Assumption A.2 ensure that average exports are *well-behaved*; i.e., the *average firm* of a country with an *AA* on j and a lower wage will export more of j . Next, we must consider how the number of firms in this country's industry j is affected by the higher *AA* and the lower wage. Everything else being equal, potential entrants to industry j in this country have greater expected profits than entrants to other countries. The non-profit entry condition A.3 is then fulfilled by having a lower price index \tilde{p}_i^j in this country. In fact, the necessary condition for this mechanism to work is that a decrease in the domestic industry price index \tilde{p}_i^j reduces the profits of domestic firms relatively more than the profits of the exporters to this country (see Assumption A.6 below). In this way, from the perspective of potential entrants to the country that has an *AA* on j and a lower wage, the lower price level of j at home balances out the larger expected profits from exports.²⁸

Next, the lower price level of j in the country with the *AA* and a lower wage implies greater demand for j in this market as well as lower imports (foreign firms find this market less profitable). Therefore, the total sales of the domestic firms in this country must be greater than the total sales of the domestic firms in the other countries (this is achieved by a combination of having a greater fraction of more-efficient firms and a larger number of firms). In turn, larger total sales by this country's firms in their very competitive domestic market (the tougher competition materializes in the lower price index \tilde{p}_i^j) imply larger exports to other destinations.

This result is made precise in the next proposition and the formal arguments are provided in the corresponding proof in Appendix A. Before, we state Assumption A.6 as follows:

A.6 For each j , we can define a positive valued function of the ratio $\tilde{c}_{ni}^j(z)/\tilde{p}_n^j$, which we denote as $\pi^j\left(\tilde{c}_{ni}^j(z)/\tilde{p}_n^j\right)$, such that $\pi_{ni}^j(z) = \pi^j\left(\tilde{c}_{ni}^j(z)/\tilde{p}_n^j\right) \cdot \alpha^j Y_n$. This function satisfies that if $z > z_{ni}^j$, then $\partial\pi^j/\partial\left(\tilde{c}_{ni}^j(z)/\tilde{p}_n^j\right) < 0$ and $\partial^2\pi^j/\partial d_{ni}\partial\left(w_i/\tilde{p}_n^j\right) > 0$.

Note that the operating profit that a seller from source i obtains in destination n can be written as $\pi_{ni}^j(z) = \left[1 - \frac{\tilde{c}_{ni}^j(z)}{\tilde{p}_n^j}\right] s_{ni}^j(z) \alpha^j Y_n$. It is then straightforward to verify that the Cournot (except for a firm that has a market share of 0.5 or more) and DSMC models are consistent with Assumption

²⁸A lower price index \tilde{p}_i^j means that, on average, the good j is cheaper in country i for a given quality. Because the average quality in the market of the country with the *AA* is higher, it might be that the average price of good j without adjusting for quality is also higher in this market.

A.6 by noting that for these market structures $\pi^j \left(\tilde{c}_{ni}^j(z)/\tilde{p}_n^j \right)$ is given by $\left[s^j \left(\tilde{c}_{ni}^j(z)/\tilde{p}_n^j \right) \right]^2$ and $\frac{1}{\gamma} s^j \left(\tilde{c}_{ni}^j(z)/\tilde{p}_n^j \right)$, respectively.

To better understand the assumption $\partial^2 \pi^j / \partial d_{ni} \partial \left(w_i / \tilde{p}_n^j \right) > 0$, consider the following implication that compares two producers from two different countries that have the same efficiency and pay the same wage. An increase in their output price index in one of the domestic markets benefits the domestic producer more than the exporter to this market; i.e., if $\tilde{p}' > \tilde{p} > 0$, then $\pi \left(\frac{1}{\tilde{p}'} \frac{w}{z^{1+\sigma}} \right) - \pi \left(\frac{d}{\tilde{p}'} \frac{w}{z^{1+\sigma}} \right) > \pi \left(\frac{1}{\tilde{p}} \frac{w}{z^{1+\sigma}} \right) - \pi \left(\frac{d}{\tilde{p}} \frac{w}{z^{1+\sigma}} \right)$, where $d > 1$. If this condition did not hold, then relative price reductions in the domestic market (which are then shown to be the result of the greater entry of domestic firms) would not help to reach the zero-profit condition A.3. Another implication of this assumption is that a firm's profits are more negatively affected by a reduction in the domestic-market price index of their output than by an identical reduction in an export-market price index.

Proposition 3 *Consider an equilibrium in which two countries i' and i'' export good j , and let Assumptions A.2 – A.4 and A.6 hold. If $i' \succ_{AA}^j i''$, $w_{i'} \leq w_{i''}$, $d_{i'}^j = d_{i''}^j$ and $Y_{i'}^j = Y_{i''}^j$, then:*

1. *the ratio of the price index of good j to the wage is lower (in quality-adjusted units) in the domestic market of country i' ; i.e., $\tilde{p}_{i'}^j / w_{i'} \leq \tilde{p}_{i''}^j / w_{i''}$.*
2. *country i' has a greater international specialization in good j ; i.e., $E_{i'}^j / Y_{i'} \geq E_{i''}^j / Y_{i''}$.*

Moreover, if in addition to the previous conditions, $i' \succ_{AA}^j i''$ and Assumption A.2b holds, then $E_{i'}^j / Y_{i'} > E_{i''}^j / Y_{i''}$.

Next, we link horizontal specialization (rather than AA, which we did in Section 3) to quality. The following corollary is an intermediate step in showing this link.

Corollary 4 *Consider an equilibrium in which two countries i' and i'' export good j , and let Assumptions A.2 – A.6 hold. If $E_{i'}^j / Y_{i'} > E_{i''}^j / Y_{i''}$, $w_{i'} \geq w_{i''}$, $d_{i'}^j = d_{i''}^j$ and $Y_{i'}^j = Y_{i''}^j$, then $i' \succ_{AA}^j i''$. Moreover, if $E_{i'}^j / Y_{i'} = E_{i''}^j / Y_{i''}$, $w_{i'} = w_{i''}$ and Assumption A.2b holds, then $i' \sim_{AA}^j i''$.*

To verify the corollary, note that if $w_{i'} \leq w_{i''}$ and $E_{i''}^j / Y_{i''} > E_{i'}^j / Y_{i'}$, then Proposition 3 implies that $i' \succ_{AA}^j i''$ is impossible and, therefore, $i'' \succ_{AA}^j i'$ (by Assumption A.5).²⁹ Using this corollary, we can now substitute the condition in Proposition 2 that appears in terms of AA by a condition in terms of the export ratios E_i^j / Y_i , thereby linking horizontal specialization and wages to the average export quality of each good.

²⁹This last statement in the corollary follows from A.2b and $i' \succ_{AA}^j i''$ (or $i'' \succ_{AA}^j i'$, respectively), which imply $E_{i'}^j / Y_{i'} > E_{i''}^j / Y_{i''}$ (or $E_{i'}^j / Y_{i'} < E_{i''}^j / Y_{i''}$, respectively).

Corollary 5 *Consider an equilibrium in which two countries i' and i'' export good j to market n ($n \neq i', i''$), and let Assumptions A.2 – A.6 hold. Suppose that efficiency in industry j is quality-biased. If $E_{i'}^j/Y_{i'} > E_{i''}^j/Y_{i''}$, $w_{i'} \geq w_{i''}$, $d_{i'}^j = d_{i''}^j$ and $Y_{i'} = Y_{i''}$, then $Q_{ni'}^j > Q_{ni''}^j$. Moreover, if A.2b also holds in addition to Assumptions A.2–A.6, and if $E_{i'}^j/Y_{i'} \geq E_{i''}^j/Y_{i''}$, $w_{i'} > w_{i''}$, $d_{i'}^j = d_{i''}^j$ and $Y_{i'} = Y_{i''}$, then $Q_{ni'}^j > Q_{ni''}^j$.*

5 US imports of Apparel and Clothing Accessories

The measurement of quality involves serious methodological issues and remains an active area of research.³⁰ For instance, prices might not be a good proxy for quality. More-efficient producers may sell at lower prices in monopolistic competition markets in spite of producing higher quality because they may apply identical markups as the less-efficient producers and have lower marginal costs.³¹ This is especially problematic for the use of prices as a proxy for quality when, as in this paper, we are interested in the link between relatively high sales (horizontal specialization), which may tend to be associated to lower prices, and high quality. Thus, a systematic test of the predictions in this paper’s model would require a specific effort on the measurement of quality and is left for future research. However, it is convenient to provide an empirical illustration of the main prediction of the paper. Note that, although low unit values might not be indicative of low quality if relative sales are high, high unit values and high relative sales are difficult to explain without referring to high quality. We exploit this circumstance to use unit values as proxies for quality to explore the correlation between horizontal specialization and the average unit value of exports in the apparel and clothing accessories sector.

We use the data on exports to the US of the 233 6-digit products included in chapters 61 and 62 (apparel and clothing accessories) of the Harmonized System nomenclature, revision 1996. This sector exhibits some interesting characteristics for this exercise: it is the manufacturing sector with the largest set of exporting countries to the US (over 100 exporters that include low-, medium-, and high-income countries); it contains many different 6-digit products (233); and unit values show significant differences (after elimination of outliers, the coefficient of variation of the product unit prices across countries is 1.02 when averaged across the 233 products). Using a single destination country (the US) has the advantage of eliminating the necessity to control for potentially relevant

³⁰Khandelwal (2010), Hallak and Schott (2011), and Feenstra and Romalis (2012) are important contributions in this respect.

³¹Moreover, in industries exhibiting decreasing marginal costs, more-efficient firms may have even higher incentives to reduce prices regardless of their potentially higher quality. Recent estimates indicate the existence of significant increasing returns to scale in most industries that go beyond the existence of a fixed cost (Diewert and Fox, 2008). In this respect, the textile industry may be one of the least problematic in using use price as a proxy for quality because it is one of the very few sectors for which increasing returns are rejected.

characteristics of the destination market.³²

5.1 Empirical Procedure

We run two types of regressions. First, we pool in the same regressions all of the 233 products. Thus, the first equation to be estimated is

$$\ln p_{US,i}^j = \delta_1^j + \delta_2 \ln HS_i^j + \delta_3 \ln PCGDP_i + \delta_4 \ln d_{US,i} + \delta_5 \ln GDP_i + u_i^j, \quad (12)$$

where superscript j indicates one of the 233 products at the 6-digit level, $p_{US,i}^j$ is the average unit value of country i 's exports of good j to the US (the ratio of the value of exports over the quantity exported), δ_1^j is a product j fixed effect to control for differences in unit values across goods, HS_i^j is the measure of the horizontal specialization of country i in good j , $PCGDP_i$ is the exporter's per capita GDP used as a proxy for its wage level, $d_{US,i}$ is the average distance between the exporter's major cities and the US's major cities, GDP_i is the exporter's GDP, and u_i^j is the error term. Second, we run independent panel regressions for each product j using annual data for a short period of time, as follows:

$$\ln p_{US,it}^j = \delta_{1t}^j + \delta_2^j \ln HS_{it}^j + \delta_3^j \ln PCGDP_{it} + \delta_4^j \ln d_{US,i} + \delta_5^j \ln GDP_{it} + u_{it}^j, \quad (12a)$$

where subscript t indicates the time period, and δ_{1t}^j is a time fixed effect to control for differences in unit values across time. Each of these two types of regressions is run using two alternative HS_i^j measures: the share of exports of j in the country's GDP (E_i^j/GDP_i), which is the measure that directly stems from the theoretical model; and the country's revealed comparative advantage in j ($RCA_i^j = (E_i^j/E_i) / (E_W^j/E_W)$), where $E_i \equiv \sum_{j=1}^J E_i^j$ and subscript W refers to world magnitudes), which is Balassa (1965)'s popular measure of specialization across goods.³³

³²The production of an important portion of the apparel and clothing accessories sector has been offshored from rich countries to low-wage countries. However, offshoring does not necessarily break the link between *AA* and quality, *conditional on wages*. The firms that offshore the production of the higher-quality varieties are expected to search for more experienced workers and middle managers. Because these factors are more likely to be found in countries that already have a specialization in the industry, the offshoring of the higher-quality products is more likely to be directed toward countries whose specialization in the industry is already high (for a given wage level).

³³As an additional control for country i 's market access (or trade frictions), we could include the ratio of total exports to GDP, E_i/GDP_i , in the equation. It turns out that if we include this variable, it is then indifferent to use the ratio E_i^j/GDP_i or RCA_i^j as the measure of horizontal specialization. To see this, note that

$$\begin{aligned} \ln p_{US,i}^j &= \delta_1^j + \delta_2 \ln \left(E_i^j / GDP_i \right) + \delta_3 \ln PCGDP_i + \delta_4 \ln d_{US,i} + \delta_5 \ln GDP_i + \delta_6 \ln (E_i / GDP_i) + u_i^j \\ &= \left[\delta_1^j + \delta_2 \ln \left(E_W^j / E_W \right) \right] + \delta_2 \ln RCA_i^j + \delta_3 \ln PCGDP_i + \delta_4 \ln d_{US,i} + \delta_5 \ln GDP_i + (\delta_6 + \delta_2) \ln (E_i / GDP_i) + u_i^j. \end{aligned}$$

We also estimated this last equation and found E_i/GDP_i to be not significant, whereas the coefficients and significance for the remaining variables were almost identical to those found in the estimation of equation (12) with $HS_i^j = RCA_i^j$.

Note that the use of these two measures of horizontal specialization in these regressions may involve two potential econometric problems. First, on the left-hand side of the regression equations, we have $\ln p_{US,i}^j = \ln E_{US,i}^j - \ln x_{US,i}^j$, while on the right-hand side, we have either $\ln E_i^j / GDP_i = [\ln E_i^j - \ln GDP_i]$ or $\ln RCA_i^j = [\ln E_i^j - \ln E_i] - [\ln E_W^j - \ln E_W]$. Because E_i^j includes $E_{US,i}^j$ as one of the components, measurement errors in $E_{US,i}^j$ could be carried into E_i^j . Thus, if $E_{US,i}^j$ represents an important component of E_i^j , the estimation of δ_2^j could have an upward bias. Second, US country-specific trade barriers and agreements can simultaneously affect the total value of a country's exports to the US (and to the world because the US market could be a significant portion of the world market) and the average unit value of exports to the US. Specifically, tariffs and quotas tend to increase the import unit values (because they tend to increase the average quality of imports for similar reasons as those stemming from higher transportation costs) while reducing the total volume of these imports. Thus, from the point of view of the exporting country, tariffs and quotas on a given good tend to reduce the volume of exports (and, therefore, the specialization of the country) in that good, while the export unit value of the good increases. The opposite effects would occur in the case of preferential trade agreements.³⁴ All of these phenomena (tariffs, quotas and preferential trade agreements) would introduce a negative bias in the estimation of δ_2^j .

These potential problems can be solved by using measures for the countries' horizontal specialization that exclude the exports to the US. These measures are denoted by $E_i^{exUS,j} / GDP_i$ and $RCA_i^{exUS,j}$ and defined as follows:

$$E_i^{exUS,j} / GDP_i \equiv \frac{E_i^j - E_{US,i}^j}{GDP_i}; \quad RCA_i^{exUS,j} \equiv \frac{E_i^j - E_{US,i}^j}{E_i - E_{US,i}} / \frac{E_W^j - E_{US,W}^j}{E_W - E_{US,W}}.$$

Thus, country i 's exports of j to the US, $E_{US,i}^j$, which are used to calculate the left-hand side unit values $p_{US,i}^j$, do not enter the calculation of the new measures of horizontal specialization. Hence, there is no reason to expect that measurement errors in $E_i^{exUS,j} / GDP_i$ and $RCA_i^{exUS,j}$ are correlated with measurement errors in $p_{US,i}^j$. Moreover, $E_i^{exUS,j} / GDP_i$ and $RCA_i^{exUS,j}$ are unlikely to be correlated with potentially omitted determinants of $p_{US,i}^j$ such as US trade barriers and agreements because these two measures only depend on the exports of country i to countries other than the US. Therefore, using $E_i^{exUS,j} / GDP_i$ and $RCA_i^{exUS,j}$ directly as regressors in place of E_i^j / GDP_i and RCA_i^j , respectively, or as instruments for E_i^j / GDP_i and RCA_i^j eliminates the potential econometric problems that we discussed above.

This may explain why the estimated coefficients for E_i / GDP_i and RCA_i^j are so similar in Table 1.

³⁴FDI by large importing discount chain stores (e.g., Wal-Mart and Kmart) could also have similar (symmetric) effects: they would simultaneously increase a country's exports to the US and the world while lowering the unit value of its exports to the US. See Gereff (1999) for the importance of large chain stores for imports of apparel.

5.2 Data

The trade data on quantities (in Tons) and values at FOB prices are from the BACI database of the CEPII.³⁵ The pooled regressions use the data for 2006, which is the year that maximizes the number of observations. The independent regressions for each product use 2005–2008 panel data (the original UN Comtrade database provides less accurate data on physical quantities for most commodities prior to 2005).

Although the data from BACI have previously been verified for consistency, they still contain a noticeable number of outliers. Moreover, for each product, some of the countries are reported to export an extremely small number of units to the US. These small numbers raise doubts about the true character of the countries as producers and exporters of the product. The observations for these countries are likely to reflect marginal and atypical commercial activities and re-exports. To avoid allowing the econometric results to depend on a small number of outliers and on minuscule occasional exporters, two filters are applied to these data. First, for each product at the 6-digit level, we exclude all observations whose import unit value is larger than 10 times or smaller than 1/10 of the median unit value of the corresponding year. Second, for each product, we drop all observations from countries whose exports in physical units are less than 1/10,000 of the mean export per country in the sample.

The data on the distances between the exporters and the US are based on the weighted bilateral distances between the countries' largest cities, as also provided by the CEPII. *PCGDP* and *GDP* data are from the WDI of the World Bank and correspond to the PPP values in constant 2005 international dollars.

5.3 Results

Table 1 summarizes the results from the estimation of equation (12) by pooling in a single regression the 2006 data for all of the 6-digit products included in chapters 61 and 62 of the HS-96. The equation includes 233 fixed effects (one for each product) and the data include approximately 12,000 observations. The results using LS are shown in columns 1 and 3, whereas columns 2 and 4 show the results using 2SLS with $E_i^{exUS,j}/GDP_i$ and $RCA_i^{exUS,j}$, respectively, as instruments.³⁶ Standard errors are computed clustering by country. In all of the four regressions, both measures of

³⁵BACI is the world trade database developed by the CEPII, which provides bilateral values and quantities of exports at the HS 6-digit product disaggregation. This database uses original data provided by the United Nations Statistical Division (COMTRADE database) and reconciles the declarations of the exporter and the importer. See Gaulier and Zignago (2010) for details.

³⁶The measures of horizontal specialization that exclude the exports to the US have a very high predicting power for the measures that include them. For instance, the F -statistics of the first stage regressions of all of the IV estimations that include the RCA measure in either of the two tables, are never below 100.

horizontal specialization are positive and significant at the 1% level and show a very similar positive coefficient. Furthermore, $PCGDP$ is always positive and significant, which is consistent with the previous results in the literature (e.g., Schott 2004), whereas the remaining controls (distance and exporter size) are not significant at any level.

Table 2 summarizes the results from independent estimations of equation (12a) for each of the 6-digit products that have at least 50 different exporting countries to the US. This condition reduces the number of goods to 113. We use a panel of annual data for the 2005–2008 period. The estimation method is 2SLS. In panel 1, we use $E_i^{exUS,j}/GDP_i$ as an instrument of E_i^j/GDP_i , whereas in panel 2, we use $RCA_i^{exUS,j}$ as an instrument of RCA_i^j . Standard errors are computed clustering by country. For each panel and for the columns 2–6 of the results, the figures in each row show the percentage of the total number of regressions (one for each product) that yield either a positive or a negative sign at different levels of statistical significance (the percentages always refer to the 113 products). The coefficients found for both measures of horizontal specialization are similar and overwhelmingly positive, with either 60.2% or 50.4% of the products showing significant coefficients at the 10% level, depending on the measure being used, and 50.4% or 43.4% of the products showing significant coefficients at the 5% level.

The estimates for the remaining coefficients deserve some brief comments. Nearly all of the products show a positive and significant coefficient for exporter per capita GDP. Thus, far from reducing the significance of $PCGDP$ for export unit values, regressing it together with a measure of horizontal specialization appears to increase its significance. Distance appears not to be significant for apparel products,³⁷ whereas exporter size is positively correlated with average quality for a sizable portion of products. This latter effect deserves further investigation in the future.³⁸

Overall, the data on the exports of apparel and clothing accessories to the US appear to be consistent with the main implication of the model. Conditional on income, higher international specialization in apparel and clothing accessories tends to be associated with higher average export quality as proxied by unit values. However, this is a very limited empirical exercise. Because unit values might not be a good proxy for quality in many industries, conducting a systematic empirical test of the predictions of this model’s paper will require a more sophisticated empirical approach

³⁷This result is not inconsistent with previous studies. Although export prices and distance to destination are positively correlated in most industries (Baldwin and Harrigan, 2010), Johnson (2012) finds that prices are decreasing in the difficulty of entering the destination markets in several important industries that include apparel.

³⁸The following argument could help explain a positive sign of GDP. If conditional on AA , GDP size has a negative effect on horizontal specialization in the apparel and clothing accessories sector (e.g., because, in contrast to other sectors, there are no economies of scale in this sector), then a large GDP and high specialization would be indicative of a high AA in this sector and, therefore, we would expect higher average export quality. At any rate, an exploration of this argument would require an analysis of the effect of size on horizontal specialization that is beyond the scope of this paper.

to capture quality than the approach applied in this exercise.

6 Concluding Comments

Empirical research has documented the importance of country specialization across both the horizontal and the vertical dimensions of goods when characterizing the current patterns of trade. This paper analyzes the interaction between these two dimensions of specialization. In the equilibrium of this paper’s model, each good tends to be exported to each market by a finite number of heterogeneous producers from more than one country. Moreover, each country exports a range of qualities for each good that overlaps with the ranges of other countries following non-trivial patterns that relate to differences in wages, trade frictions and absolute advantage. The main result is that, conditional on wages and other variables and specifications, the average quality of a country’s exports in a given industry increases with the country’s international specialization in the industry.

There appears to be a number of relevant directions for further research. Introducing demand non-homotheticities in the model and conducting a systematic empirical investigation of its predictions are two of these directions. Also, the combination of the MLRP assumption on the firm efficiency distributions and the assumptions on the cross-derivatives of market shares and operating profits that we use here appear to provide a fruitful and fairly general basis for the analysis of aggregates in models with heterogeneous producers. This combination of assumptions may aid in generalizing prior results in the trade literature that have been developed under particular efficiency distributions such as Pareto or particular market structures such as DSMC. From the point of view of economic policy, a frequent goal of advanced countries in light of the increasing competition from lower-wage countries is to increase their specialization in the higher-quality varieties of each good. The analysis in this paper of the connection between the horizontal and the vertical dimensions of specialization may help to understand in which industries a country has better opportunities to evolve *from exporting quantity to exporting quality*.

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A Relegated Proofs of the Propositions

We borrow some concepts from statistics as follows. Let $G_i(z)$ be a cumulative distribution function $G_i : Z \rightarrow [0, 1]$. Then, $G_{i'}(z) \succ_{FOSD} G_{i''}(z)$ indicates that $G_{i'}(z)$ weakly first-order stochastically dominates $G_{i''}(z)$, whereas $G_{i'}(z) \succ_{FOSD} G_{i''}(z)$ indicates that $G_{i'}(z) \succ_{FOSD} G_{i''}(z)$ holds but $G_{i''}(z) \succ_{FOSD} G_{i'}(z)$ does not. The following lemma is recurrently used in this Appendix:

Lemma 1 *Consider two countries i' and i'' that produce good j ; a mapping $h : Z \rightarrow \mathbb{R}_+$ that satisfies $h(\bar{z}_{i'}^j) > 0$ and $h(\bar{z}_{i''}^j) > 0$; and the cumulative distribution functions $G_i : Z \rightarrow [0, 1]$, $i = i', i''$, which are defined as*

$$G_i(z_s) \equiv \sum_{z=z_0}^{z_s} \frac{h(z) \cdot m_i^j(z)}{\sum_{z=z_0}^{\bar{z}} h(z) \cdot m_i^j(z)}.$$

If $i' \succ_{AA}^j i''$, then $G_{i'}(z) \succ_{FOSD} G_{i''}(z)$. Moreover, if $i' \succ_{AA}^j i''$, then $G_{i'}(z) \succ_{FOSD} G_{i''}(z)$.

Proof of Lemma 1

To show that $i' \succ_{AA}^j i''$ implies $G_{i'}(z) \succ_{FOSD} G_{i''}(z)$, we proceed by contradiction and suppose that there is $z_t \in Z$, $z_t \leq \bar{z}_{i''}^j$, such that $G_{i'}(z_t) > G_{i''}(z_t)$. Thus,

$$\begin{aligned} G_{i'}(z_t) &= \frac{\sum_{z=z_0}^{z_t} h(z) m_{i'}^j(z)}{\sum_{z=z_0}^{\bar{z}} h(z) m_{i'}^j(z)} = \frac{1}{1 + \left[\sum_{z=z_{t+1}}^{\bar{z}} h(z) m_{i'}^j(z) \right] / \left[\sum_{z=z_0}^{z_t} h(z) m_{i'}^j(z) \right]} \\ &> G_{i''}(z_t) = \frac{\sum_{z=z_0}^{z_t} h(z) m_{i''}^j(z)}{\sum_{z=z_0}^{\bar{z}} h(z) m_{i''}^j(z)} = \frac{1}{1 + \left[\sum_{z=z_{t+1}}^{\bar{z}} h(z) m_{i''}^j(z) \right] / \left[\sum_{z=z_0}^{z_t} h(z) m_{i''}^j(z) \right]}. \end{aligned} \quad (13)$$

To verify that the denominators are strictly positive, note that the hypothesis $0 \leq G_{i''}(z_t) < G_{i'}(z_t) \leq 1$ guarantees $\sum_{z=z_0}^{z_t} h(z) m_{i''}^j(z) > 0$ and, therefore, implies that $h(z_s) > 0$ for some

$z_s \leq z_t < \bar{z}_{i''}^j \leq \bar{z}_i^j$, which in turn leads to $0 < h(z_s)m_{i''}^j(z_s) \leq \sum_{z=z_0}^{z_t} h(z)m_{i''}^j(z)$ (recall that for each $z \in Z$ such that $z \leq \bar{z}_i^j$, we have $m_i^j(z) > 0$). Reorganizing terms in (13) and dividing the expressions on the left- and the right-hand sides by $m_{i'}^j(z_t)$ and $m_{i''}^j(z_t)$, respectively, the inequality becomes

$$\frac{\sum_{z=z_{t+1}}^{\bar{z}} h(z) \cdot m_{i'}^j(z)/m_{i'}^j(z_t)}{\sum_{z=z_0}^{z_t} h(z) \cdot m_{i'}^j(z)/m_{i'}^j(z_t)} < \frac{\sum_{z=z_{t+1}}^{\bar{z}} h(z) \cdot m_{i''}^j(z)/m_{i''}^j(z_t)}{\sum_{z=z_0}^{z_t} h(z) \cdot m_{i''}^j(z)/m_{i''}^j(z_t)}. \quad (14)$$

Compare the two numerators. As $m_{i'}^j(z)/m_{i'}^j(z_t) \geq m_{i''}^j(z)/m_{i''}^j(z_t)$ for every $z \in Z$ and $z \geq z_t$ (because $i' \succ_{AA}^j i''$), and $h(z)$ is positive valued, we have $\sum_{z=z_{t+1}}^{\bar{z}} h(z) \cdot m_{i'}^j(z)/m_{i'}^j(z_t) \geq \sum_{z=z_{t+1}}^{\bar{z}} h(z) \cdot m_{i''}^j(z)/m_{i''}^j(z_t)$. Now, compare the two denominators. As $m_{i'}^j(z)/m_{i'}^j(z_t) \leq m_{i''}^j(z)/m_{i''}^j(z_t)$ for every $z \in Z$ and $z \leq z_t$ (because $i' \succ_{AA}^j i''$), we have $\sum_{z=z_0}^{z_t} h(z) \cdot m_{i'}^j(z)/m_{i'}^j(z_t) \leq \sum_{z=z_0}^{z_t} h(z) \cdot m_{i''}^j(z)/m_{i''}^j(z_t)$. These two inequalities contradict the inequality in (14) and, therefore, the initial hypothesis. Hence, $G_{i'}(z_t) \leq G_{i''}(z_t)$ for any $z_t, z_t \leq \bar{z}_{i''}^j$. Moreover, for every $z \in Z$ such that $z \geq \bar{z}_{i''}^j$ we have $G_{i'}(z) \leq G_{i''}(z) = 1$. Therefore, $G_{i'}(z) \succ_{FOSD} G_{i''}(z)$.

Finally, consider the case $i' \succ_{AA}^j i''$. Taking into account $m_{i''}^j(z) = 0$ for $z > \bar{z}_{i''}^j$, $h(\bar{z}_{i'}^j) \cdot m_{i'}^j(\bar{z}_{i'}^j) > 0$ and $\bar{z}_{i''}^j < \bar{z}_{i'}^j$, we deduce $G_{i'}(\bar{z}_{i''}^j) < G_{i''}(\bar{z}_{i''}^j) = 1$. Therefore, $G_{i'}(z) \succ_{FOSD} G_{i''}(z)$. ■

Proof of Proposition 1

Recall from Subsection 2.2 and Assumption A.1 that prices $\tilde{p}_{ni}^j(z)$, price indexes \tilde{p}_n^j , marginal costs $\tilde{c}_{ni}^j(z)$ and market shares $s_{ni}^j(z)$ are continuous and positive-valued functions of the vector of wages $(w) \in \mathbb{R}_{++}^I$. Normalize the labor supply units such that $\sum_{i=1}^I L_i = 1$ and consider the following continuous and positive-valued mappings $\Psi_i(Y, w) : R_{++}^{2I} \rightarrow R_+$ and $\Phi_i(Y, w) : R_{++}^{2I} \rightarrow R_+$:

$$\Psi_i(Y, w) \equiv \sum_{j=1}^J \sum_{z \in Z} \sum_{n=1}^I \alpha^j Y_n s_{ni}^j(z) m_i^j(z); \quad i = 1, \dots, I.$$

$$\Phi_i(Y, w) \equiv w_i + \left[\min \left\{ 1, \sum_{j=1}^J \sum_{z \in Z} \sum_{n=1}^I \frac{d_{ni}^j}{z^{1+\sigma^j}} \frac{1}{\tilde{p}_{ni}^j(z)} \alpha^j Y_n s_{ni}^j(z) m_i^j(z) - L_i \right\} \right]^2; \quad i = 1, \dots, I.$$

The first mapping is just expression (10) for each country's income, whereas the second mapping is a simple continuous transformation of the labor excess demand for each country that corresponds to expression (11). In order to extend the domain of $\Psi_i(Y, w)$ and $\Phi_i(Y, w)$ to all the vectors in R_{++}^{2I} we have to check their boundedness as Y_i or w_i go to zero for some i . Market shares are bounded between 0 and 1 (the bound is implied by the market equilibrium condition $\sum_{i=1}^I \sum_{z \in Z} s_{ni}^j(z) m_i^j(z) = 1$), and so are the functions $\Psi_i(Y, w)$. In turn, the functions $\Phi_i(Y, w)$ are also bounded between 0 and 1 (note that $0 < (-L_i)^2 < 1$). Thus, we define

$\bar{\Psi}_i(Y', w') : R_+^{2I} \rightarrow R_+$ and $\bar{\Phi}_i(Y', w') : R_+^{2I} \rightarrow R_+$ as $\bar{\Psi}_i(Y', w') = \lim_{\{(Y, w)\} \rightarrow (Y', w')} \Psi_i(Y, w)$ and $\bar{\Phi}_i(Y', w') = \lim_{\{(Y, w)\} \rightarrow (Y', w')} \Phi_i(Y, w)$, where the sequences $\{(Y, w)\}$ take values in \mathbb{R}_{++}^{2I} .

Now, let Δ^{2I} be the standard $2I$ -dimensional simplex $\Delta^{2I} = \left\{ \delta \in \mathbb{R}^{2I} \mid \delta_i \geq 0, \text{ and } \sum_{i=1}^{2I} \delta_i = 1 \right\}$. Define the mapping $\Gamma(\delta) : \Delta^{2I} \rightarrow \Delta^{2I}$ as follows:³⁹

$$\Gamma(Y, w) = \frac{1}{\lambda(Y, w)} \begin{pmatrix} \bar{\Psi}_1(Y, w) \\ \dots \\ \bar{\Psi}_I(Y, w) \\ \bar{\Phi}_1(Y, w) \\ \dots \\ \bar{\Phi}_I(Y, w) \end{pmatrix}, \text{ where } \lambda(Y, w) \equiv \sum_{i=1}^I [\bar{\Psi}_i(Y, w) + \bar{\Phi}_i(Y, w)]. \quad (15)$$

As $\bar{\Psi}_i(Y, w)$ and $\bar{\Phi}_i(Y, w)$ are positively valued and continuous in (Y, w) , so is $\Gamma(Y, w)$ (note that $\lambda(Y, w)$ is strictly positive because at least one of the coordinates of each δ is strictly positive and $\sum_{i=1}^I \sum_{z \in Z} s_{ni}^j(z) m_i^j(z) = 1$ for each n and j , which implies that at least one term in the sum that defines $\lambda(Y, w)$ is strictly positive). Furthermore, $\Gamma(Y, w)$ maps a compact non-empty set into itself. Therefore, by the Brouwer fixed point theorem, there exist a fixed point $(Y^*, w^*) = \Gamma(Y^*, w^*)$.

Next, let us confirm that the fixed point (Y^*, w^*) solves (10) and (11), and is strictly positive. First, we show that $\lambda^* \equiv \lambda(Y^*, w^*) = 1$. Consider the product of λ^* times the sum of the first I components of $\Gamma(Y^*, w^*)$. Recalling $\sum_{j=1}^J \alpha^j = 1$ and $\sum_{i=1}^I \sum_{z \in Z} s_{ni}^{j*}(z) m_i^j(z) = 1$, we get:

$$\lambda^* \sum_{i=1}^I Y_i^* = \sum_{i=1}^I \bar{\Psi}_i(Y^*, w^*) = \sum_{n=1}^I Y_n^* \sum_{j=1}^J \alpha^j \sum_{i=1}^I \sum_{z \in Z} s_{ni}^{j*}(z) m_i^j(z) = \sum_{n=1}^I Y_n^*.$$

Therefore, $\lambda^* = 1$. Now, $(Y^*, w^*) = \Gamma(Y^*, w^*)$ and $\lambda^* = 1$ imply that (Y^*, w^*) solves $Y_i = \bar{\Psi}_i(Y, w)$ and therefore (10) for every $i = 1, \dots, I$. Similarly, it implies that (Y^*, w^*) solves $w_i^* = \bar{\Phi}_i(Y^*, w^*)$ and therefore (11) for every $i = 1, \dots, I$.

Finally, let us verify that (Y^*, w^*) is strictly positive. Assume $w_i^* = 0$ for some i and recall $\lim_{w_i \rightarrow 0} \tilde{p}_{ni}^j(z) = 0$ (Assumption A.1). It follows that if $Y_n s_{ni}^j(z) m_i^j(z) > 0$ for some n and z , then $\bar{\Phi}_i(Y^*, w^*) = 1$ and we reach the contradiction $w_i^* = 0 = \bar{\Phi}_i(Y^*, w^*) = 1$. Conversely if $Y_n s_{ni}^j(z) m_i^j(z) = 0$ for all n and z , then $\bar{\Phi}_i(Y^*, w^*) = (-L_i)^2$ and we also reach a contradiction $w_i^* = 0 = \bar{\Phi}_i(Y^*, w^*) = (-L_i)^2$. Hence we conclude $w_i^* > 0$ for all i . Next, note that $w_i^* > 0$ and (11) imply that for each i we must have $\alpha^j Y_n s_{ni}^j(z) m_i^j(z) > 0$ for some n, j and z . Using this and

³⁹Recall from standard practice that finding the equilibrium vectors (Y^*, w^*) in the simplex implicitly fixes the *numeraire*. It can be verified that the equilibrium prices $\tilde{p}_{ni}^j(z)$ are homogeneous of degree one in the vector of wages and market share functions $s_{ni}^j(z)$ are homogeneous of degree zero in the vector of prices and wages. In turn, the mappings $\bar{\Psi}_i(Y, w)$ and $\bar{\Phi}_i(Y, w)$ are homogeneous of degree one in (Y, w) .

$\bar{\Psi}_i(Y^*, w^*) = Y_i^*$, we conclude $Y_i^* > 0$ for all i . ■

Proof of Proposition 2

In this proof we compare the exports of good j from two countries's (i' and i'') to destination n . For brevity, we suppress the superscript j and the subscript n from all the variables. Note that $\sum_{z \in Z} s_i(z) m_i(z) > 0$ for some $z \in Z$ and $i = i', i''$ because both countries export j to n . For each $i = i', i''$ consider the following system of weights for each efficiency category $z \in Z$: $g_i(z) \equiv \frac{[s_i(z)/q(z)]m_i(z)}{\sum_{z \in Z} [s_i(z)/q(z)]m_i(z)}$. Note that $Q_i = \sum_{z \in Z} q(z)g_i(z)$. Also define the cdf $G_i(z) : Z \rightarrow [0, 1]$ as $G_i(z_t) = \sum_{z=z_0}^{z_t} g_i(z)$. We now proceed through two claims.

Claim 1: *If $d_{i'}w_{i'} = d_{i''}w_{i''}$ and $i' \succ_{AA}^j i''$, then $Q_{i'} \geq Q_{i''}$. Moreover, if $i' \succ_{AA}^j i''$, then $Q_{i'} > Q_{i''}$.*

The mapping $s_i(z) : Z \rightarrow \mathbb{R}_+$ is identical for both i' and i'' because $\tilde{c}_{i'}(z) = \tilde{c}_{i''}(z)$ and is strictly positive for $z = \bar{z}_{i'}^j$ and $z = \bar{z}_{i''}^j$ because both countries export to n . Hence, we can apply Lemma 1 with $h(z) = s_i(z)/q(z)$, which implies $G_{i'}(z) \succ_{FOSD} G_{i''}(z)$ if $i' \succ_{AA}^j i''$ and $G_{i'}(z) \succ_{FOSD} G_{i''}(z)$ if $i' \succ_{AA}^j i''$. Then, recalling that $q(z)$ strictly increases with z because $\sigma^j > 0$ and using the basic properties of *FOSD*, we conclude that $Q_{i'} \geq Q_{i''}$ if $i' \succ_{AA}^j i''$ and $Q_{i'} > Q_{i''}$ if $i' \succ_{AA}^j i''$. ■

Claim 2: *If $d_{i'}w_{i'} \geq w_{i''}d_{i''}$ and $i' \sim_{AA}^j i''$, then $Q_{i'} \geq Q_{i''}$. Moreover, if $d_{i'}w_{i'} > d_{i''}w_{i''}$ and A.2b holds, then $Q_{i'} > Q_{i''}$.*

As noted in the main text and Assumption A.2, a higher value of $d_{ni}^j \cdot w_i$ affects average export quality $Q_i = \sum_{z=\bar{z}_{ni}^j}^{\bar{z}} q(z)g_i(z)$ through two mechanisms: by forcing the least efficient firms out the market (because $\partial \bar{z}_{ni}^j / \partial (d_{ni}^j w_i / \bar{p}_n^j) \geq 0$) and, within the set of active exporters, by increasing the relative market share of the most efficient firms (because $\partial^2 \ln s_{ni}^j(z) / \partial (d_{ni}^j w_i / \bar{p}_n^j) \partial z \geq 0$). The impact of the first mechanism is simple because if the relative weights $g_i(z)$ are kept constant within the set of active exporters and $q(z)$ is increasing in z , then it is straightforward to verify that Q_i increases as we increase \bar{z}_{ni}^j . The second mechanism requires a more detailed analysis, as follows. Consider the derivative

$$\frac{\partial g_i(z)}{\partial (d_i w_i)} = \frac{\frac{\partial s_i(z)}{\partial (d_i w_i)} \frac{m_i(z)}{q(z)}}{\sum_{z \in Z} \frac{s_i(z)}{q(z)} m_i(z)} - \frac{\frac{s_i(z) m_i(z)}{q(z)} \sum_{z \in Z} \frac{\partial s_i(z)}{\partial (d_i w_i)} \frac{m_i(z)}{q(z)}}{\left[\sum_{z \in Z} \frac{s_i(z)}{q(z)} m_i(z) \right]^2} = g_i(z) \left[\frac{\partial \ln [s_i(z)]}{\partial (d_i w_i)} - \sum_{z \in Z} g_i(z) \frac{\partial \ln [s_i(z)]}{\partial (d_i w_i)} \right]$$

for each $z > \bar{z}_i$ (i.e., for the efficiencies of the exporters of j to n), and note that $\sum_{z \in Z} \frac{\partial g_i(z)}{\partial (d_i w_i)} = 0$. Now, note that Assumption A.2 implies $\partial \ln [s_i(z)] / \partial (d_i w_i) < 0$ for $z > \bar{z}_i$ and increases with z . Suppose $\partial \ln [s_i(z)] / \partial (d_i w_i)$ is constant across $z \in Z$. It follows $\partial g_i(z) / \partial (d_i w_i) = 0$ for each z , which implies $G_{i'}(z) = G_{i''}(z)$ and, therefore, $G_{i'}(z) \succ_{FOSD} G_{i''}(z)$. Hence, because $q(z)$ increases

with z , we have $Q_{i'} \geq Q_{i''}$. Alternatively, suppose that $\partial \ln [s_i(z)] / \partial (d_i w_i)$ strictly increases with z (Assumption A.2b). Then, to satisfy $\sum_{z \in Z} \frac{\partial g_i(z)}{\partial (d_i w_i)} = 0$, the difference $\frac{\partial \ln [s_i(z)]}{\partial (d_i w_i)} - \sum_{z \in Z} g_i(z) \frac{\partial \ln [s_i(z)]}{\partial (d_i w_i)}$ must be positive for some z and negative for some other z . Moreover, there must exist \hat{z} within the interval of exporting efficiencies (i.e., $\bar{z}_i \geq \hat{z} > \underline{z}_i$) such that $\frac{\partial g(z)}{\partial (d_i w_i)} > 0$ for each $z \in Z$ such that $\hat{z} < z \leq \bar{z}_i$, and $\frac{\partial g(z)}{\partial (d_i w_i)} < 0$ for each $z \in Z$ such that $\hat{z} > z > \underline{z}_i$. Hence, higher $d_i w_i$ implies a shift in the country export weights $g_i(z)$ from the firms with low z (those with $z < \hat{z}$) to the firms with high z (those with $z > \hat{z}$). Hence, if $d_{i'} w_{i'} > d_{i''} w_{i''}$, $i' \sim_{AA}^j i''$, and $\partial^2 \ln s_{ni}^j(z) / \partial (d_{ni}^j w_i / \tilde{p}_n^j) \partial z > 0$, then $G_{i'}(z) \succ_{FOSD} G_{i''}(z)$. Therefore, because $q(z)$ strictly increases with z , we have $Q_{i'} > Q_{i''}$.

Finally, combining Claims 1 and 2 yields that if $d_{i'} w_{i'} \geq d_{i''} w_{i''}$ and $i' \succ_{AA}^j i''$, then $Q_{i'} \geq Q_{i''}$; and if $i' \succ_{AA}^j i''$ or if A.2b holds and $d_{i'} w_{i'} > d_{i''} w_{i''}$, then $Q_{i'} > Q_{i''}$. ■

Proof of Proposition 3

We proceed through a series of four claims:

Claim 1.a: *If $i' \succ_{AA}^j i''$, $w_{i'} = w_{i''}$, $d_{i'}^j = d_{i''}^j$ and $Y_{i'} = Y_{i''}$, then $\tilde{p}_{i'}^j \leq \tilde{p}_{i''}^j$.*

The hypotheses $d_{i'} = d_{i''}$, $w_{i'} = w_{i''}$ imply $\pi_{ni'}^j(z) = \pi_{ni''}^j(z)$ for each z and each third country $n \neq i', i''$. Moreover, $\sum_{z \in Z} \sum_{n \neq i', i''} \pi_{ni'}^j(z) f_{i'}^j(z) \geq \sum_{z \in Z} \sum_{n \neq i', i''} \pi_{ni''}^j(z) f_{i''}^j(z)$ because $\sum_{n \neq i', i''} \pi_{ni''}^j(z)$ increases with z and $i' \succ_{AA}^j i''$. Therefore, the zero-profit condition A.3 together with assumption A.4 imply that profits at destinations i' and i'' must satisfy

$$\sum_{z \in Z} \left[\pi_{i'i'}^j(z) + \pi_{i'i''}^j(z) \right] f_{i'}^j(z) - \sum_{z \in Z} \left[\pi_{i''i''}^j(z) + \pi_{i''i'}^j(z) \right] f_{i''}^j(z) = A + B \leq 0, \quad (16)$$

where

$$\begin{aligned} A &\equiv \sum_{z \in Z} \left(\left[\pi_{i'i'}^j(z) - \pi_{i''i''}^j(z) \right] - \left[\pi_{i'i''}^j(z) - \pi_{i''i'}^j(z) \right] \right) f_{i''}^j(z) \\ B &\equiv \sum_{z \in Z} \left[\pi_{i'i'}^j(z) + \pi_{i''i'}^j(z) \right] \left[f_{i'}^j(z) - f_{i''}^j(z) \right]. \end{aligned}$$

We know $B \geq 0$ because $i' \succ_{AA}^j i''$ and $\pi_{ni}^j(z)$ increases with z . Hence we must have $A \leq 0$. Contrary to the claim, suppose that $\tilde{p}_{i'}^j > \tilde{p}_{i''}^j$. Then, assumption A.6 implies $A > 0$. This contradicts $A \leq 0$ and, therefore, we conclude that $\tilde{p}_{i'}^j \leq \tilde{p}_{i''}^j$. ■

Claim 1.b: *If $i' \sim_{AA}^j i''$, $w_{i'} \leq w_{i''}$, $d_{i'}^j = d_{i''}^j$ and $Y_{i'} = Y_{i''}$, then $w_{i'} / \tilde{p}_{i'}^j \geq w_{i''} / \tilde{p}_{i''}^j$.*

From the zero-profit condition A.3 and $i' \sim_{AA}^j i''$ (which implies $f_{i'}^j(z) = f_{i''}^j(z)$), we have $\sum_{z \in Z} \sum_{n=1}^I \left[\pi_{ni'}^j(z) - \pi_{ni''}^j(z) \right] f_{i'}^j(z) = 0$. Note that $w_{i'} d_{i'}^j \leq w_{i''} d_{i''}^j$ implies $\pi_{ni'}^j(z) \geq \pi_{ni''}^j(z)$ for

$n \neq i', i''$ and every z . Therefore, profits at destinations i' and i'' must satisfy

$$A \equiv \sum_{z \in Z} \left(\left[\pi_{i'i'}^j(z) - \pi_{i''i''}^j(z) \right] - \left[\pi_{i'i''}^j(z) - \pi_{i''i'}^j(z) \right] \right) f_{i''}^j(z) \leq 0.$$

Next, contrary to the claim suppose $w_{i'}/\tilde{p}_{i'}^j < w_{i''}/\tilde{p}_{i''}^j$ and recall $d_{i'i''}^j = d_{i''i'}^j$. We then have

$$\pi^j \left(\frac{w_{i'}}{z\tilde{p}_{i'}^j} \right) - \pi^j \left(\frac{w_{i''}}{z\tilde{p}_{i''}^j} \right) \geq \pi^j \left(\frac{d_{i'i''}^j w_{i'}}{z\tilde{p}_{i'}^j} \right) - \pi^j \left(\frac{d_{i''i'}^j w_{i''}}{z\tilde{p}_{i''}^j} \right) \geq \pi^j \left(\frac{d_{i''i'}^j w_{i''}}{z\tilde{p}_{i'}^j} \right) - \pi^j \left(\frac{d_{i'i''}^j w_{i'}}{z\tilde{p}_{i''}^j} \right),$$

for each z , where the first inequality follows from assumption A.6 and is strict for some z (e.g., for those z corresponding to firms from country i' that are active in the domestic market). Hence, $w_{i'}/\tilde{p}_{i'}^j < w_{i''}/\tilde{p}_{i''}^j$ implies $A > 0$. This contradicts $A \leq 0$ and, therefore, we conclude $w_{i'}/\tilde{p}_{i'}^j \geq w_{i''}/\tilde{p}_{i''}^j$. ■

Claim 2.a: If $i' \succ_{AA}^j i''$, $w_{i'} = w_{i''}$, $d_{i'}^j = d_{i''}^j$ and $Y_{i'} = Y_{i''}$, then $\sum_{z \in Z} s_{ni'}^j m_{i'}^j(z) \geq \sum_{z \in Z} s_{ni''}^j m_{i''}^j(z)$ for each $n \neq i', i''$, $\sum_{z \in Z} s_{i'i'}^j m_{i'}^j(z) \geq \sum_{z \in Z} s_{i'i''}^j m_{i''}^j(z)$ and $E_{i'}^j/Y_{i'} \geq E_{i''}^j/Y_{i''}$, with strict inequalities if $i' \succ_{AA}^j i''$.

First, we show $\sum_{z \in Z} s_{i'i''}^j(z) m_{i'}^j(z) \geq \sum_{z \in Z} s_{i''i'}^j(z) m_{i''}^j(z)$; second, we show that country- i' firms' total share in each third country destination $n \neq i', i''$ is also larger; third, we show that for the exports between i' and i'' , we have $\sum_{z \in Z} s_{i'i'}^j(z) m_{i'}^j(z) \geq \sum_{z \in Z} s_{i'i''}^j(z) m_{i''}^j(z)$; and fourth, we show $E_{i'}^j/Y_{i'} \geq E_{i''}^j/Y_{i''}$.

From $d_{i'i'}^j = d_{i''i''}^j$ for every $i \neq i', i''$ and $\tilde{p}_{i'}^j \leq \tilde{p}_{i''}^j$ (Claim 1.a), we have $\sum_{z \in Z} s_{i'i'}^j(z) m_{i'}^j(z) \leq \sum_{z \in Z} s_{i''i''}^j(z) m_{i''}^j(z)$ for every $i \neq i', i''$. Therefore, because $\sum_{i=I} \sum_{z \in Z} s_{ni}^j(z) m_i^j(z) = 1$ in each market n , we have:

$$\sum_{z \in Z} \left[s_{i'i'}^j(z) - s_{i''i''}^j(z) \right] m_{i'}^j(z) \geq \sum_{z \in Z} \left[s_{i'i''}^j(z) - s_{i''i'}^j(z) \right] m_{i''}^j(z), \quad (17)$$

Furthermore, $s_{i''i''}^j(z) \geq s_{i'i'}^j(z)$ and $s_{i'i''}^j(z) \geq s_{i''i'}^j(z)$ for every z because $\tilde{p}_{i'}^j \leq \tilde{p}_{i''}^j$, $w_{i'} = w_{i''}$ and $d_{i'i''}^j = d_{i''i'}^j$. It follows that

$$C_1 \cdot \sum_{z \in Z} s_{i''i''}^j(z) m_{i''}^j(z) \geq D_1 \cdot \sum_{z \in Z} s_{i'i''}^j(z) m_{i''}^j(z), \quad (18)$$

where $C_1 \equiv \sum_{z > z_{i''i''}^j} \frac{s_{i''i''}^j(z) - s_{i'i'}^j(z)}{s_{i''i''}^j(z)} \frac{s_{i''i''}^j(z) m_{i''}^j(z)}{\sum_{z \in Z} s_{i''i''}^j(z) m_{i''}^j(z)} = 1 - \sum_{z > z_{i''i''}^j} \frac{s_{i'i'}^j(z)}{s_{i''i''}^j(z)} \frac{s_{i''i''}^j(z) m_{i''}^j(z)}{\sum_{z \in Z} s_{i''i''}^j(z) m_{i''}^j(z)}$ and $D_1 \equiv \sum_{z > z_{i'i''}^j} \frac{s_{i''i''}^j(z) - s_{i'i''}^j(z)}{s_{i''i''}^j(z)} \frac{s_{i''i''}^j(z) m_{i''}^j(z)}{\sum_{z \in Z} s_{i''i''}^j(z) m_{i''}^j(z)} = 1 - \sum_{z > z_{i'i''}^j} \frac{s_{i'i''}^j(z)}{s_{i''i''}^j(z)} \frac{s_{i''i''}^j(z) m_{i''}^j(z)}{\sum_{z \in Z} s_{i''i''}^j(z) m_{i''}^j(z)}$. Note that Assumption A.2 implies $s_{i'i''}^j(z)/s_{i''i''}^j(z)$ (which is lower than 1) weakly increases with z . Then, Lemma 1 (with $h(z) = s_{i''i''}^j(z)$ in the lemma) and $i' \succ_{AA}^j i''$ imply $C_1 \leq D_1$. Therefore,

eq. (18) implies $\sum_{z \in Z} s_{i''i'}^j(z) m_{i'}^j(z) \geq \sum_{z \in Z} s_{i''i''}^j(z) m_{i''}^j(z)$. Moreover, if Assumption A.2b holds (which means that $s_{i''i'}^j(z)/s_{i''i''}^j(z)$ strictly increases with z) and $i' \succ_{AA}^j i''$, then the inequalities are strict; i.e., $C_1 < D_1$ and $\sum_{z \in Z} s_{i''i'}^j(z) m_{i'}^j(z) > \sum_{z \in Z} s_{i''i''}^j(z) m_{i''}^j(z)$.

Second, define $C_2 \equiv \sum_{z > \underline{z}_{i''i'}} \frac{s_{ni''}^j(z)}{s_{i''i''}^j(z)} \frac{s_{i''i''}^j(z) m_{i''}^j(z)}{\sum_{z \in Z} s_{i''i''}^j(z) m_{i''}^j(z)}$ and $D_2 \equiv \sum_{z > \underline{z}_{i''i''}} \frac{s_{ni''}^j(z)}{s_{i''i''}^j(z)} \frac{s_{i''i''}^j(z) m_{i''}^j(z)}{\sum_{z \in Z} s_{i''i''}^j(z) m_{i''}^j(z)}$. Note that Assumption A.2 implies that $s_{ni''}^j(z)/s_{i''i''}^j(z)$ weakly increases with z because relative differences in prices cannot exceed trade frictions; i.e., $d_{ni''}^j/\tilde{p}_n^j \geq 1/\tilde{p}_{i''}^j$. Thus, Assumption A.2, Lemma 1 (with $h(z) = s_{i''i''}^j(z)$), and $i' \succ_{AA}^j i''$ imply $C_2 \geq D_2$. Therefore, for each n (with strict inequality if $n \neq i''$), we have

$$\sum_{z > \underline{z}_{i''i''}} \frac{s_{ni''}^j(z) m_{i''}^j(z)}{\sum_{z \in Z} s_{i''i''}^j(z) m_{i''}^j(z)} \geq \sum_{z > \underline{z}_{i''i''}} \frac{s_{ni''}^j(z) m_{i''}^j(z)}{\sum_{z \in Z} s_{i''i''}^j(z) m_{i''}^j(z)}.$$

Then, comparing the denominators using the result in the previous paragraph, we find $\sum_{z \in Z} s_{ni''}^j m_{i''}^j(z) \geq \sum_{z \in Z} s_{ni''}^j m_{i''}^j(z)$ for each $n = 1, \dots, I$. Moreover, because $s_{ni''}^j(z) = s_{ni'}^j(z)$ for each z and $n \neq i', i''$ (because $w_{i'} = w_{i''}$ and $d_{i'}^j = d_{i''}^j$), we find $\sum_{z \in Z} s_{ni'}^j m_{i'}^j(z) \geq \sum_{z \in Z} s_{ni''}^j m_{i''}^j(z)$ for each $n \neq i', i''$. Furthermore, if Assumption A.2b holds and $i' \succ_{AA}^j i''$, then the inequalities are strict; i.e., $C_2 < D_2$ and $\sum_{z \in Z} s_{ni'}^j m_{i'}^j(z) > \sum_{z \in Z} s_{ni''}^j m_{i''}^j(z)$ for each $n \neq i', i''$.

Third, recalling that $s_{i'i'}^j(z) \geq s_{i'i''}^j(z)$ for every z (because $\tilde{p}_{i'}^j \leq \tilde{p}_{i''}^j$) and that the argument in the previous paragraph implies $\sum_{z \in Z} s_{i'i''}^j m_{i''}^j(z) \geq \sum_{z \in Z} s_{i'i''}^j m_{i''}^j(z)$, yields $\sum_{z \in Z} s_{i'i'}^j m_{i'}^j(z) \geq \sum_{z \in Z} s_{i'i''}^j m_{i''}^j(z)$. Moreover, if Assumption A.2b holds and $i' \succ_{AA}^j i''$, then $\sum_{z \in Z} s_{i'i'}^j m_{i'}^j(z) > \sum_{z \in Z} s_{i'i''}^j m_{i''}^j(z)$.

Fourth, combining all the previous results and recalling $E_{ni}^j = \sum_{z \in Z} s_{ni}^j m_i^j(z) \alpha^j Y_n$, $E_i^j = \sum_{n \neq i} E_{ni}^j$ and $Y_{i'} = Y_{i''}$, yields $E_{i'}^j/Y_{i'} \geq E_{i''}^j/Y_{i''}$, with strict inequality if Assumption A.2b holds and $i' \succ_{AA}^j i''$. ■

Claim 2.b: If $i' \sim_{AA}^j i''$, $w_{i'} \leq w_{i''}$, $d_{i'}^j = d_{i''}^j$, and $Y_{i'} = Y_{i''}$, then $m_{i'}^j(z) \geq m_{i''}^j(z)$ for each z and $E_{i'}^j/Y_{i'} \geq E_{i''}^j/Y_{i''}$.

Recall that under these hypotheses, Claim 1.b implies $w_{i'}/\tilde{p}_{i'}^j \geq w_{i''}/\tilde{p}_{i''}^j$, which also implies $\tilde{p}_{i'}^j \leq \tilde{p}_{i''}^j$ because $w_{i'} \leq w_{i''}$. Therefore, expression (17) still holds and we also have $s_{i'i'}^j(z) \leq s_{i'i''}^j(z)$ and $s_{i''i'}^j(z) \geq s_{i''i''}^j(z)$ for every z . Therefore,

$$\sum_{z \in Z} \left[s_{i''i''}^j(z) - s_{i''i'}^j(z) \right] \frac{m_{i''}^j(z)}{\sum_{z \in Z} m_{i''}^j(z)} \sum_{z \in Z} m_{i''}^j(z) \geq \sum_{z \in Z} \left[s_{i''i''}^j(z) - s_{i''i'}^j(z) \right] \frac{m_{i''}^j(z)}{\sum_{z \in Z} m_{i''}^j(z)} \sum_{z \in Z} m_{i''}^j(z).$$

Now note that $i' \sim_{AA}^j i''$ implies $m_{i'}^j(z)/\sum_{z \in Z} m_{i'}^j(z) = m_{i''}^j(z)/\sum_{z \in Z} m_{i''}^j(z)$ for each z . Hence, we must have $\sum_{z \in Z} m_{i'}^j(z) \geq \sum_{z \in Z} m_{i''}^j(z)$. Moreover, because $i' \sim_{AA}^j i''$, we must have $m_{i'}^j(z) \geq m_{i''}^j(z)$ for each z .

The latter result on the number of firms in combination with $s_{i' i''}^j(z) \geq s_{i' i''}^j(z)$ for each z , implies $E_{i' i''}^j \geq E_{i' i''}^j$ and in combination with $s_{n i'}^j(z) \geq s_{n i''}^j(z)$ for each z and $n \neq i', i''$ (which results from $d_{i' i''}^j w_{i'} \leq d_{i' i''}^j w_{i''}$), implies $\sum_{n \neq i''} E_{n i'}^j \geq \sum_{n \neq i''} E_{n i''}^j$. Therefore, recalling $Y_{i'} = Y_{i''}$, we have $E_{i'}^j / Y_{i'} \geq E_{i''}^j / Y_{i''}$. ■

B Continuity of Prices and Market Shares in Cournot

Consider $\tilde{p}_{ni}^j(z)$ and $s_{ni}^j(z)$ as functions of the vector of wages $(w) = (w_1, \dots, w_I) \in \mathbb{R}_{++}^I$. First, note that (8) implies that having a single active firm in a market would require $\frac{\tilde{c}_{ni}^j(z)}{\tilde{p}_n^j} = 0$ for that firm, which is impossible because wages are strictly positive. Thus, for any vector of wages $(w) \in \mathbb{R}_{++}^I$, we must have more than one active firm in each market; i.e., $\sum_{i=1}^I \sum_{z > z_{ni}^j} m_i^j(z) \geq 2$. Then, expression (9) implies that \tilde{p}_n^j is always positive valued. Second, the price \tilde{p}_n^j is clearly continuous at wages (w) such that no firm category z goes from being active to being inactive (i.e., at any (w) such that for each z and i , either $z > z_{ni}^j$ or $z < z_{ni}^j$). Third, \tilde{p}_n^j is also continuous at wages such that some firms go from inactive to active (i.e., at (w) such that $z_{ni}^j = z$ for some i and z). To see this, rewrite expression (9) as $1 = \sum_{i=1}^I \sum_{z \geq z_{ni}^j} m_i^j(z) - \sum_{i=1}^I \sum_{z \geq z_{ni}^j} \frac{\tilde{c}_{ni}^j(z)}{\tilde{p}_n^j} m_i^j(z)$ and note that if $z = z_{ni}^j$ for some i and z , then $\frac{\tilde{c}_{ni}^j(z)}{\tilde{p}_n^j} = 1$. Therefore, \tilde{p}_n^j is also continuous at this vector of wages. Finally, it is then immediate from expression (8) to verify that market shares $s_{ni}^j(z)$ are also continuous and positive-valued functions of the vector of wages.

C Sketch of the Model with a Continuum of Goods

In this Appendix, we outline how the model could be amended along the lines of probabilistic trade models with a continuum of goods (e.g., Eaton and Kortum, 2002 and 2010). This could allow rewriting the propositions in terms of exogenous variables; specifically, it could allow substituting the endogenous wages w_i and incomes Y_i in the hypotheses of the propositions with country general-state-of-technology parameters T_i and the labor supplies L_i , respectively. This could be interesting from a theoretical point of view although, from an empirical perspective, what we can directly observe is not aggregate technology parameters but wages or income per capita. The basic idea is that as the number J of goods becomes large and because of the Law of Large Numbers, two economies that have identical primitives (i.e., general state of the technology T_i , labor force L_i , and market access d_i) will tend in equilibrium toward identical aggregate endogenous variables (w_i , Y_i and total exports E_i) regardless of potentially large differences in efficiency, output and exports in each particular industry. It must be emphasized that the goal of this appendix is not to fully

describe a new model but only to suggest some guidelines along which the model could be recast as a symmetric probabilistic model with a continuum of goods.

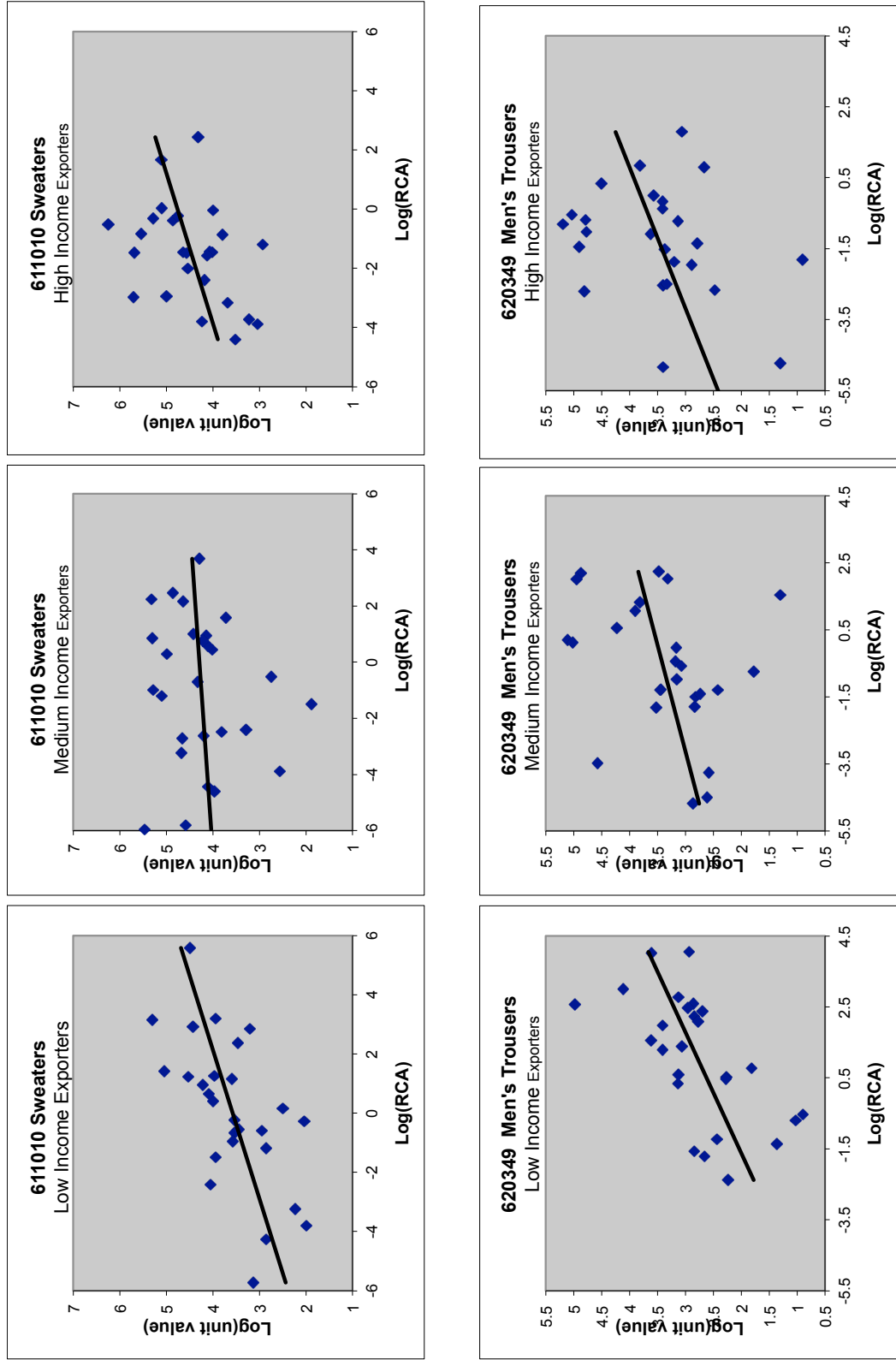
We could consider an economy with a continuum number of goods of measure J (although the number of producers and varieties of each good remains finite). Industries are symmetric in the sense that $\alpha^j = \alpha$, $\sigma^j = \sigma$ and $d_i^j = d_i$ for all j and i . The set of firms in each country i and industry j is the result of a sequence of independent draws from the density function $f_i^j(z)$ defined in Section 4. Each of the density functions $f_i^j(z)$ is indexed by a parameter θ_i^j that takes values in the ordered set Θ . Thus, we can write $f_i^j(z) = f_{\theta_i^j}(z)$. Moreover, for each j , the collection of densities $f_{\theta_i^j}$, $i = 1, \dots, I$ has the MLRP in z . Specifically, if $\theta_{i'}^j > \theta_{i''}^j$, then $f_{\theta_{i'}^j}(z_1)/f_{\theta_{i'}^j}(z_0) \geq f_{\theta_{i''}^j}(z_1)/f_{\theta_{i''}^j}(z_0)$ for any $z_1, z_0 \in Z$ such that $z_1 > z_0$.⁴⁰

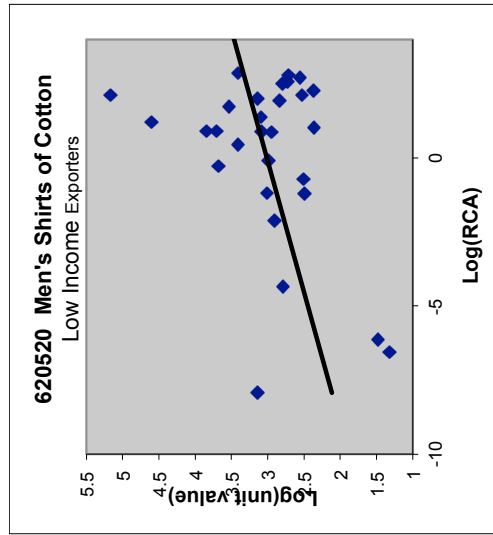
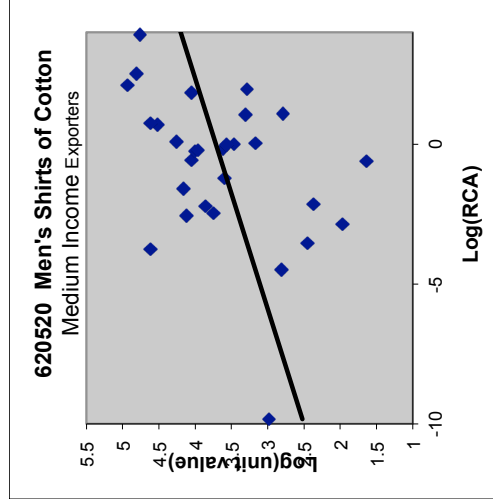
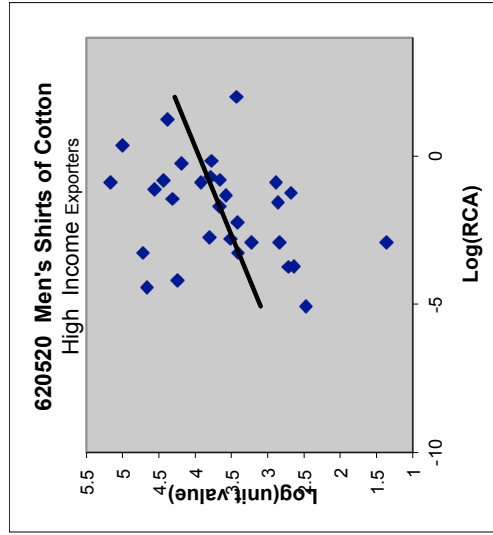
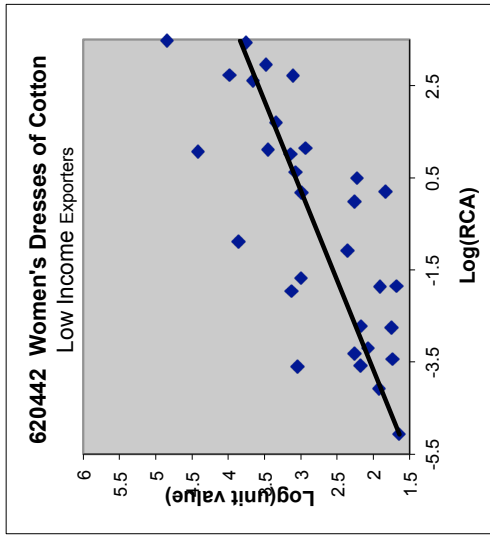
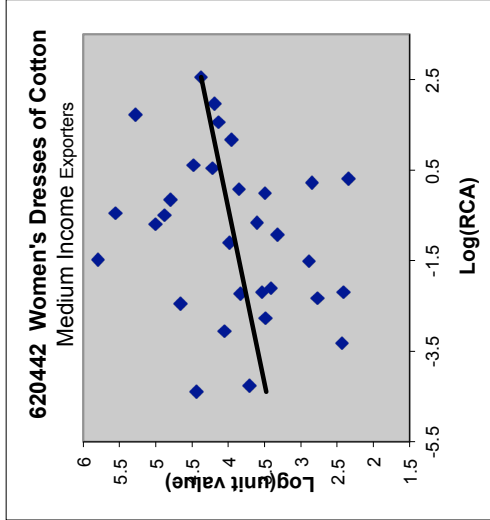
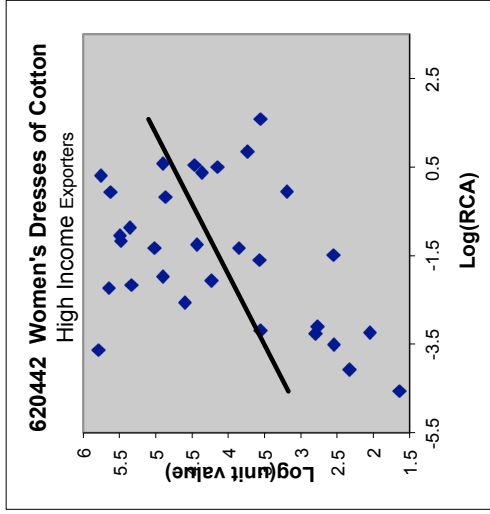
In turn, for each country i , the industry indexes θ_i^j , $j \in [0, J]$, are the result of a sequence of i.i.d. draws from a density function $g_i(\theta)$ with support Θ . Finally, the country density functions $g_i(\theta)$, $i = 1, \dots, I$ are indexed by a parameter T_i , such that if $T_{i'} > T_{i''}$ then $E[g_{i'}(\theta)] > E[g_{i''}(\theta)]$. T_i can be interpreted as an index that measures the technological level of country i . It positively affects the fraction of industries in which the country tends to have an *AA* over other countries.

Summarizing, the set of firms in each industry j is the result of independent draws from a collection of I independent probability functions (one for each source country), which are parameterized by the indexes in the collection $\theta^j \equiv \{\theta_1^j, \dots, \theta_I^j\}$. Each of these collections of indexes is, in turn, the result of I independent draws from a collection of I independent probability functions that are parameterized by the indexes T_i , $i = 1, \dots, I$. Thus, the primitives characterizing each country $i = 1, \dots, I$ are T_i , d_i and L_i . Now, if for any two countries i' and i'' we have $T_{i'} = T_{i''}$, $d_{i'} = d_{i''}$ and $L_{i'} = L_{i''}$, then both countries face identical symmetric joint distribution of firm efficiencies across industries and destination markets because each θ_i^j is the result of an independent random draw. Thus, with a continuum of products and by the Law of Large Numbers, the two countries would tend to have the same aggregate variables; i.e., $w_{i'} = w_{i''}$, $Y_{i'} = Y_{i''}$ and $E_{i'} = E_{i''}$ (although for each particular industry, the two countries can exhibit large differences in the efficiency distribution of firms). A symmetric probabilistic model with a continuum of goods built along these lines could, in principle, allow replacing the endogenous variables w_i and Y_i in the hypothesis of the propositions with the exogenous variables T_i and L_i , respectively.

⁴⁰These features would be similar to certain aspects of the model in Costinot, Donaldson and Komunjer (2012), where the index θ_i^j corresponds to a parameter of a Fréchet distribution. These authors refer to this parameter as the *fundamental productivity* of country i in industry j .

Figure 1. Correlations between Exporter's RCA and Exports' Average Unit Value for selected goods (6-digit HS1996 products)





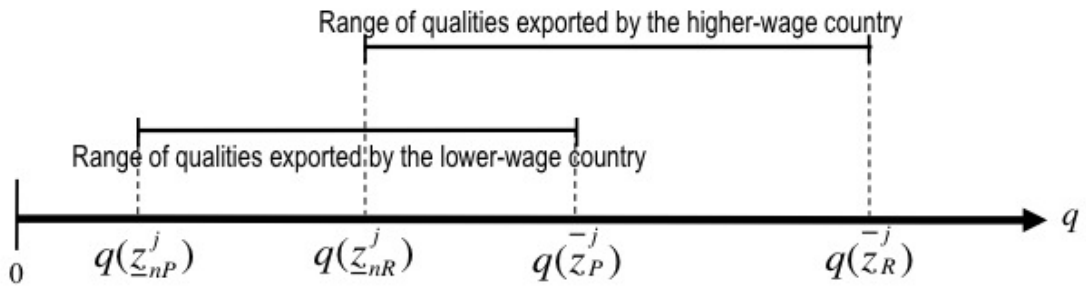


Figure 2.a

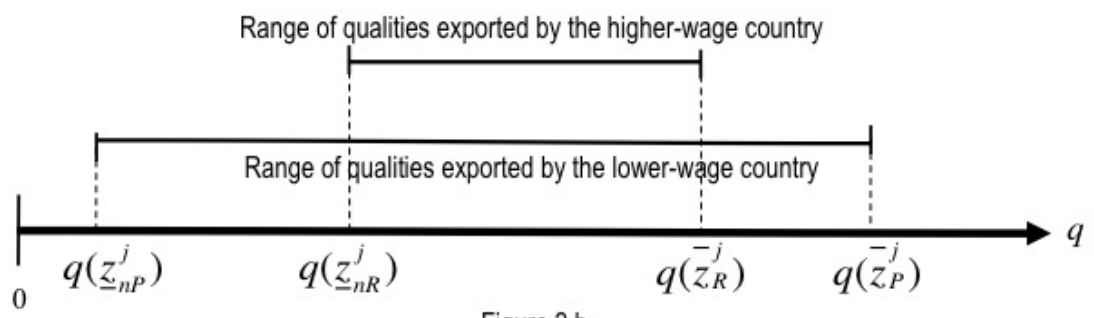


Figure 2.b

Figure 2: The range of qualities for good j that are exported by two countries. Each figure represents one of the two possible cases: in Figure 2a (resp. Figure 2b), the higher-wage country R (resp. the lower-wage country P) has an absolute advantage in good j .

Table 1: Export Unit Value and Exporter Specialization Across Goods
 Pooling the 233 products at the 6-digit level in chapters 61 and 62 of the HS96 classification
 (articles of apparel and clothing accessories)

	Dependent variable is export unit value			
	LS	2SLS	LS	2SLS
E^j/GDP		0,077*** (0,026)		
$E^{exUS,j}/GDP$	0,063*** (0,021)			
RCA^j				0.072*** (0.024)
$RCA^{exUS,j}$			0.061*** (0.020)	
$PCGDP$	0,308*** (0,056)	0,328*** (0,059)	0.344*** (0.054)	0.361*** (0.055)
$Distance$	-0,093 (0,121)	-0,057 (0,123)	-0.043 (0.120)	-0.036 (0.118)
GDP	0,036 (0,029)	0,046 (0,030)	0.030 (0.029)	0.040 (0.030)
<i>Number of products</i>	233	233	233	233
<i>Observations</i>	11,946	11,946	11,946	11,946
<i>R-square</i>	0.37	0.35	0.36	0.35

Results of regressing the unit value of the exports of good j to the US on different measures of the exporting country's horizontal specialization ($E^{exUS,j}/GDP$, E^j/GDP , $RCA^{exUS,j}$ and RCA^j). As additional controls, the estimated equation includes exporter PPP per capita income ($PCGDP$), the distance between the US and the exporter, and exporter $PPPGDP$ (see equation (12)). All the variables are in logs and all specifications include 233 commodity fixed effects. Columns (1) and (3) use least squares, whereas columns (2) and (4) use two-stage least squares. In the 2SLS regressions, $E^{exUS,j}/GDP$ is used as an instrument of E^j/GDP and $RCA^{exUS,j}$ as an instrument of RCA^j . Standard errors shown in parenthesis are robust to heteroskedasticity and are clustered by country. All data correspond to 2006. *** means significant at 0.01-percent.

Table 2: Export Unit Value and Exporter Specialization Across Goods

Independent panel regressions for each of the 6-digit products in chapters 61 and 62 of the HS96 classification, with an average of at least 50 observations (countries) per year. Two-stage least squares.

		Average estimated coefficient	% of positive coefficients			% of negative coefficients	
			P-value	P-value	P-value	P-value	P-value
			<i>Any</i>	<i><10%</i>	<i><5%</i>	<i><10%</i>	<i><5%</i>
Panel 1	<i>E^j/GDP</i>	0.078	90.3	60.2	50.4	0.0	0.0
	<i>PCGDP</i>	0.283	100.0	98.2	96.5	0.0	0.0
	<i>Distance</i>	-0.038	37.2	1.8	0.0	0.9	0.9
	<i>GDP</i>	0.046	82.3	34.5	22.1	1.8	0.0
Panel 2	<i>RCA^j</i>	0.068	85.8	50.4	43.4	0.0	0.0
	<i>PCGDP</i>	0.311	100.0	98.2	95.6	0.0	0.0
	<i>Distance</i>	-0.019	38.9	2.7	0.9	0.9	0.0
	<i>GDP</i>	0.037	77.9	27.4	21.2	0.9	0.0

Number of regressions (= number of products): 113

Minimum number of observations per regression: 200

Average number of observations per regression: 273.2

Average number of different countries per regression: 68.3

Panel data regressions of the unit value of the exports of good j to the US on two measures of the exporting country's horizontal specialization: E^j/GDP and RCA^j . The estimation method is two-stage least squares. $E^{exUS,j}/GDP$ is used as an instrument of E^j/GDP in panel 1 and $RCA^{exUS,j}$ as an instrument of RCA^j in panel 2. In addition to including one of the measures of specialization, the equations also include exporter PPP per capita income ($PCGDP$), the distance between the US and the exporter, exporter $PPPGDP$, and a constant (see equation (12a)). All the variables are in logs. The same two equations (one corresponding to each panel) were independently estimated for each of the 6-digit products in chapters 61 and 62 of the HS96 (articles of apparel and clothing accessories) with an average of at least 50 observations (or exporting countries) per year. The regressions use annual data for the period 2005-2008. In each panel, each row shows the percentage of regressions (one for each product) that yield a positive or a negative sign for the corresponding variable at different levels of statistical significance. Robust standard errors were clustered by country.

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