Product and Process Productivity: Implications for quality choice and conditional exporter premia*

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Abstract

We develop a model of international trade with two dimensions of firm heterogeneity. The first dimension is "process productivity", which is how we denote the standard concept of productivity as modeled in the literature. The second one is "product productivity", defined as firms' ability to develop high-quality products spending small fixed outlays. The distinction between these two sources of productivity, together with the assumption that iceberg trade costs decrease with quality, deliver various *conditional* exporter premia as theoretical predictions. Conditional on size, exporters sell higher quality products, charge higher prices, pay higher input prices and higher wages, and use capital more intensively. Some of these predictions had already been documented in the empirical literature but lacked a theoretical framework for properly interpreting them. We conduct systematic tests of these predictions using manufacturing establishment data for India, the U.S., Chile, and Colombia, and find strong support for the model.

JEL codes: F10, F12, F14,

Keywords: Product productivity, process productivity, quality, fixed costs, exports, conditional exporter premia

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1 Introduction

Understanding firms' exporting behavior is one of the most important open questions in international trade. In the first place, identifying determinants of their exporting behavior is critical for understanding trade patterns across countries, the field's predominant goal in the last two centuries. In the second place, the impressive export performance of rapidly-growing developing countries, particularly the recent case of China, suggests that the ability of firms to succeed in international markets might be a key driver of sustained economic growth.

While work in international trade has traditionally focused on sector-level determinants of trade, a growing new literature emphasizes the role of factors that operate at the firm level. In this literature usually a single attribute, heterogeneously distributed across firms, is modeled as the sole determinant of firms' ability to conduct business successfully, both domestically and abroad. This attribute is often modeled as productivity, either in its standard form (e.g. Bernard et al. 2003, Melitz 2003, Chaney 2008, Arkolakis 2010) or as the ability to produce quality with low variable costs (Verhoogen 2008, Baldwin and Harrigan 2011, Johnson 2011, Kugler and Verhoogen 2011). In either case, these models share the property that the endowment of the single attribute is monotonically related to firms' revenue (henceforth our measure of firm size) and export status. Therefore, they predict a threshold firm size above which all firms export and below which none do.

"Single-attribute" models have the ability to explain various *exporter premia* documented in the empirical literature. For example, exporters are observed to be larger than non-exporters. They are also more productive, pay higher wages, and use production techniques that are more intensive in the use of capital and skilled labor (Bernard and Jensen 1995, 1999; Bernard et al. 2007, Verhoogen 2008, Bustos 2011). Exporters are also more likely to adopt ISO 9000 (Verhoogen 2008), charge higher prices for their output (Kugler and Verhoogen 2011, Iacovone and Javorcik 2012), and pay higher prices for their intermediate inputs (Kugler and Verhoogen 2011). This evidence generally comes from a positive coefficient on an exporter dummy when each of these firm outcomes is regressed on that dummy and a set of industry controls.

The observed exporter premia could merely arise because firm outcomes, as export status, are correlated with firm size. For example, it is well-known that larger firms pay higher wages (Brown and Medoff 1989). To disentangle size from exporting as the underlying driver of exporter premia, researchers have customarily appealed to the intuitive approach of estimating *conditional exporter premia* (CEPs). CEPs are obtained by adding firm revenue or number of employees to the regressions described above as a control for size. Since Bernard and Jensen (1995) first documented CEPs for the United States, CEPs have also been documented by Bernard and Jensen (1999), Isgut (2001), Van Biesebroeck (2005), De Loecker (2007), and Bernard et al. (2007), among others, for average wages and capital intensity, and by Kugler and Verhoogen (2011) for output and input prices.

The evidence of *conditional* exporter premia cannot be properly interpreted through the lenses of single-attribute models. These models can explain why exporters exhibit systematic differences from non-exporters but are unable to explain why those differences persist after conditioning on firm size. Since single-attribute models predict the same export status for equally-sized firms, they cannot account for the existence of exporters and non-exporters of the same size in the first place. Thus, in a regression framework an exporter dummy should have no explanatory power once firm size is (properly) controlled for.[1]

The prevalence of equally-sized exporters and non-exporters across the size spectrum is salient in Figure 1, which plots the fraction of exporters in each of 40 size quantiles (defined by industry) for each of the four countries in our sample. The figure sets the following puzzle: If the reason exporters enter foreign markets is because they are more productive, then how can non-exporters attain their same size? The latter firms need to have a compensating advantage. We allow for a compensating advantage by introducing "product productivity" as a second source of firm heterogeneity (discussed below). Not only can our model explain Figure 1, but also it generates as predictions conditional exporter premia for quality (CEP 1), output prices (CEP 2), input prices (CEP 3), average wages (CEP 4), and capital intensity (CEP 5). We evaluate these predictions systematically as a test of our model using plant-level data from India, the United States, Chile, and Colombia.

We distinguish two types of productivity. On the one hand, we model "process productivity" (φ) as the standard way of modeling productivity in the economics literature, i.e. the ability to produce output using few variable inputs. On the other hand, we model "product productivity" (ξ) as the ability to produce quality incurring low fixed outlays. The importance of fixed outlays for producing quality goods has long been emphasized in the IO literature (e.g. Shaked and Sutton 1983). This literature recognizes that conceiving, designing, and producing a product that consumers are willing to pay extra for entails incurring fixed expenses associated with activities such as R&D, advertising, and quality control. In turn, the management and marketing literature recognizes that not all firms are as effective in spending such fixed outlays. Furthermore, they emphasize that while some firms

[1] To the extent that the effect of firm size is non-linear, failure to control for its non-linear effect may spuriously manifest as an exporter premia due to correlation between size and export status.

base their success on an efficient management of the production process (high φ) others thrive based on their ability to create goods that consumers value through product differentiation (high ξ) (e.g. Porter 1980, Rust et al 2002). In light of these literatures, distinguishing product productivity from process productivity seems a natural and appealing modeling choice to account for the observed CEPs.

A critical element of our theoretical framework is our modeling of iceberg trade costs, $\tau(\lambda)$, as a decreasing function of quality λ. This assumption captures in a reduced form the fact that transport costs as a fraction of price are decreasing in product quality (Alchian and Allen 1964, Hummels and Skiba 2004). It also captures differences in preference for quality across countries (Hallak 2006, 2010), which we show can be isomorphically expressed as an iceberg trade cost.[2] The trade cost factor $\tau(\lambda)$ introduces a wedge between relative profits in the domestic and foreign markets. High quality firms, due to lower trade costs, earn relatively more abroad. The role of $\tau(\lambda)$ is crucial to generate CEPs. If τ did not depend on quality, a "combined productivity" parameter $\eta = \eta(\varphi, \xi)$ would be a summary measure of firm size, profits, and export status. In that case, the model would collapse into a single-attribute model isomorphic to Melitz (2003) – as our model does in the closed economy – with η as the single heterogeneous parameter. Such a model would be unable to yield CEPs as predictions.

In the model, φ and ξ are exogenously distributed among firms. Quality (λ) shifts out demand but increases marginal and fixed costs. Under this framework, firms can achieve the same size with different combinations of φ and ξ and different choices of quality and export status. In particular, conditional on size (revenue), exporters sell higher quality products than domestic firms. This is the main result of the paper. The simple intuition behind this result is that, once we condition on firm size, exporters can only have an advantage in one of these parameters, not in both. Hence, since $\tau(\lambda)$ decreases with quality, firms that choose to produce high quality (those with relatively high ξ and low φ) will be the ones to export because their higher quality gives them a relative advantage in the export market.[3] It follows immediately from this result that exporters will set higher prices than equally-sized domestic firms, giving rise to a CEP for price. Also, we derive predictions for supply-side CEPs (for input price, average wage and capital intensity) by assuming that higher product quality requires higher-quality intermediate inputs and labor, and more capital-intensive production techniques.[4]

[2] For exports to lower-income countries, this income effect may operate in the opposite direction, potentially violating the assumption that $\tau(\lambda)$ decreases with quality. As discussed later, however, our findings suggest that this violation does not occur even in the case of the United States.

[3] This result also explains why low quality products are usually found to be handicapped in export markets (e.g. World Bank 1999, WTO 2005, Brooks 2006, Verhoogen 2008, Iacovone and Javornik 2009, Artopoulos et al. 2011).

[4] As discussed later, our model does not necessarily imply unconditional exporter premia.

Our model also has different implications for the effects of trade liberalization compared with those of a benchmark model with constant τ – which collapses into a Melitz (2003) model with $\eta = \eta(\varphi, \xi)$ as a single measure of firm heterogeneity. First, rather than a threshold firm size, in our model firms across the size distribution enter the foreign market following trade liberalization. Due to their lower quality, some domestic firms do not find the foreign market profitable despite being large. Smaller firms, by contrast, may become exporters. Second, trade liberalization in our model induces market share reallocation towards high-ξ firms relative to high-φ firms. Although welfare still goes up, unlike in the benchmark model (revenue-weighted) average η may decline. In our model, this measure fails to take into account the new aggregate productivity gains associated with market share reallocations toward high-ξ firms, which economize on trade costs by producing high quality products.

We test for CEPs in ISO-9000 adoption (a proxy for product quality), output prices, input prices, average wage, and capital intensity employing manufacturing firm-level data from four countries: India, the United States, Chile, and Colombia. Based on data availability, we test for quality CEP in India, output and input price CEPs for India and the United States, and average wage and capital intensity CEPs for all four countries in our sample. Consistent with the model predictions, we find evidence of positive and significant CEPs across countries and outcome variables. These results are robust to a number of alternative specifications that address concerns about measurement error in revenue and rule out potential alternative explanations.[5]

Finally, we explore the underpinnings of $\tau(\lambda)$ using firm-level data on export shipments by destination for the U.S. and India. Specifically, we examine how export prices relate to firms' average destination distance and average destination per-capita income. We find that these two channels matter differently for the two countries. For India, only the average income of firms' export destinations is a significant factor explaining variation in export prices across exporters. For the U.S., both average distance and average income have a significant effect on firms' export prices. In the case of average income, although it significantly explains variation in export prices across firms in both countries, the estimated magnitude of this effect for the U.S. is less than a third of the magnitude for India.

Distinguishing process productivity from product productivity as two distinct concepts has potential implications beyond predicting CEPs. For example, it could be important for work exploring deeper determinants of measured productivity and its dynamics over time, the extent to which productivity gains spill over across firms, and the type of public policies that can promote those gains.[6] The

[5] The only exception is capital-intensity in the U.S., which is discussed later.

[6] In a Web Appendix available online on the authors' websites, we explore the implications of our model for traditional

existence of firm capabilities that matter differently for domestic and export market success should also have implications for international organizations and government agencies involved in export promotion and productive development programs. Specifically, our model highlights the importance of enhancing firms' ability to design and produce high quality goods – which face lower constraints to be marketed internationally – relative to fostering efficiency in the production process.

The rest of the paper is organized as follows. Section 2 develops the model and derives the CEPs. Section 3 presents the empirical estimation of CEPs and various robustness tests. Section 4 explores the role of destination distance and income as underlying channels for the price CEP. Section 5 concludes.

2 A model with heterogeneous product and process productivity

2.1 Set up

Demand The model is developed in partial equilibrium. We assume monopolistic competition with constant-elasticity of substitution (CES) demand, augmented to account for product quality:

$$q_j = p_j^{-\sigma} \lambda_j^{\sigma-1} W_j \; ; \qquad \text{where } W_j = EP^{\sigma-1} + I_j^x \tau(\lambda_j)^{1-\sigma} E^* P^{*\sigma-1}. \tag{1}$$

Each firm produces only one variety so j indexes product varieties as well as firms. In the demand equation, q_j is the quantity, p_j is the price, and λ_j is the quality of variety j, while $\sigma > 1$ is the elasticity of substitution. Product quality is modeled as a demand shifter that captures all attributes of a product other than price that consumers value. It captures both tangible attributes such as the product's durability and functionality, and intangible attributes such as the appeal of its design and the image it conveys. W_j is a measure of combined market potential for firm j, E is the exogenously given level of expenditure in the domestic market, P is the CES price index, and stars denote foreign variables. Foreign demand is only available for a firm that pays a fixed exporting cost f_x, in which case the indicator function I_j^x takes a value of 1.

Quality iceberg transport costs Foreign demand is adjusted by the trade discount factor $\tau(\lambda)$. This factor, treated formally as an iceberg trade cost in the model, introduces a wedge between foreign and domestic demand. It can be written as $\tau(\lambda) = \frac{t(\lambda)}{\lambda^\delta}$ to highlight two sources of this wedge. In the numerator, $t(\lambda)$ represents iceberg transport costs, assumed to be decreasing in quality. In the presence of per-unit charges, transport costs constitute a smaller proportion of price for high quality

productivity measures.

products (Alchian and Allen 1964; Hummels and Skiba 2004). Our modeling of trade costs captures in a reduced form the essence of the Alchian-Allen effect while maintaining the tractability of the iceberg assumption.[7,8] In the denominator of $\tau(\lambda)$, the term λ^δ captures differences across countries in the intensity of preference for quality. High-income countries tend to demand goods of higher quality (Hallak 2006, 2010) and set more stringent quality standards (Maskus et al. 2005). This term adjusts foreign demand for each quality level depending on whether the intensity of preference for quality in the foreign country is stronger ($\delta > 0$) or weaker ($\delta < 0$) than in the home country. We include the term λ^δ as part of the trade discount factor $\tau(\lambda)$ for analytical simplicity. Appendix 1 shows that the demand system (1) can be derived from a CES utility function augmented with preferences for quality as in Hallak (2006). Under this framework, differences across countries in the intensity of those preferences can be isomorphically expressed as an iceberg trade cost.[9]

In the remainder of the paper, we assume that $\tau(\lambda)$ is continuous, twice differentiable, and decreasing in λ ($A.1$).[10] Also, defining the quality-elasticity of trade costs as $\varepsilon_\tau(\lambda) = \frac{-\tau'(\lambda)\lambda}{\tau(\lambda)}$, we further assume that this elasticity is bounded from above ($A.2$) and decreasing in λ ($A.3$). Thus:

A.1 $\frac{d\tau(\lambda)}{\partial\lambda} \leq 0$; **A.2** $\varepsilon(\lambda) < \frac{\alpha}{(\sigma-1)} - (1-\beta)$; **A.3** $\frac{d\varepsilon(\lambda)}{\partial\lambda} < 0$.

If $\delta \geq 0$, it is easy to check that assumption $A.1$ is implied by $dt(\lambda)/d\lambda < 0$. If $\delta < 0$, $A.1$ imposes that the influence of transport costs outweighs the effect of income. In turn, assumption $A.3$ implies that trade costs decrease with quality at a decreasing rate ($dt^2(\lambda)/d\lambda^2 > 0$).

These conditions guarantee a solution for the profit-maximization problem of the firm.

Product and Process Productivity Firms are characterized by two heterogeneous attributes, process productivity (φ) and product productivity (ξ). Both are exogenously drawn from a bi-variate distribution $v(\varphi, \xi)$ with support $[0, \overline{\varphi}] \times [0, \overline{\xi}]$. As is standard in the literature, φ is modeled as the ability of a firm to produce a given output at low variable cost. Hence, marginal costs are given by:

$$c(\lambda, \varphi) = \frac{\kappa}{\varphi}\lambda^\beta \; ; \qquad 0 \leq \beta < 1 \tag{2}$$

where κ is a constant and β is the quality-elasticity of marginal costs.

[7] Lugovskyy and Skiba (2011) propose theoretical underpinnings for the function $t(\lambda)$.

[8] Hallak and Sivadasan (2011) provide alternative interpretations of the factor $t(\lambda)$ in terms of costs of return shipping and asymmetric information problems in export transactions.

[9] Note that a high- (low-)quality firm exporting to a low- (high-)δ country might enjoy a trade "benefit" ($\tau < 1$).

[10] A minimum export quality requirement, as modeled in Hallak and Sivadasan (2009), would be a particular case of this assumption.

Product quality also involves incurring fixed costs. They are represented by the following function:

$$F(\lambda, \xi) = F_0 + \frac{f}{\xi}\lambda^{\alpha} \; ; \qquad\qquad \alpha > 0 \tag{3}$$

where f is a constant and α is the quality-elasticity of fixed costs.[11] These costs can be thought of as product design and development costs or costs associated with implementing control systems to prevent item defects.

Assuming that the production of quality requires fixed outlays is standard in the IO literature (Shaked and Sutton 1983; Motta 1993; Sutton 2007). However, we assume here that firms are heterogeneous in their ability to achieve quality with a given investment on those outlays. We refer to this ability as the *product productivity* (ξ) of a firm. A high-ξ firm, for example, may be one with an R&D department that is effective in generating and implementing innovative ideas for new products, or one with a work environment that fosters design creativity or that can rapidly translate evolving consumer tastes into designs that meet those tastes.[12]

Process productivity (φ) is the standard interpretation that economists give to the term "productivity". By contrast, product productivity (ξ) is generally ignored or underemphasized. This is particularly true in the theory of productivity estimation, which typically assumes that the productivity of a firm only affects its variable costs.[13] The wisdom of the asymmetric treatment given to product versus process productivity is questionable. It is widely recognized that a firm's effectiveness in generating marketable outcome from fixed expenditures is as key for its competitiveness as its effectiveness in lowering variable costs. In fact, strategy and marketing researchers have long distinguished product differentiation (also quality leadership or customer satisfaction) from cost leadership (or productivity) as alternate approaches for achieving a competitive advantage in the marketplace (Porter 1980; Phillips et al. 1983, Anderson et al 1994). Management scholars, in turn, emphasize the different organizational competencies entailed by each approach (March 1991, Levinthal and March 1993, Anderson et al. 1997, Rust et al. 2002, Raisch et al. 2009) and debate whether the orga-

[11] In Yeaple (2005) and Bustos (2011), firms can incur a fixed cost to adopt a superior technology that reduces marginal costs. This type of investment would be isomorphic to our fixed cost, which shifts the demand curve out, only if $\tau(\lambda) = \tau$.

[12] In a dynamic pure vertical differentiation model, Klette and Kortum (2004) make a similar assumption. They assume exogenous firm heterogeneity in the extent to which a given innovation improves product quality.

[13] Standard approaches to estimate TFP recover a single-dimensional measure. An interesting question is how this measure relates to φ and ξ. In the Web Appendix (section 3), we show that the productivity residuals from a Cobb-Douglas OLS regression show almost no correlation with φ and ξ, whereas the revenue-based Solow productivity residual (denoted TFPR by Foster et al., 2008) is strongly correlated with log λ. We also show that if data on variable costs and fixed costs (both general and those specifically related to quality) were available, both φ and ξ could be identified.

nizational structure, practices, and incentive systems that are conducive to fostering competence in product differentiation are compatible with increasing competence in cost leadership. In our context, distinguishing these two types of productivity is critical for explaining firms' exporting behavior and for making sense of the observed CEPs. In addition, the distinction could have important implications for research on deeper determinants of firm dynamics, aggregate productivity, and policies aimed at fostering international competitiveness and export development.

2.2 Firms' optimal choices

Given demand (equation 1), firm revenue is determined by

$$r(p_j, \lambda_j) = \widetilde{p_j}^{1-\sigma} W_j \tag{4}$$

where $\widetilde{p_j} \equiv \frac{p_j}{\lambda_j}$ is the quality-adjusted price. For a domestic firm, $W_j = W = EP^{\sigma-1}$. In this case, revenue depends only on $\widetilde{p_j}$, as do operating profits $\pi^o(p_j, \lambda_j)$ which are proportional to revenue. For exporters, in contrast, W_j is a function of quality. In their case, quality introduces an advantage in the export market via $\tau(\lambda)$.

Firms choose price and quality to maximize post-entry profits:

$$\pi(p_j, \lambda_j) = \frac{1}{\sigma} \widetilde{p_j}^{1-\sigma} W_j(\lambda_j) - F(\lambda_j) - I_j^x f_x. \tag{5}$$

The optimal price is given by the standard CES solution for *fob* prices: $p = \frac{\sigma}{\sigma-1} \frac{\kappa}{\varphi} \lambda^{\beta}$. The solution for optimal quality depends instead on the export status of the firm. To characterize this solution, we divide the firm's problem in three parts. First, we find the optimal quality for a firm that serves only the domestic market. Then we find the optimum for a firm that exports. Finally, we compare profits in both cases to determine whether the firm decides to enter the export market.

Domestic case The domestic case has a closed-form solution. Optimal quality is given by

$$\lambda_d(\varphi, \xi) = \left[\frac{1-\beta}{\alpha} \left(\frac{\sigma-1}{\sigma} \right)^{\sigma} \left(\frac{\varphi}{\kappa} \right)^{\sigma-1} \frac{\xi}{f} EP^{\sigma-1} \right]^{\frac{1}{\alpha'}} \tag{6}$$

where $\alpha' \equiv \alpha - (1-\beta)(\sigma-1) > 0$ due to $A.2$ and the fact that $\varepsilon(\lambda) > 0$ by $A.1$. The solution for λ_d shows that optimal quality increases with φ and ξ as these two parameters reduce, respectively, marginal and fixed costs of production.

Using equation (6), the optimal price for a domestic firm can be expressed as

$$p_d(\varphi, \xi) = \left(\frac{\sigma}{\sigma-1} \right)^{\frac{\alpha-\beta-(\sigma-1)}{\alpha'}} \left(\frac{\kappa}{\varphi} \right)^{\frac{\alpha-(\sigma-1)}{\alpha'}} \left[\frac{1-\beta}{\alpha} \frac{\xi}{f} EP^{\sigma-1} \right]^{\frac{\beta}{\alpha'}}. \tag{7}$$

Conditional on φ, high-ξ firms set a higher price because they produce higher quality and thus have a higher marginal cost. Instead, the effect of φ on price, conditional on ξ, is ambiguous. A direct effect lowers the price via a lower marginal cost. An indirect effect raises marginal cost and price via a higher choice of quality. Whether one or the other effect dominates depends on the sign of $\alpha-(\sigma-1)$.

Given equations (6) and (7), the resulting quality-adjusted price can be expressed as:

$$\widetilde{p}(\varphi,\xi)=A\eta(\varphi,\xi)^{\frac{-1}{\sigma-1}}\left(EP^{\sigma-1}\right)^{\frac{-1-\beta}{\alpha'}}; \qquad A\equiv\left(\frac{\alpha}{1-\beta}\right)^{1-\beta}\left(\frac{\sigma-1}{\sigma}\right)^{1+\sigma(1-\beta)}, \tag{8}$$

where the term $\eta(\varphi,\xi)\equiv\left[\left(\frac{\varphi}{\kappa}\right)^{\frac{\alpha}{\alpha'}}\left(\frac{\xi}{f}\right)^{\frac{1-\beta}{\alpha'}}\right]^{\sigma-1}$ is a convenient way of summarizing information about the productivity parameters of the firm. We denote this summary measure "combined productivity". Firms with the same η charge the same quality-adjusted price.

Using equation (4), revenue can also be expressed as a function of η:

$$r_d(\varphi,\xi)=\eta H\left(EP^{\sigma-1}\right)^{\frac{\alpha}{\alpha'}}; \qquad H\equiv\left(\frac{\sigma-1}{\sigma}\right)^{\frac{\alpha\sigma-\alpha'}{\alpha'}}\left(\frac{1-\beta}{\alpha}\right)^{\frac{\alpha-\alpha'}{\alpha'}}. \tag{9}$$

Furthermore, by substituting the solution for λ_d (equation 6) into the fixed cost equation (3) it is easy to show that fixed costs also are a function of η. Hence, profits inherit this property as well:[14]

$$\pi_d(\varphi,\xi)=\eta J\left(EP^{\sigma-1}\right)^{\frac{\alpha}{\alpha'}}-F_0; \qquad J\equiv\left(\frac{\sigma-1}{\sigma}\right)^{\frac{\alpha\sigma}{\alpha'}}\left(\frac{1-\beta}{\alpha}\right)^{\frac{\alpha}{\alpha'}}\left(\frac{\alpha'}{\alpha-\alpha'}\right). \tag{10}$$

Equations (9) and (10) show that, in the domestic case, combined productivity (η) is a summary determinant of size and profits. Thus, domestic firms with the same value of η obtain equal revenue and profits regardless of which combination of φ and ξ generates that value. Notice, however, that despite having the same η, firms will have different λ and charge different p. Therefore, unlike in quality-based models with a single heterogeneous factor (e.g. Kugler and Verhoogen 2011) price here is not monotonically related to size.

Firms remain in the market only if they make non-negative profits, $\pi_d(\eta(\varphi,\xi))\geq 0$. Hence, a critical value $\underline{\eta}$ determines firm survival and establishes a survival cut-off function in $\varphi-\xi$ space:

$$\underline{\xi}(\varphi)=f\left(\frac{F_0}{J}\right)^{\frac{\alpha'}{\alpha-\alpha'}}\left(\frac{\varphi}{\kappa}\right)^{\frac{-\alpha}{1-\beta}}\left(EP^{\sigma-1}\right)^{\frac{-\alpha}{\alpha-\alpha'}}. \tag{11}$$

[14]This property stems from the fact that the two components of the profit function, $\pi^o(\lambda)$ and $F(\lambda)$, are particular cases of the polynomial form $a\lambda^b$. Thus, their ratio is proportional to the ratio of their derivatives. As a result, fixed costs are optimally chosen to be proportional to operating profits, which implies that they are also proportional to revenue and post-entry profits.

Equation (11) shows that for each value of φ, there is a minimum $\underline{\xi}(\varphi)$ such that firms above this minimum earn non-negative profits. Figure 2 displays this cut-off function. In the figure, each firm is represented by a single point, i.e. a (φ, ξ) combination. Firms above the curve $\underline{\xi}(\varphi)$ survive while those below it exit the market (firms along the curve have equal revenue and profits). The negative slope of $\underline{\xi}(\varphi)$ highlights a trade-off between process productivity (φ) and product productivity (ξ). For example, firms with more (less) efficient production processes may be less (more) effective in making appealing designs. Since η is a summary statistic for domestic revenue and profits, in the closed economy the model collapses into a one-dimensional model isomorphic to Melitz (2003).

Exporting case The exporting case cannot be solved in closed form. However, we can characterize important features of its solution and provide a graphical representation of the equilibrium. First, any firm (φ, ξ) will generate more revenue and choose a higher quality if it decides to export ($r_x(\varphi, \xi) > r_d(\varphi, \xi); \lambda_x(\varphi, \xi) > \lambda_d(\varphi, \xi)$, see Appendix 2.$a$). Intuitively, serving a larger market increases revenue while the larger market and the prospects of reducing trade costs provide incentives to invest in quality upgrading. Second, $\eta(\varphi, \xi)$ is no longer a sufficient statistic for revenue and profits. Since trade costs depend on quality, which is relatively more sensitive to ξ than to φ compared with domestic revenue and profits, profits in the exporting case (π_x) inherit this higher relative sensitivity to ξ compared to profits in the domestic case (π_d). Consequently, "export isoprofit curves" ($\xi_{\pi_x=k}(\varphi)$) are flatter than "domestic isoprofit curves" ($\xi_{\pi_d=k}(\varphi)$) at any point (see Appendix 2.b). This result is due to the wedge introduced by $\tau(\lambda)$. In contrast, in a benchmark case were $\tau(\lambda) = \tau$, revenue and profits for exporters could also be written as functions of η. In that case, the model would collapse again to a one-dimensional model isomorphic to Melitz (2003).

The export status decision After solving the domestic and the exporting cases, the firm compares profits under each case and decides to export if $\Delta\pi(\varphi, \xi) \equiv \pi_x(\varphi, \xi) - \pi_d(\varphi, \xi) \geq 0$. Define the export cut-off curve $\underline{\xi}_x(\varphi)$ as the value of ξ that solves $\Delta\pi(\varphi, \xi) = 0$ for each φ. This curve is displayed in figure 2. Since $\Delta\pi(\varphi, \xi)$ is increasing in both arguments, it has a negative slope (see Appendix 2.c). The curve divides the set of surviving firms into two groups. Firms located between $\underline{\xi}(\varphi)$ and $\underline{\xi}_x(\varphi)$ serve only the domestic market while firms located above $\underline{\xi}_x(\varphi)$ export. Given that export isoprofit curves are flatter than domestic ones at any point, the export cut-off curve $\underline{\xi}_x(\varphi)$ is flatter than both. Thus, moving down along $\underline{\xi}_x(\varphi)$, profits in the exporting and domestic cases both increase (see Appendix 2.d). Domestic revenue also increases as domestic isorevenue and isoprofit curves coincide.

2.3 Testable predictions

In this two-dimensional model, size and export status are not monotonically related. This feature of the model is a necessary condition to deliver CEP predictions as it generates domestic firms and exporters with the same size. Together with ancillary assumptions about input requirements for the production of quality, the model generates five conditional exporter premia (CEP 1-5).[15] The following proposition explains CEP 1. This is the main prediction of the model.

Proposition 1. Conditional on size (revenue), quality is higher for exporters than for non-exporters.

Proof. Let a and b be two firms with equal size ($\overline{r} = r_a = r_b$) but different export status. Consider *w.l.o.g.* that a is the exporter while b is the non-exporter. By equation (4), $\overline{r} = (\widetilde{p}_a)^{1-\sigma}(EP^{\sigma-1} + \tau(\lambda_a)^{1-\sigma}E^*P^{*\sigma-1}) = (\widetilde{p}_b)^{1-\sigma}EP^{\sigma-1}$. Since $\tau(\lambda_a)^{1-\sigma}E^*P^{*\sigma-1} > 0$, then $(\widetilde{p}_a)^{1-\sigma} < (\widetilde{p}_b)^{1-\sigma}$. Hence, $\widetilde{p}_a > \widetilde{p}_b$.

Conditional on their optimal choice of quality, a prefers to export while b prefers not to do it. Hence, the potential operating profits that firms can make in the export market (π_x^o) and the fixed exporting cost (f_x) satisfy $\pi_{xa}^o \geq f_x > \pi_{xb}^o$, or

$$\pi_{xa}^o = \frac{1}{\sigma}(\widetilde{p}_a)^{1-\sigma}\tau(\lambda_a)^{1-\sigma}E^*P^{*\sigma-1} \geq f_x > \frac{1}{\sigma}(\widetilde{p}_b)^{1-\sigma}\tau(\lambda_b)^{1-\sigma}E^*P^{*\sigma-1} = \pi_{xb}^o. \tag{12}$$

Combining the above inequalities, $(\widetilde{p}_a)^{1-\sigma}\tau(\lambda_a)^{1-\sigma} > (\widetilde{p}_b)^{1-\sigma}\tau(\lambda_b)^{1-\sigma}$. Hence, $\tau(\lambda_a)^{1-\sigma} > \tau(\lambda_b)^{1-\sigma}$. Since $\tau(\lambda)$ decreases with λ, the last inequality proves that $\lambda_a > \lambda_b$. □

Proposition 1 states that, among equally sized firms, the exporter (firm a) has a higher quality ($\lambda_a > \lambda_b$) than the non-exporter (firm b). In turn, the latter charges a lower quality-adjusted price ($\widetilde{p}_b < \widetilde{p}_a$), which is how it compensates for its lack of exports with higher sales in the domestic market.

The mapping of these results to the underlying firm parameters (φ_a, ξ_a) and (φ_b, ξ_b) is illustrated graphically in Figure 3. Note first that the exporter cannot possess higher φ *and* higher ξ; in that case it would be a larger firm. Consequently, the non-exporter needs to have some compensating advantage. The figure displays an exporter (firm a) and a non-exporter (firm b) with $\xi_a > \xi_b$ and $\varphi_a < \varphi_b$. This restriction on these firms' figure location needs to hold. To see this, start with a generic exporter such as firm a, which must be located above $\underline{\xi}_x(\varphi)$. Consider the revenue that this firm would make if it did not export. From previous results, we know that $r_d(\varphi_a, \xi_a) < r_x(\varphi_a, \xi_a)$. Find firm m located at the intersection of a's (dotted) *domestic* isorevenue curve and $\underline{\xi}_x(\varphi)$. By transitivity, we easily establish

[15] Hallak and Sivadasan (2011) show that all CEP can be generated from an "interim" model with exogenous quality and marginal costs. This model, however, does not relate these variables to underlying productivity attributes.

that $r_d(\varphi_m, \xi_m) < r_x(\varphi_a, \xi_a)$. We have also established that domestic revenue increases moving down along $\underline{\xi}_x(\varphi)$. Hence there is a point such as d in the figure that satisfies $r_d(\varphi_d, \xi_d) = r_x(\varphi_a, \xi_a)$. Then, any non-exporter b with the same revenue as a ($r_d(\varphi_b, \xi_b) = r_x(\varphi_a, \xi_a)$) needs to be located on d's domestic isorevenue curve, as shown in the figure.[16]

A typical isorevenue curve, therefore, consists of two disjoint parts. An upper-left portion contains only exporters on the same *export* isorevenue curve. This is the part that starts at point c and goes up through a. A bottom-right portion contains only non-exporters on the same *domestic* isorevenue curve. This part starts at point d and goes down through b. Domestic firms on this portion compensate their lack of exports with higher domestic sales. Exporters exhibit higher ξ and lower φ than non-exporters because export profits are more sensitive to ξ relative to φ than domestic profits. A higher ξ induces exporters to choose higher quality levels, which gives them a relative advantage in the export market. On the other hand, a lower φ explains why they charge a more expensive quality-adjusted price, and hence make lower domestic sales.

Two properties of the model are key to break the monotonicity between firm size and export status. First, with only one source of heterogeneity (φ or ξ) this sole parameter would monotonically determine quality, size, and export status. Such a model would not be able to explain the existence of exporters and non-exporters of equal size. Second, $\tau(\lambda)$ introduces a wedge between the export and the domestic markets providing high-quality firms with a relative advantage abroad. If $\tau(\lambda) = \tau$, the size of a firm would be monotonically related to its export decision as both would depend on η only.

The following corollaries to proposition 1 explain CEP $2 - 5$:

Corollary 1. *Conditional on size, exporters charge higher prices than non-exporters.*

Proof. Consider an exporter a and a non-exporter b such that $r_a = r_b$. By proposition 1, $\lambda_a > \lambda_b$ and $\widetilde{p}_a > \widetilde{p}_b$. Since $\widetilde{p} = \frac{p}{\lambda}$, then $p_a > p_b$. □

While proposition 1 is the fundamental prediction of the model, corollary 1 is the most important empirical prediction as it can be tested directly with observable data. The remaining corollaries rest on ancillary assumptions about input requirements of quality production. Let $p^I(\lambda)$ and $w(\lambda)$ be the average price of intermediate inputs and the average wage necessary to produce quality λ, respectively. Similarly, define $k(\lambda)$ as the capital-labor ratio for quality λ. The following assumptions postulate that these three functions increase with quality:

[16] For sufficiently low (high) levels of revenue, all firms could be domestic (exporters). Also, we require a sufficiently large support for φ and ξ to ensure that the largest non-exporter obtains more revenue than the smallest exporter.

A.4 $\frac{dp^I(\lambda)}{d\lambda} > 0$, $\frac{dw(\lambda)}{d\lambda} > 0$, and $\frac{dk(\lambda)}{d\lambda} > 0$

In the Web Appendix (section 1.A), we provide deeper fundamentals for these assumptions (partially drawing from Verhoogen 2008) and show how they can provide underpinnings for equations (2) and (3). Proposition 1 and assumption $A.4$ deliver the following corollaries:

Corollary 2. *Conditional on size, exporters pay higher input prices than non-exporters*

Corollary 3. *Conditional on size, exporters pay higher average wages than non-exporters*

Corollary 4. *Conditional on size, exporters use physical capital more intensively*

Proof. Let a and b be two firms such that $r(c_a, \lambda_a) = r(c_b, \lambda_b)$. By proposition 1, if only firm a exports, then $\lambda_a > \lambda_b$. From $A.4$, it follows directly that $p^I(\lambda_a) > p^I(\lambda_b)$, $w(\lambda_a) > w(\lambda_b)$ and $k(\lambda_a) > k(\lambda_b)$. □

The theoretical results of corollaries 1, 2, 3, and 4 predict conditional exporter premia on output prices (CEP 2) and input usage (CEP $3-5$). These theoretical predictions are novel. Models of firm heterogeneity with quality differentiation predict *unconditional* exporter premia for quality and price (Verhoogen 2008, Baldwin and Harrigan 2011, Johnson 2011, Kugler and Verhoogen 2011) and for input use (Verhoogen 2008, Kugler and Verhoogen 2011). However, they do not explain why those premia still hold once size is held constant.[17]

Proposition 1 and corollaries 1, 2, 3 and 4 can be weakened to be stated in expected values across exporters and non-exporters. In that form, section 3 takes these predictions to the data.[18]

2.4 Implications for the effects of trade liberalization

Our model also has implications for the effects of trade liberalization. In this section, we briefly summarize those implications obtained from simulating our model. The calibration and quantitative results of the simulation are described in the Web Appendix (section 2). We compare the implications of our model with those of a benchmark model where $\tau(\lambda) = \tau$. As discussed above, in that case our model collapses to a model isomorphic to Melitz (2003) with η as the single heterogeneous attribute.

Single-attribute models predict that a threshold size divides exporters from domestic firms. Hence, it is the largest domestic firms that benefit from trade by accessing the foreign market. In our model, in contrast, as an economy opens up to trade the largest firms (those with high η) are not necessarily

[17] Our model does not necessarily predict unconditional exporter premia. The presence of unconditional premia will largely depend on the relationship between firm size and the variable of interest. This relationship, in turn, is determined by the shape of the joint distribution $v(\varphi, \xi)$ on which we do not impose restrictions.

[18] The existence of a free-entry industry equilibrium is shown in the Web Appendix (section 1.B).

those that export. Rather, firms enter the export market across the size distribution. This result emphasizes the broader point that exporting success requires different firm capabilities than success in the domestic market. In particular, firms with relatively high ξ have an advantage for producing quality and hence perform relatively better in the export market. This result also implies that improving firms' organizational structure, practices, and incentives to enhance their ability to design and develop high quality products has a differential impact on export market performance.

Our model also has interesting implications for reallocation effects of trade liberalization on aggregate productivity and welfare. In the benchmark model, (revenue-weighted) average η grows unequivocally. Consistent with Melitz (2003), trade liberalization induces market share reallocations toward firms endowed with larger values of this single attribute. These are the largest firms in autarky and those predicted to become exporters. In our model, average η may go down as market share reallocations benefit firms with high ξ relative to firms with high φ. The intuition behind this result is that average η cannot predict welfare changes because it is no longer a relevant measure of aggregate productivity. In the open economy, aggregate productivity gains also come from reallocating market shares toward high-ξ/high-λ firms to save on trade costs $\tau(\lambda)$. Nevertheless, welfare still increases.

3 Empirical evidence on Conditional Exporter Premia

In this section, we use plant-level micro data sets from India, the United States, Chile and Colombia to test the five CEPs predicted by our model. Section 3.1 describes data sources, key variables and methodology. Section 3.2 presents the baseline results and robustness tests. Section 3.3 discusses robustness to alternate explanations.

3.1 Data, variable definitions and methodology

3.1.1 Data sources and definition of variables

Our empirical analysis utilizes establishment(plant)-level manufacturing data from India, the United States, Chile and Colombia. Because our theory hinges on a differentiated-product demand structure, we focus on manufacturing industries producing "differentiated" products according to Rauch's (1999) liberal classification. We discuss data sources briefly below. More specific description of data sources, data cleaning, and concordances is provided in the Web Appendix (Section 4).

For India, we use a cross-section of the Annual Survey of Industries (ASI) for the year 1997-98. In addition to establishment-level information (classified by 4-digit NIC categories), this survey includes information on quantity and value of outputs and inputs at a highly disaggregated 5-digit 'item code' level. This allows us to construct output and input prices (unit values). Also, it has information on whether plants have obtained ISO 9000 certification, which we use as a direct proxy for quality. The ASI uses a size-stratified sampling methodology. Thus, we use sampling weights in our analysis.

For the United States, we use data from the 1997 Census of Manufactures (CMF) collected by the U.S. Census Bureau. The CMF includes detailed information on establishment inputs and outputs classified at the 4-digit SIC level. Following common practice we exclude small "administrative records" plants that contain imputed data. A distinctive feature of our work is the use of seven-digit SIC information in the CMF to derive product-level input and output unit values (or prices).[19]

We use manufacturing censuses for Chile and Colombia to examine only average wage and capital intensity CEPs because those data sets do not include product-level information. Both censuses cover all manufacturing plants with more than 10 employees and classify establishments at the 4-digit ISIC level. The coverage period is 1991-96 for Chile and 1981-91 for Colombia.[20]

Testing the predictions of the model requires data on export status, revenue, quality, output and input prices, average wage, and capital intensity. While a direct measure of quality is unavailable, in the Indian data set each plant reports if it has obtained ISO 9000 certification. We discuss in section 3.2 why this quality management certification could be a good proxy for quality (λ). All variables, except for output and input prices, are defined at the establishment level. For both India and the U.S., output prices (unit values) are constructed based on revenues that exclude all freight charges. Export status is captured by a dummy variable defined to equal one for plants reporting positive exports. Revenue is total sales, labor is total employment and average wage is the ratio of total wages to total employment. Capital, for Chile, is constructed using the perpetual inventory method. For India, the U.S., and Colombia, it is measured as reported total fixed assets. The ownership links available in the U.S. data set allows us to aggregate establishments into firms and thus perform robustness analysis defining variables at the firm level. For India and the United States, price (both for outputs and inputs) is defined as unit value, computed as the ratio of value to quantity.

Panels 1, 2, 3 and 4 of Table 1 present summary statistics for establishments in "differentiated"

[19] Foster et al. (2008) use CMF output unit values at the 7-digit level for a small set of homogenous products. One potential drawback of using unit values is that quantity data is unavailable for a large fraction of establishments and products (particularly in the case of inputs). However, since our model's predictions compare establishments (firms) within industries, lack of information for entire products or industries should not bias our results.

[20] Further details about these datasets can be found in Sivadasan (2007) for India, the LRD technical documentation manual (Monahan 1992) for the U.S., and Roberts and Tybout (1996) for Chile and Colombia.

sectors in our final samples for India, the U.S., Chile and Colombia, respectively. The number of observations for output prices for India and input and output prices for the U.S. is lower relative to other variables because price data are not available for all establishments and product lines.

Since our analysis focuses on differences between exporters and non-exporters within industries, we exclude industries with no exporters from our sample. Hence, the fraction of exporters that can be inferred from the table by dividing the number of exporters by the total number of establishments overestimates the prevalence of exporting in the full sample. There is also a higher prevalence of exporting in the sample of product prices than in the sample of establishments due to our assumption that an exporting establishment exports all product lines and to the fact that larger firms, which are more likely to export, are also more likely to have multiple product lines.

To mitigate the influence of outliers, all variables are winsorized by 1% on both tails of the distribution. For reasons discussed later, in our baseline analysis we standardize all variables (except dummies), by subtracting industry means and dividing by industry standard deviations.[21] Hence, means and standard deviations reported in Table 1 correspond to standardized variables.[22] The unconditional mean of output and input prices is higher for exporters than for non-exporters in both India (panel 1) and the U.S. (panel 2). Panel 1 also shows a higher rate of ISO 9000 adoption in India among exporters (17%) than among non-exporters (3%). Finally, in all four panels, the mean values for average wage and capital intensity are higher for exporters than for non-exporters.

3.1.2 Methodology

In equilibrium, output and input prices, quality, revenue, capital intensity, average wage, and export status are jointly determined as functions of φ and ξ. Proposition 1 and corollaries $1-4$ all impose restrictions on conditional expectations derived from that joint distribution. Defining an indicator variable for export status, D, the weak versions of proposition 1 and the corollaries can be written as

$$E\left[Y\,|_{r,D=1}\right] > E\left[Y\,|_{r,D=0}\right], \quad \forall r, \qquad Y = \left\{\lambda, p, p^I, w, k\right\}. \tag{13}$$

[21] When using price data, "industries" correspond to product codes (5-digit item code for India and 7-digit SIC code for the U.S.). For other variables, they are defined at the 4-digit level (SIC for the U.S., NIC for India and ISIC for Chile and Colombia). All our specifications using panel data from Chile and Colombia include industry-year pair fixed effects. Because nominal variables (capital intensity and wage) enter regressions in logarithms, our results are invariant to deflating them using industry level deflators.

[22] To be specific, the standardized version of variable x for observation i in industry (or product) j is defined as $x^s_{ij} = \frac{x_i - \bar{x}_j}{\sigma_{xj}}$ where $\bar{x}_j$ and σ^x_j are the mean and standard deviation of x within industry j, respectively.

Assuming a linear separable form for the conditional expectations: $E\left[Y\left|_{r,D}\right.\right] = g_Y(r) + \delta_Y D$, we can write these predictions as:

$$y = g_Y(r) + \delta_Y D + u \tag{14}$$

which is the empirical framework typically used by the literature to obtain CEPs. In equation (14), $g_Y(r)$ is a flexible control for size, and δ_Y is the conditional exporter premium. The disturbance u is a random component, uncorrelated with the conditioning variables, that captures variation in the dependent variable across firms that have the same revenue and export status but different φ and ξ. We estimate (14) using ordinary least squares. In specifications with potentially multiple observations per plant, standard errors are clustered at the plant level to account for potential correlation in the error term. It is worth noting that the coefficients in (14) *do not* capture causal relationships. The exporter premium δ_Y should be interpreted as the difference in the expected value of Y between an exporter and a non-exporter of equal size.

Although our model and its predictions are essentially relevant to a single industry, we pool observations in all differentiated-product industries to estimate equation (14). We address the potential impact of industry heterogeneity in two ways. First, in our empirical implementation we allow the coefficients of the polynomial $g_Y(r)$ to vary by product or industry (note that the constant in the polynomial is in fact an industry-specific fixed effect). Also, to flexibly capture non-linearities, we specify both a parametric (a third order polynomial) and a semi-parametric (industry-specific size-decile fixed effects) form for $g_Y(r)$. Second, we standardize both the dependent and the independent variables using product/industry-specific means and standard deviations to improve comparability across sectors. In particular, standardization prevents particular products/industries from driving the overall results.[23] Nevertheless, we also report results using non-standardized variables.

3.2 Baseline results

Quality CEP Although we do not have direct measures of product quality, an extensive literature suggests that ISO 9000 certification may be a good proxy, particularly in the context of our model. First, ISO 9000 is correlated with direct measures of product quality (e.g. Brown et al. 1998, Withers

[23] As an illustration, consider measuring the relative price charged by exporters using data from two industries with equal number of firms. Suppose in industry 1 exporters price at a premium of 40% relative to non-exporters, while in industry 2 exporters price at a discount of 10%. If we use non-standardized prices we obtain a mean export price premium of 15%. This figure could be misleading if the price premium in industry 1 is low relative to the price dispersion in that industry while in industry 2 the price discount is high relative to the price dispersion.

and Ebrahimpour 2001). Second, consistent with our assumption that upgrading quality is costly but shifts demand out, Guler et al. (2002) document that obtaining ISO 9000 involves a considerable organizational effort and monetary investment (about $125,000), and impacts both local and international demand as governments and private companies often require this certification from suppliers. There is also evidence that the certification helps improve measures of customer satisfaction (Buttle, 1997).[24]

Table 2 presents results from estimating equation (14) across establishments for ISO 9000 certification as the dependent variable. Each entry in the table displays the estimate of the exporter premium, δ_Y, in the indicated specification. The first two columns are displayed as a benchmark. Column 1 includes industry-specific fixed effects but no controls for size while column 2 includes industry-specific polynomials of order 2 in size. Columns 3 and 4 are our baseline (preferred) specifications. Column 3 includes an industry-specific size polynomial of order 3. Column 4 includes industry-specific size-decile fixed effects. Industries are defined at the 4-digit NIC level.

We find that exporters are substantially more likely to obtain ISO 9000 certification *conditional on size*. The estimated probability premium is at least 7.5 percentage points higher for exporters (relative to a mean level of 3% for non-exporters in Table 1), and is statistically significant in all specifications at the 1 percent level. This finding supports the main theoretical prediction of the model.[25]

Output price CEP We measure output price as the unit value per product line. For multi-product plants, we include one price observation per line of differentiated product but keep plant revenue as the size measure. Also, since information on exports is not disaggregated by product line, we assume that a plant exports all of its product lines. Standard errors are clustered at the plant level.

Panel 1 of Table 3 presents the results for India and panel 2 for the United States. The table shows a positive output price CEP in all specifications. For India, all standardized specifications yield a statistically significant premium for exporters. In the non-standardized case, the premium is not statistically significant in the benchmark specifications of columns 1 and 2 but it is larger and significant in the baseline specifications of columns 3 and 4, where size is flexibly controlled for. In those specifications the standardized price premium is 17.7% and 16.9%, respectively. For the U.S., the estimated price premium is smaller (13.6% and 13.5% in the baseline specifications) but statistically

[24] Verhoogen (2008) also uses ISO 9000 certification as a proxy for quality.

[25] Following a referee's suggestion, we assume values of $\sigma = 4$ and $\sigma = 6$ to construct a proxy function for quality derived from equation (1), namely: $f(\lambda) \equiv \log(\lambda) + \frac{1}{\sigma-1}\log(W_j(\lambda)) = \frac{1}{\sigma-1}q_j + \frac{\sigma}{\sigma-1}p_j$. Table A.1 of the Web Appendix displays similar results using this proxy for quality, with positive (but noisier) CEP for India and positive and statistically significant CEP for the United States.

significant in all specifications.[26]

The fact that exporters charge higher prices than non-exporters *conditional on size* is a key prediction of our model. Compared to the quality CEP discussed above, it is more amenable to estimation as prices are more directly observed than quality. Compared to the input-use CEP discussed below, it does not require ancillary assumptions about input requirements for quality production. As discussed earlier, this finding has been previously documented (see Kugler and Verhoogen 2011) but lacked a theoretical framework that could explain it. Nevertheless, it constitutes additional support for the empirical relevance of the two-dimensional model we propose in this paper.

We conduct a number of robustness checks (results are presented in the Web Appendix). First, since we model differentiated products, we implement our empirical strategy on non-differentiated products (homogeneous and reference-priced) where the theoretical predictions may not apply. In India, the premium is insignificant for non-differentiated products while in the U.S. it is significant but smaller than for differentiated products (Table $A.2$). Second, to address potential concerns related to our assumption that multiproduct exporters export all their products and to our use of establishment sales as the size control, we examine a sample restricted to single-product establishments and examine a sales-weighted index of standardized prices for each plant. For the U.S., the magnitude and significance levels of the CEP estimates are very similar to the baseline. For India, the estimates are significant in both robustness exercises for the cubic-polynomial size control but not for the one with size-deciles controls. However, the estimated magnitude of the CEP is not substantially altered (Table $A.3$). Finally, we restrict our definition of exporters to establishments with export sales above 2% of total revenue and, alternatively, we retain only the largest product line for each establishment. The results confirm the robustness of the baseline results (Table $A.4$).

In a number of other (unreported) robustness checks, we find the results robust to: (a) using different winsorization cutoffs (including no winsorization) for the price variable; (b) excluding products whose definition includes the terms NEC or NES ("Not Elsewhere Classified/Specified") for India, and excluding product codes ending with 0 or 9 for the U.S.; (c) for India, excluding products measured in "numbers" because of potential heterogeneity in units (e.g. different pack sizes), and for the U.S.

[26] The magnitude of the premium conditional on size (columns 2 to 4) is larger than when size is not controlled for (column 1), particularly for the United States. Since export status and size are strongly correlated both in the India and in the U.S. datasets, the bias on the export dummy in Column 1 largely depends on the correlation between size and price – though non-linear components of the relationship also play a role. The correlation is negative in the U.S. sample, explaining the significantly smaller coefficient in Column 1. For India, the size-price correlation is close to zero but displays a U-shaped relationship, making the estimates more sensitive to which non-linear controls are included.

excluding potential non-manufacturing product codes (i.e. first digit not 2 or 3); and (d) examining the subset of product codes with available price data for all occurrences and also with at least 25 observations to ensure that results are not driven by missing observations within product codes.

One final concern is that the findings could reflect higher mark-ups charged in the export market. The empirical evidence, however, suggests just the opposite. Applying a structural model to three manufacturing industries in Colombia, Das et al. (2007) estimate foreign-market demand elasticities to almost double domestic-market ones in two sectors, and no significant difference in the third sector. Aw et al. (2001) compare export and domestic prices charged by the same firm on the same product in the Taiwanese electronics industry in 1986 and 1991. Out of 54 product/years they investigate, they find higher domestic prices in 40 cases (8 significant) and lower domestic prices in 14 cases (none significant). Finally, De Loecker and Warzynski (2009) attribute their finding that exporters charge higher prices than non-exporters as higher markups. However, they also find suggestive evidence that the estimated markups may be driven by quality differences rather than by greater market power.[27]

Input price CEP We compute input prices as the unit value of each establishments' inputs. We examine only inputs purchased by establishments whose main output product is differentiated and weight each input-price observation by the share of the input in total costs. Table 4 shows the results. The input price CEP is positive and significant in all specifications with standardized variables, both for India and for the United States. The exporter premium is also positive in all specifications with non-standardized variables although in two of the eight specifications it is not significant.

We undertake similar robustness checks as in Section 3.2. In particular, we check robustness to defining as exporters plants that export at least 2% and to only including observations for the main establishment input. We find that the baseline results are robust (not reported). This evidence is also in line with previous findings documented by Kugler and Verhoogen (2011).

Wage and capital intensity CEPs In this section, we present empirical evidence of CEP in (log) average wage and capital intensity (measured as the log ratio of capital to labor). To save space, for each of the four countries we only present the preferred specifications with the cubic and size-decile

[27] In particular, they find higher markups for exports to Western Europe. They note that "Our results are clearly consistent with the quality hypothesis, given that it is expected that quality standards are higher in Western European markets than in the Slovenian domestic market. Furthermore, the implied productivity differences obtained in the previous section are not able to explain the 16.5 percent higher markups, suggesting an important role of quality differences among exporters and domestic producers."

controls for size. The unit of observation is the establishment. The evidence in this section mimics results reported by earlier studies (see Introduction to this paper).

Table 5 shows a significantly positive average wage CEP for all countries in all specifications. In the standardized case, the estimates in columns 2, 4, 6, and 8 imply a 13.6% of standard deviation exporter wage premium in India, 9.7% in the U.S., 13.1% in Chile and 9.2% in Colombia. The results in row 2 using the non-transformed variables are similar.[28]

For capital intensity, the results in rows 3 and 4 of Table 5 show a positive and significant CEP for India, Chile and Colombia in both specifications. For example, the estimation using standardized variables and the most flexible control for size indicates that exporters in India have 18.8% (of standard deviation) higher log capital to worker ratio, conditional on revenue. The corresponding premium is 25.0% for Chile and 14.7% for Colombia. In the case of the U.S., in contrast, the capital intensity CEP appears to be negative. Since this result is at odds with previous results reported in the literature using similar specifications (e.g. Bernard and Jensen 1999), we repeat the estimation using 1992 Census data. We find an insignificant (almost zero) premium in 1992 (Table $A.6$). In contrast, for wages and prices the 1992 results are consistent with the 1997 results. Given the non-robustness of the capital intensity results for the U.S. across years, we are cautious about adopting any particular interpretation for the negative premium in 1997 and leave it for further scrutiny in future research.[29]

3.3 Robustness to alternate models/explanations

3.3.1 Robustness to single-attribute models plus measurement error in size

Since firm size and export status are correlated variables, measurement error in the size control variable could lead to spuriously finding CEP when the true premium is zero. We address this concern in three ways. All empirical results in this section are presented in the Web Appendix.

First, we use employment as an alternative measure of firm size. Since employment is also monoton-

[28] Though wage rates better capture unobserved worker ability, we also analyzed the share of non-production workers in the total wage bill and the share of non-production workers in total employment (see Table $A.5$). The non-production wage-bill share is significantly higher for exporters in the U.S., Chile and Colombia but statistically insignificant for India. The share of non-production employment is higher for exporters in the U.S. and Colombia, but not significantly different from zero for India and Chile.

[29] One hypothesis could be that quality upgrading requires a higher capital intensity in labor-abundant countries where production methods are relatively intensive in unskilled labor (e.g. need of machinery to improve cutting precision) but requires increasing the intensity of skilled labor in capital-abundant countries where production methods are already intensive in the use of capital (e.g. need of artisan “touches”).

ically related to firm size in single-attribute models, it can be used as an alternative size control to test those models as the null hypothesis.[30] The estimated results show that rather than becoming smaller, as expected if measurement error was driving the results, the estimated CEP increases in almost all cases (Table $A.7$, Panel 1).

Second, using *establishment* rather than *firm* size could be a source of measurement error for multi-establishment firms if the heterogeneous attributes and the fixed costs are determined at the firm level. Exploiting information on ownership links available in the U.S. Census Longitudinal Business Database – but not in the other three data sets – we aggregate establishments up to the firm level and re-estimate our baseline specification. As an additional check, we repeat the analysis using only single-establishment firms. The baseline results are robust to these alternate checks (Table $A.8$).

Finally, we exploit the panel nature of the data for Chile and Colombia to control for transient shocks to revenue. For each establishment, we form four-year means for the dependent variables (average wage and capital intensity) and revenue over the latest available period of data – 1993-96 for Chile and 1988-91 for Colombia (we exclude export entrants and exiters during the period to avoid transitional dynamics). The baseline results are again confirmed (Table $A.9$).

3.3.2 Robustness to alternate multi-attribute models

Several multi-attribute models have been proposed in the literature. Though built to explain other implications of firm heterogeneity, we can evaluate whether they can explain the observed CEPs. The most common one is a model that combines productivity differences à la Melitz (2003) with heterogeneous fixed or sunk export costs (Das et al. 2007, Eaton et al. 2008, Ruhl 2008, Armenter and Koren 2010).[31] Under this framework, a less productive exporter might have the same size as a more productive non-exporter if the former has lower export costs. In that case, the exporter's lower productivity would imply higher output prices and thus explain a positive price CEP. However, this model would not explain why exporters are more likely to acquire ISO 9000 certification, pay higher wages, and use capital more intensively. By contrast, combining Kugler and Verhoogen (2011) with heterogeneous trade costs would yield the prediction of a negative price CEP since the less productive exporter would have a lower quality. In either case, firms with equal productivity should display identical sales in the domestic market. Thus, controlling for the latter instead of total sales, we should

[30] Our model indicates that we should use revenue as the size control. Thus, while using employment is appropriate for testing single-attribute models as the null, under our framework as the null this approach could yield biased results.

[31] Heterogeneity in variable trade costs would work analogously.

not observe systematic differences between output prices of exporters and domestic firms. The results in panel 2 of Table $A.7$ show, however, that this is not the case: exporters charge higher prices even conditional on *domestic* sales.

An alternative explanation could be that some productive, high-quality exporters are small because they are young firms.[32] To address this possibility, we estimated price CEPs for the U.S. including only 1997 data on plants that existed in 1992 (i.e. at least 5 years old) and exporters that were also exporting in 1992 (i.e. excluding new entrants into the export market). The estimated results in fact become stronger (Table $A.10$). Other models introduce variation in products' appeal across markets (e.g., Eaton et al. 2008, Kee and Krishna 2008, Bernard et al. 2011, Nguyen 2011). While these models can naturally explain Figure 1, they cannot explain the systematic CEPs observed in the data.

Two alternate sources of heterogeneity could potentially explain some of our results. One, firms may be heterogeneous in access to financial capital. While the predictions of such a model would depend on how financial constraints are assumed to affect firm size and export status, we ran the baseline price regressions excluding products above the median of the Rajan and Zingales' (1998) measure of external finance dependence. We found a positive and significant premium even in industries that are less dependent on external finance (Table $A.11$). Two, less productive firms could produce lower quality and sell at lower prices (as in Kugler and Verhoogen 2011) but have better access to government contracts. To address this concern, we constructed a product-level measure of dependence on government purchases (fraction of output consumed by state and federal government) using detailed input-output tables for the U.S., and ran the baseline price regressions excluding products above the median for this measure. The results (also in Table $A.11$) show a positive and significant CEP even in industries that are relatively less dependent on government purchases.

4 Underlying sources of the foreign/domestic profit wedge

In this section, we exploit variation in export destinations across firms to explore the relative role of non-iceberg trade costs and income per capita as underlying determinants of the wedge that $\tau(\lambda)$ introduces between foreign and domestic profits. To the extent non-iceberg transport costs are an important determinant of $\tau(\lambda)$, we would expect firms exporting on average to farther destinations to produce higher quality and hence charge a higher price. To the extent per-capita income is an important source of $\tau(\lambda)$, we would expect higher quality and export prices for firms that export on

[32] We thank a referee for raising this point.

average to richer countries.[33] While our model collapses all export destinations into only one export market, these would be natural implications of an extension to multiple destinations. In such an extension, the same composition effect that selects high quality producers to the export market in our model would select an increasingly smaller subset of the highest quality producers as distance and income per capita increase.[34]

We use data on export shipments by destination for India (2003-04) and the U.S. (1997). A detailed description of these data sets can be found in the Web Appendix. For each firm and Harmonized System product code (8-digit for India and 10-digit for the U.S.) we calculate the average price ($\bar{p}$) as the total export value aggregated across destinations divided by the total export quantity (when quantities are reported in different units we break the product code accordingly). The average distance ($\bar{d}$) and average per-capita income ($\bar{g}$) are defined for each exporter as the log of the average distance and income per capita across export destinations, respectively. We use quantity weights for $\bar{d}$ and $\bar{g}$ to match the quantity weights implicit in calculating $\bar{p}$. Using standardized variables, we estimate:

$$\bar{p} = \beta \bar{d} + \alpha \bar{g} + g(r) + u.$$

The U.S. shipment dataset has firm identifiers (or firm names) that we use to link it to the Manufacturing Census using information in the U.S. Census Business Register. Hence, we can use firm revenue as the control for firm size. For India, the shipments and manufacturing data cannot be linked. Therefore, we use total exports as an imperfect proxy for firm size.

The results are presented in Table 6. Panel 1 presents the estimates for India and Panel 2 those for the United States. The results for India show that exporters who ship their goods to richer countries tend to charge higher prices. The elasticity estimate is significant in all specifications with a magnitude close to 5.5%. Indian exporters who ship to more distant countries also charge higher prices but the estimated elasticity is small (between 0.2% and 0.3%) and not significant. The results for the U.S. instead suggest a stronger role of distance relative to income per capita. The elasticity of price with respect to average distance is positive (15%) and significant. The elasticity to average per-capita

[33] When the income per capita of a country is high as in the case of the U.S., the average per-capita income of a firm's export destinations could be lower than the domestic per-capita income. If this average is sufficiently low, it could more than offset the effect of distance and hence overturn proposition 1 and its corollaries. The results of section 3 and the ones we present here, however, indicate that this is not the case.

[34] A recent literature shows that export prices vary within firms across destinations, which suggests that firms tailor their quality to the destination market (Bastos and Silva 2010, Manova and Zhang 2012, Harrigan et al. 2012). While our assumption that firms choose only one quality level rules out quality variation across destinations, we think that allowing for this variation would still deliver our predictions for average quality and price variation across firms.

income is statistically significant but substantially smaller in magnitude than the estimated elasticity for India (less than 2%).

This exercise suggests that both non-iceberg transport costs and differences in the demand for quality across countries with dissimilar income are relevant sources of $\tau(\lambda)$. The results also suggest that the underpinnings of this wedge vary by level of development, with distance-related factors more important for a high-income country like the United States, and income-related factors more important for a low-income country like India. Nevertheless, further theoretical, empirical, and data collection work would be needed to carefully identify the relative importance of each underlying source.[35]

5 Conclusion and discussion

We develop a model of international trade with product productivity and process productivity as two dimensions of firm heterogeneity. Product quality is endogenous and variable trade costs are a function of quality. The model predicts CEPs for quality, output and input prices, average wage and capital intensity, and hence rationalizes evidence of CEPs in the empirical literature that so far had not been properly interpreted. We also test for CEPs using establishment-level data from India, the U.S., Chile and Colombia and find strong support for these predictions. In addition, using firm-level trade shipments data we explore underpinnings for the dependence of trade costs on quality. We find that output price across Indian exporters is correlated with the average (per-capita) income of their export destinations, while for the U.S. they are correlated both with their average income and their average distance – though the magnitude of the effect of income is one third the magnitude for India.

Our model has implications that diverge strongly from those of traditional single-attribute models. While those models predict the largest firms to be the ones that enter foreign markets in response to trade liberalization, our model predicts that many of those large firms will be unwilling to pay the required quality upgrading costs. By contrast, many smaller firms across the size distribution that have high product productivity will become exporters. As a result, resources reallocate toward the latter firms. Though traditional measures of aggregate productivity may not go up after trade liberalization, this reallocation is still welfare improving as there are new efficiency gains that come

[35] Following the suggestion of a referee, we substituted input prices and wages for output price as the dependent variable to check that results are not driven by higher mark ups (only for the U.S. can we link input and export destination data). We found positive correlations for both average distance and GDP per capita in most specifications. The correlations are stronger (and more statistically significant) for distance than for GDP per capita (see Table $A.12$), consistent with the results of Table 6.

from economizing on trade costs by producing high quality.

This model highlights the importance of distinguishing product and process productivity as distinct, but essential, sources of competitiveness. In particular, it emphasizes the fact that the export market rewards one type of firm capability relatively more than the other compared to the relative returns to those capabilities in the domestic market. Distinguishing product and process productivity could also help identify deeper determinants of productivity growth and its dynamics, and hence for designing effective public policies aimed at fostering economic development.

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Appendix 1. Demand system Utility is given by $U = \left(\int_{j \in \Omega_k} \left(\lambda_j^{\delta_k} q_j \right)^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}}$, where $\sigma > 1$ is the elasticity of substitution, $\delta_k > 0$ is the intensity of preference for quality in market k and Ω_k is the set of all varieties available in that market. Solving the consumer's problem yields market demand for variety j: $q_{j,k} = p_{j,k}^{-\sigma} \lambda_j^{\delta_k(\sigma-1)} E_k P_k^{\sigma-1}$, where $P_k^{1-\sigma} \equiv \int_{j \in \Omega_k} p_j^{1-\sigma} \lambda_j^{\delta_k(\sigma-1)} dj$. Assume for simplicity that $\delta_d = 1$. Then, domestic revenue is given by $r_{j,d} = p_{j,d} q_{j,d} = p_{j,d}^{1-\sigma} \lambda_j^{\sigma-1} E P^{\sigma-1}$. Since preferences are CES, firms charge prices $p_{j,x} = t(\lambda_j) p_{j,d}$ in the foreign market. Thus, foreign revenue is $r_{j,x} = I_j^x t(\lambda_j)^{1-\sigma} p_{j,d}^{1-\sigma} \lambda_j^{\delta_x(\sigma-1)} E^* P^{*\sigma-1}$. Defining $\delta \equiv \delta_x - \delta_d$, we can express foreign revenue as $r_{j,x} = I_j^x \left(\frac{t(\lambda_j)}{\lambda_j^{\delta}} \right)^{1-\sigma} p_{j,d}^{1-\sigma} \lambda_j^{(\sigma-1)} E^* P^{*\sigma-1}$. Let $\tau(\lambda_j) = \frac{t(\lambda_j)}{\lambda_j^{\delta}}$. Then, we can write total revenue as: $r_j = p_{j,d}^{1-\sigma} \lambda_j^{\sigma-1} \left(E P^{\sigma-1} + I_j^x \tau(\lambda_j)^{1-\sigma} E^* P^{*\sigma-1} \right)$.

Appendix 2. Graphical representation

a. Quality and revenue are higher in the exporting case

Proof. In the exporting case, the first order condition for optimal quality is:

$$\Upsilon \left(\frac{\varphi}{\kappa} \right)^{\sigma-1} \left[(1-\beta) E P^{\sigma-1} \tau(\lambda)^{\sigma-1} + (1-\beta+\varepsilon(\lambda)) E^* P^{*\sigma-1} \right] - \frac{f \alpha \lambda^{\alpha'}}{\xi \tau(\lambda)^{1-\sigma}} = 0 \tag{15}$$

where $\Upsilon = \left(\frac{\sigma}{\sigma-1} \right)^{-\sigma}$. The LHS of (15) decreases with quality because $\tau(\lambda)^{\sigma-1}$ decreases with quality by $A.1$, $\varepsilon(\lambda)$ decreases with quality by $A.3$, and $\frac{\lambda^{\alpha'}}{\tau(\lambda)^{1-\sigma}}$ increases with quality by $A.2$.[36] Evaluating this expression for $\lambda = \lambda_d(\varphi, \xi)$ yields: $\Upsilon \left(\frac{\varphi}{\kappa} \right)^{\sigma-1} \left[(1-\beta+\varepsilon(\lambda)) E^* P^{*\sigma-1} \right] > 0$. Then, quality must increase to satisfy the first order condition (15). This means that $\lambda_x(\varphi, \xi) > \lambda_d(\varphi, \xi)$.

A direct implication of this result is that $F_x(\varphi, \xi) > F_d(\varphi, \xi)$. Since the firm chooses to invest in quality upgrading, operating profits (and thus revenue) must increase to justify the investment. Hence, $r_x(\varphi, \xi) > r_d(\varphi, \xi)$.

b. Export isoprofit curves are flatter than domestic isoprofit curves at any point

Proof. We first establish the continuity of both curves. In the domestic case, continuity for isorevenue and isoprofit curves is directly established from their closed-form solutions. To establish continuity in the exporting case, we can look at the FOC with respect to quality, after solving for optimal prices:

$$\Upsilon \left(\frac{\varphi}{\kappa} \right)^{\sigma-1} (1-\beta) \left[E P^{\sigma-1} + \tau(\lambda)^{1-\sigma} E^* P^{*\sigma-1} \right] + \Upsilon \left(\frac{\varphi}{\kappa} \right)^{\sigma-1} E^* P^{*\sigma-1} \tau(\lambda)^{1-\sigma} \left(\frac{-\tau'(\lambda)\lambda}{\tau(\lambda)} \right) - \frac{f}{\xi} \alpha \lambda^{\alpha'} = 0$$

The LHS is differentiable and continuous in (λ, φ, ξ) for any $\lambda \neq 0$. Since the marginal benefits of increasing quality go to infinity when $\lambda \to 0$, $\lambda = 0$ is never optimal. Then, the LHS is continuous and differentiable at the optimal quality, $\lambda_x(\varphi, \xi)$. Hence, by the implicit function theorem, $\lambda_x(\varphi, \xi)$ is continuous and differentiable in (φ, ξ). Since revenue and profits are continuous functions of $\lambda_x(\varphi, \xi)$, then $r_x(\varphi, \xi)$ and $\pi_x(\varphi, \xi)$ are also continuous and differentiable. Hence, so are isorevenue and isoprofit curves.

To prove that export isoprofit curves ($\xi_{\pi_x = k}(\varphi)$) are flatter than domestic isoprofit curves ($\xi_{\pi_d = k}(\varphi)$) at any point (φ, ξ), we compute and compare the slopes of both curves. On an isoprofit curve:

$$d\pi_i(\varphi, \xi) = \frac{\partial \pi_i}{\partial \varphi} d\varphi + \frac{\partial \pi_i}{\partial \xi} d\xi = 0, \qquad i = d, x \tag{16}$$

[36] Compute $\left(\frac{\lambda^{\alpha'}}{\tau(\lambda)^{1-\sigma}} \right)' = \lambda^{\alpha'-1} \tau(\lambda)^{\sigma-1} \left[-(\sigma-1)\varepsilon(\lambda) + \alpha' \right]$. This derivative is positive because, by $A.2$, the term in square brackets is also positive.

Profits are given by $\pi_i(\lambda;\varphi,\xi) = \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\left(\frac{\varphi}{\kappa}\right)^{\sigma-1}\lambda_i^{(1-\beta)(\sigma-1)}W - \frac{f}{\xi}\lambda_i{}^{\alpha} - F_0 - I_i^x f_x,\ i = d, x$. Taking derivatives, substituting into (16) using the FOC for λ_i in each case, and maniputaling terms yields:

$$\frac{d\xi}{d\varphi} = -\frac{\xi\alpha}{(1-\beta)\varphi} I_i^x \left[\frac{(EP^{\sigma-1} + \tau(\lambda_i)^{1-\sigma}E^*P^{*\sigma-1})}{\left((EP^{\sigma-1} + \tau(\lambda_i)^{1-\sigma}E^*P^{*\sigma-1}) - \frac{1}{(1-\beta)}\frac{\tau'(\lambda_i)\lambda_i}{\tau(\lambda)_i}\tau(\lambda_i)^{1-\sigma}E^*P^{*\sigma-1}\right)} \right] \tag{17}$$

It is easy to note that for any firm (φ,ξ) the slopes of the domestic and export isoprofit curves differ only by the presence of the term inside the square brackets. This term is positive. This means that, in absolute value, the slope is smaller in the exporting case. Since both slopes are negative, the export isoprofit curve is flatter at any (φ, ξ). Moreover, by continuity, this result also implies that both isoprofit curves cannot cross again.

c. The export cut-off curve $\underline{\xi}_x(\varphi)$ is continuous and decreasing in φ (Figure 2)

Proof. Since $\pi_x(\varphi,\xi)$ and $\pi_d(\varphi,\xi)$ are continuous and differentiable, so is $\Delta\pi(\varphi,\xi)$. Hence, by the implicit function theorem $\underline{\xi}_x(\varphi)$ is also continuous and differentiable. To prove that $\underline{\xi}_x(\varphi)$ is decreasing in φ, we only need to show that $\Delta\pi(\varphi,\xi)$ is increasing in φ and ξ.

First, compute $\frac{\partial\pi_i(\varphi,\xi)}{\partial\xi}$ and $\frac{\partial\pi_i(\varphi,\xi)}{\partial\varphi}$, $i = d, x$. By the envelope theorem, we know that

$$\frac{\partial\pi_i(\varphi,\xi)}{\partial\xi} = \frac{\partial\pi_i(\lambda(\varphi,\xi);\varphi,\xi)}{\partial\lambda(\varphi,\xi)}\frac{\partial\lambda(\varphi,\xi)}{\partial\xi} + \frac{\partial\pi_i(\lambda(\varphi,\xi))}{\partial\xi} = \frac{\partial\pi_i(\lambda(\varphi,\xi))}{\partial\xi}$$

Using this argument for every case, we obtain $\frac{\partial\pi_i(\varphi,\xi)}{\partial\varphi} = \Upsilon\left(\frac{\varphi}{\kappa}\right)^{\sigma-1}\varphi^{-1}\lambda_i(\varphi,\xi)^{(1-\beta)(\sigma-1)}W$, and $\frac{\partial\pi_i(\varphi,\xi)}{\partial\xi} = \frac{f}{\xi^2}\lambda_i(\varphi,\xi)^{\alpha}$.

As shown in Appendix 2.a, $\lambda_x(\varphi,\xi) > \lambda_d(\varphi,\xi)$. Thus, $\frac{\partial\pi_d(\varphi,\xi)}{\partial\varphi} < \frac{\partial\pi_x(\varphi,\xi)}{\partial\varphi}$ and $\frac{\partial\pi_d(\varphi,\xi)}{\partial\xi} < \frac{\partial\pi_x(\varphi,\xi)}{\partial\xi}$.

d. The export cut-off curve $\underline{\xi}_x(\varphi)$ is flatter than the domestic and export isoprofit curves (Figure 3)

Proof. Take a firm (φ,ξ) located on $\underline{\xi}_x(\varphi)$. Since the firm is indifferent between exporting and producing for the domestic market, this firm is located both on an export $(\xi_{\pi_x=k}(\varphi))$ and on a domestic $(\xi_{\pi_d=k}(\varphi))$ isoprofit curve of level k, for some $k > 0$. As shown above, $\xi_{\pi_x=k}(\varphi)$ is flatter than $\xi_{\pi_d=k}(\varphi)$ at (φ,ξ). Moreover, these two curves cross only once. Therefore, for $\varphi' > \varphi$, $\xi_{\pi_x=k}(\varphi') > \xi_{\pi_d=k}(\varphi')$, whereas for $\varphi' < \varphi$, $\xi_{\pi_x=k}(\varphi') < \xi_{\pi_d=k}(\varphi')$. Hence, firms with $\varphi' > \varphi$ located on $\xi_{\pi_x=k}(\varphi')$ prefer producing for the domestic market, while firms with $\varphi' < \varphi$ located on $\xi_{\pi_x=k}(\varphi')$ prefer to export. This implies that the export cut-off curve must be flatter than both isoprofit curves. By continuity, the export cut-off curve does not cross these isoprofit curves again. As a result, profits increase with φ on $\underline{\xi}_x(\varphi)$.

Figure 1: Percentage of establishments that are exporters, by size quantiles

The figures plot the fraction of exporters by 40 size (sales revenue) quantiles in sectors producing differentiated goods. Each establishment is assigned to one of 40 size quantiles within its 4-digit industry. Exporter fraction for a quantile is obtained by dividing the number of exporters in that quantile summed across all industries by the number of establishments in that quantile summed across all industries.

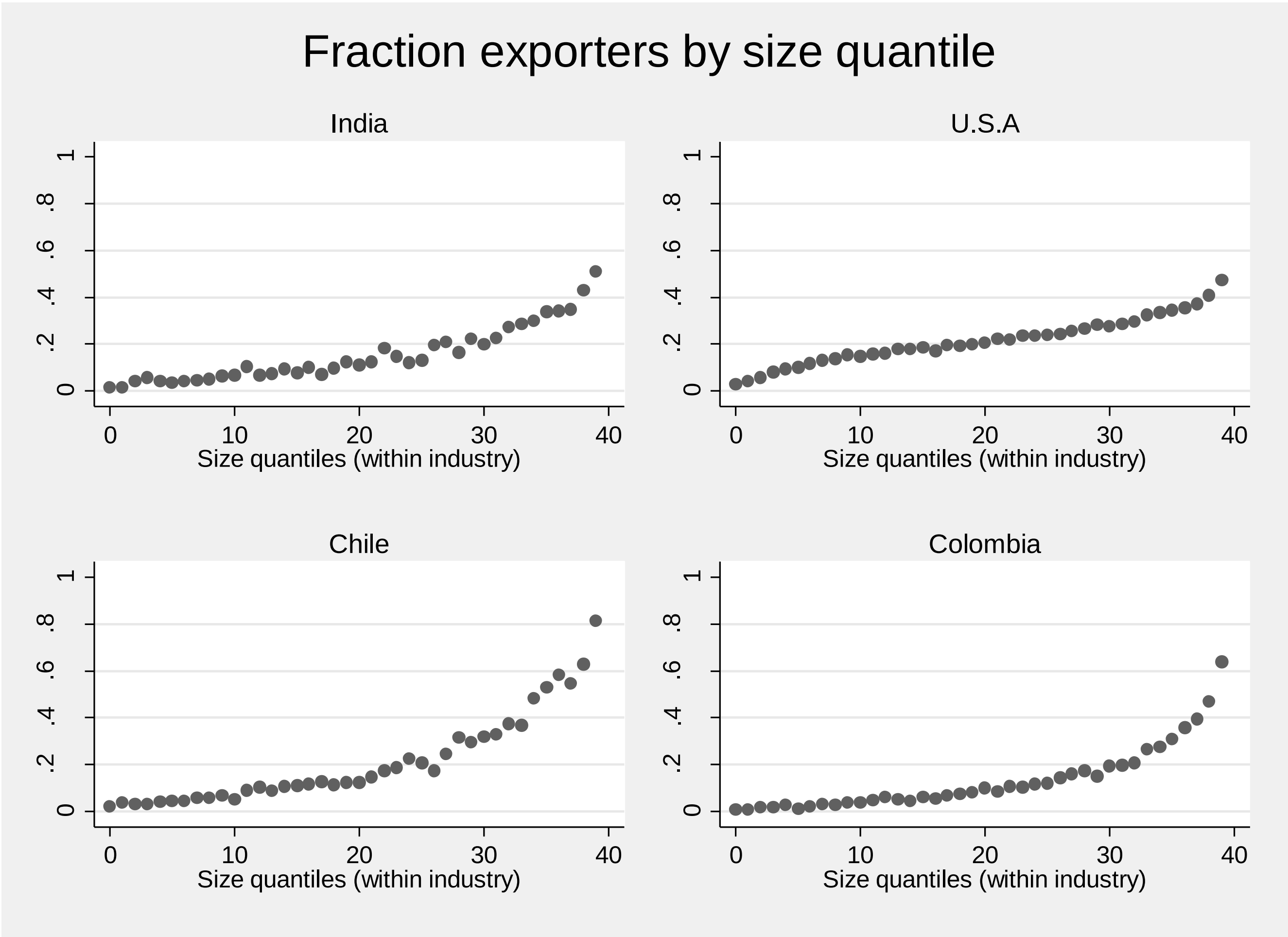

Figure 2: The export status decision

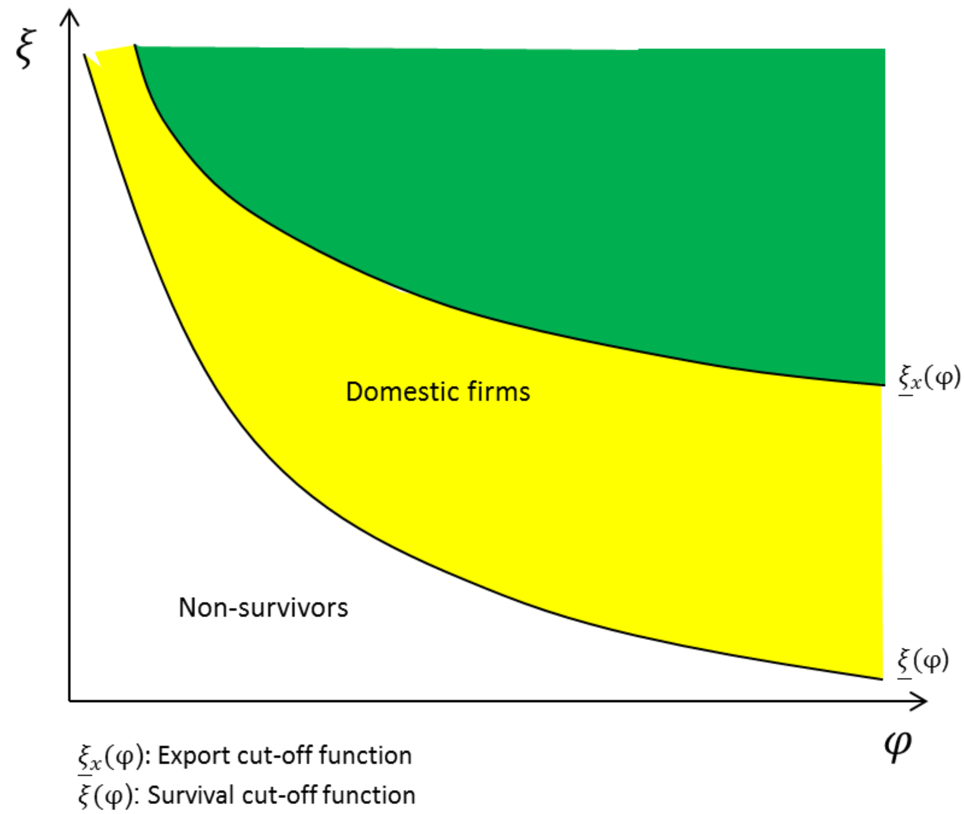

Figure 3: Firms with the same size and different export status

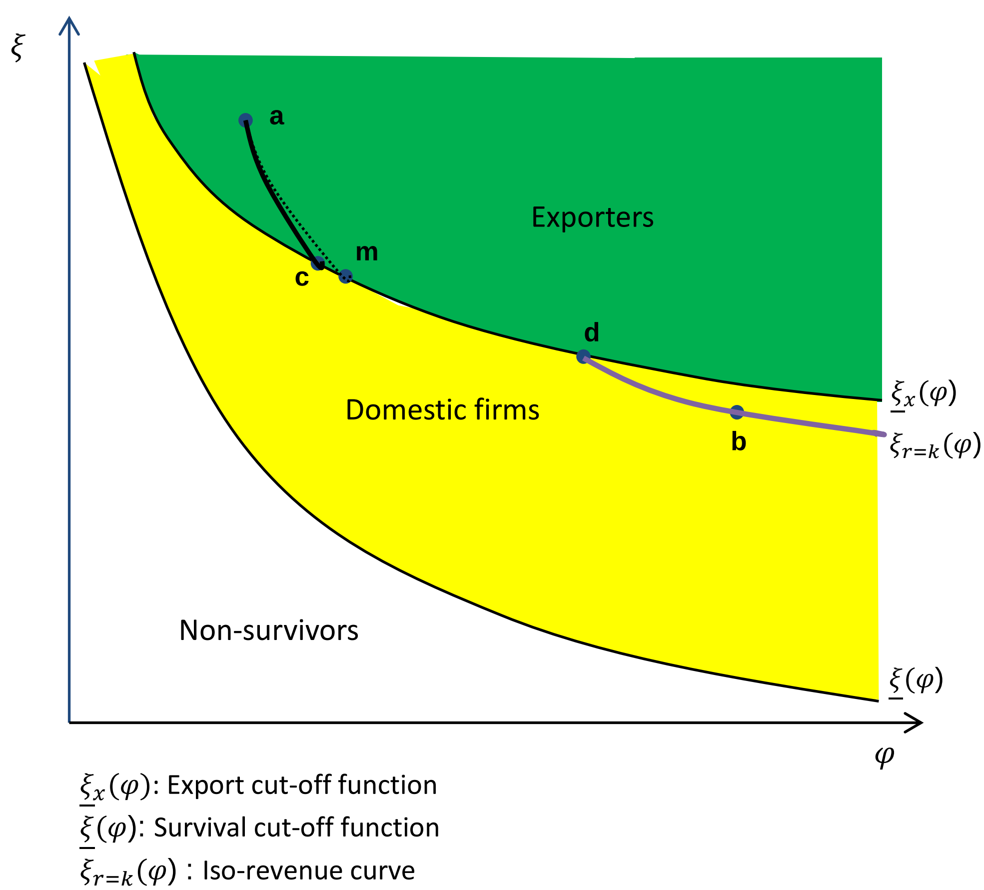

Table 1: Summary statistics

Only differentiated sectors are included. All variables (except the ISO 9000 dummy) are winsorized by 1% on both tails of the distribution and standardized using industry-specific means and standard deviations. In the case of output and input prices, "industries" are defined at the product level. Output and input price observations are at the product-plant level.

	ALL ESTABLISHMENTS			NON-EXPORTERS			EXPORTERS		
Description	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
Panel 1: India (1998)									
Standardized (log) output price	6,494	0.00	1.00	4,813	-0.01	0.96	1,681	0.06	1.05
Standardized (log) input price	15,702	-0.05	0.99	10,931	-0.07	1.02	4,771	0.07	0.98
Standardized (log) average wage rate	11,226	0.00	1.00	8,964	-0.09	0.96	2,262	0.50	1.02
Standardized (log) capital intensity (capital/labor)	11,226	0.00	1.00	8,964	-0.08	0.99	2,262	0.43	0.90
ISO 9000 dummy	15,937	0.05	0.21	13,009	0.03	0.16	2,928	0.17	0.38
Panel 2: USA (1997)									
Standardized (log) price	49,203	0.00	1.00	35,772	-0.02	0.98	13,431	0.05	1.03
Standardized (log) input price	19,126	-0.01	0.97	13,812	-0.049	0.93	5,314	0.08	1.06
Standardized (log) average wage rate	123,079	0.00	1.00	96,670	-0.06	1.03	26,409	0.21	0.86
Standardized (log) capital intensity (capital/labor)	123,079	0.00	1.00	96,670	-0.01	0.98	26,409	0.02	1.07
Panel 3: Chile (1991-96)									
Standardized (log) average wage rate	17,053	0.00	1.00	13,446	-0.17	0.96	3,607	0.62	0.87
Standardized (log) capital intensity (capital/labor)	17,053	0.00	1.00	13,446	-0.14	0.97	3,607	0.50	0.92
Panel 4: Colombia (1981-91)									
Standardized (log) average wage rate	39,990	0.00	1.00	34,714	-0.11	0.94	5,276	0.73	1.06
Standardized (log) capital intensity (capital/labor)	39,990	0.00	1.00	34,714	-0.07	0.99	5,276	0.43	0.89

Table 2: Conditional exporter quality premium – ISO 9000 certification dummy (India 1997-98)

All reported figures are coefficients on an exporter dummy which equals 1 if the establishment reports positive exports. The dependent variable is a dummy variable equal to 1 if the establishment has obtained ISO 9000 quality certification. Size is defined as log total sales of the establishment. Only differentiated sectors are included. * significant at 10%; ** significant at 5%, *** significant at 1%.

	(1)	**(2)**	**(3)**	**(4)**
Dependent variable: dummy for ISO 9000 adoption	0.142***	0.0771***	0.0751***	0.0854***
	[0.009]	[0.009]	[0.009]	[0.009]
Number observations (plants)	15,937	15,937	15,937	15,937
Industry fixed effects	Yes	Yes	Yes	No
Industry-specific size polynomial (order 2)	No	Yes	No	No
Industry-specific size polynomial (order 3)	No	No	Yes	No
Industry-specific size-decile fixed effects	No	No	No	Yes

Table 3: Conditional exporter output price premium: Baseline results

All reported figures are coefficients on an exporter dummy which equals 1 if the establishment reports positive exports. Output price is defined as a unit value (product revenue/quantity). Standardized log output price is log output price demeaned by the product-specific mean and divided by the product-specific standard deviation of log output price. Size is defined as log total sales of the establishment. Standard errors are clustered at plant level; * significant at 10%; ** significant at 5%, *** significant at 1%.

	(1)	(2)	(3)	(4)
Panel 1: India (1997-98)				
Dependent variable: Log output price (standardized)	0.112**	0.130**	0.177***	0.169**
	[0.050]	[0.060]	[0.063]	[0.073]
Dependent variable: Log output price	0.0534	0.0502	0.0872**	0.113***
	[0.035]	[0.041]	[0.040]	[0.042]
Number of observations	6,494	6,494	6,494	6,494
Panel 2: USA (1997)				
Dependent variable: Log output price (standardized)	0.082***	0.131***	0.136***	0.135***
	[0.018]	[0.019]	[0.019]	[0.020]
Dependent variable: Log output price	0.030**	0.062***	0.067***	0.066***
	[0.012]	[0.013]	[0.013]	[0.014]
Number of observations (plant-product)	49,203	49,203	49,203	49,203
Product fixed effects	Yes	Yes	Yes	No
Product-specific size polynomial (order 2)	No	Yes	No	No
Product-specific size polynomial (order 3)	No	No	Yes	No
Product-specific size-decile fixed effects	No	No	No	Yes

Table 4: Conditional exporter input price premium: Baseline results

All reported figures are coefficients on an exporter dummy which equals 1 if the establishment reports positive exports. Input price is defined as a unit value (cost/ quantity). Standardized (log) input price is (log) input price demeaned by the product-specific mean and divided by the product-specific standard deviation. Size is defined as log total sales of the establishment. Regressions are weighted by input share of total costs. Standard errors are clustered at plant level; * significant at 10%; ** significant at 5%, *** significant at 1%.

	(1)	(2)	(3)	(4)
Panel 1: India (1997-98)				
Dependent variable: Log input price (standardized)	0.141***	0.101**	0.120***	0.121*
	[0.0421]	[0.0462]	[0.0464]	[0.0682]
Dependent variable: Log input price	0.0847***	0.0385	0.0524*	0.0448
	[0.0327]	[0.0298]	[0.0295]	[0.0363]
Number of observations	15,702	15,702	15,702	15,702
Panel 2: USA (1997)				
Dependent variable: Log input price (standardized)	0.159***	0.152***	0.149***	0.182***
	[0.028]	[0.028]	[0.028]	[0.030]
Dependent variable: Log input price	0.076***	0.071***	0.067***	0.083***
	[0.017]	[0.017]	[0.017]	[0.018]
Number of observations (plant-product)	19,126	19,126	19,126	19,126
Product fixed effects	Yes	Yes	Yes	No
Product-specific size polynomial (order 2)	No	Yes	No	No
Product-specific size polynomial (order 3)	No	No	Yes	No
Product-specific size-decile fixed effects	No	No	No	Yes

Table 5: Conditional exporter wage and capital intensity premia

All reported figures are coefficients on an exporter dummy which equals 1 if the establishment reports positive exports. Standardized average wage is the wage bill of the establishment divided by the number of employees. Capital intensity is total capital divided by the number of employees. Size is defined as log total sales of the establishment. Only differentiated sectors are included. Standard errors are clustered at the plant level for Chile and Colombia; * significant at 10%; ** significant at 5%, *** significant at 1%.

	India (1997-98)		**USA (1997)**		**Chile (1991-96)**		**Colombia (1981-91)**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Dependent variable								
Log average wage (standardized)	0.138***	0.136***	0.082***	0.097***	0.106***	0.131***	0.0458*	0.0922***
	[0.032]	[0.035]	[0.014]	[0.014]	[0.027]	[0.027]	[0.025]	[0.026]
Log average wage	0.0743***	0.0748***	0.032***	0.039***	0.0500***	0.0636***	0.0270***	0.0437***
	[0.017]	[0.018]	[0.006]	[0.006]	[0.014]	[0.014]	[0.010]	[0.010]
Log capital intensity (standardized)	0.155***	0.188***	-0.191***	-0.178***	0.221***	0.250***	0.130***	0.147***
	[0.035]	[0.037]	[0.015]	[0.015]	[0.035]	[0.034]	[0.031]	[0.030]
Log capital intensity	0.224***	0.266***	-0.188***	-0.175***	0.279***	0.310***	0.145***	0.164***
	[0.047]	[0.049]	[0.015]	[0.015]	[0.039]	[0.039]	[0.035]	[0.035]
Number of observations	11,226	11,226	123,079	123,079	17,053	17,053	39,990	39,990
Industry-year fixed effects	Yes	No	Yes	No	Yes	No	Yes	No
Industry-year specific size polynomial (order 3)	Yes	No	Yes	No	Yes	No	Yes	No
Industry-year size-decile fixed effects	No	Yes	No	Yes	No	Yes	No	Yes

Table 6: Sources of conditional price premia: Using trade shipments data for India (2004-05) and USA (1997)

The dependent variable is the standardized log average price (total value/total quantity) for each firm-product group, which is effectively the log of quantity-weighted average of individual prices. Log GDP per capita is the standardized log of the quantity-weighted average of destination per capita GDP within firm-product group. Log distance is the standardized log of the quantity-weighted average of the distance to destination. Only differentiated products are included. Variables are standardized by subtracting the product-specific mean and dividing by the product-specific standard deviation. "Product" is defined as a HS–unit code category (8-digit HS for India and 10-digit HS for US). Firm size is measured as total export revenue for India and total firm revenue for US. Standard errors are clustered at firm level; * significant at 10%; ** significant at 5%, *** significant at 1%.

	(1)	(2)	(3)	(4)
Panel 1: India (2004-05)				
Log distance	0.002	0.003	0.002	0.003
	[0.0058]	[0.0060]	[0.0062]	[0.0070]
Log GDP per capita	0.0516***	0.0572***	0.0565***	0.0513***
	[0.0083]	[0.0072]	[0.0074]	[0.0085]
Observations	88,598	88,598	88,598	88,598
Panel 2: USA (1997)				
Log distance	0.145***	0.152***	0.151***	0.149***
	[0.0119]	[0.0086]	[0.0077]	[0.0090]
Log GDP per capita	0.0216***	0.0150**	0.0163***	0.0169***
	[0.0061]	[0.0061]	[0.0057]	[0.0061]
Observations	126,452	109,559	109,559	126,452
Product fixed effects	Yes	Yes	Yes	Yes
Product-specific size polynomial (order 2)	No	Yes	No	No
Product-specific size polynomial (order 3)	No	No	Yes	No
Product-specific size-decile fixed effects	No	No	No	Yes