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Firms' Exporting Behavior under Quality Constraints

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Abstract

We develop a model of international trade with two dimensions of firm heterogeneity and export quality constraints that manifest as higher variable trade costs for lower quality firms. In addition to "productivity", firms are also heterogeneous in their "caliber" – the ability to develop high-quality products with lower fixed outlays. The model predicts various *conditional* exporter premia. 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 have already been documented in the empirical literature. However, although they are apparently an intuitive implication of single-attribute models, conditional exporter premia cannot be rationalized through these models as they imply no variation in export status once size is controlled for. We test these predictions using manufacturing establishment data for India, the U.S., Chile, and Colombia, and find strong support for the model. We also investigate the sources of export quality constraints using firm-level trade shipment data for the U.S. and India. Destination per-capita income plays a key role for firms in India. For firms in the U.S., both distance and destination per-capita income play a role, though the effect of per-capita income is about a third of its magnitude for India.

JEL codes: F10, F12, F14,

Keywords: Productivity, caliber, fixed costs, exports, firm heterogeneity

1 Introduction

Understanding firms' exporting behavior is one of the most important open questions in international trade. At a policy level, the impressive export performance of rapidly-growing developing countries, particularly the recent case of China, suggests that export development might play a key role in helping countries achieve sustained rates of economic growth. Also, as governments increasingly view export development as an important objective that justifies policy intervention, understanding what makes firms succeed in export markets should help them enhance the effectiveness of such policies.[1] More generally, identifying determinants of firms' exporting behavior is critical for understanding trade patterns across countries, the field's predominant goal in the last two centuries.

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 perfectly predicts firms' revenue (henceforth our measure of firm size) and export status. Moreover, they predict a threshold firm size above which all firms export – and below which none do.

"Single-attribute" models can explain the existence of various *exporter premia* documented in the empirical literature. For example, they consistently generate the prediction that, within an industry, exporters are larger than non-exporters. They also explain why exporters are more likely to produce goods of higher quality (Verhoogen 2008), charge higher prices for their output (Baldwin and Harrigan 2011, Johnson 2011, Kugler and Verhoogen 2011), pay higher prices for their intermediate inputs (Kugler and Verhoogen 2011), and pay higher wages (Verhoogen 2008).

While these models provide a convincing framework for understanding why exporters exhibit systematic differences from non-exporters, they are unable to explain why those differences persist after conditioning on firm size, an observed regularity we term here *conditional exporter premia* (CEP).[2] Single-attribute models cannot explain CEP because they cannot even account for the existence of

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[1] The number of export promotion agencies in the world has tripled in the last two decades (Lederman et al. 2007).

[2] CEP have been documented for various outcomes and countries since Bernard and Jensen (1995) first documented this regularity for the United States. Section 2 describes this empirical evidence in detail.

exporters and non-exporters of the same size – as they predict the same export status for equally-sized firms.[3]

It is common in the empirical literature to interpret *conditional* exporter premia as driven by the same productivity advantage that determines *unconditional* exporter premia in single-attribute models. This interpretation, however, is incorrect. If the reason exporters enter foreign markets is that they are more productive, then non-exporters need to have some compensating advantage to attain the same size. Hence, unless we identify this compensating advantage and understand how it affects firm outcomes, we cannot make predictions about how those outcomes should differ between equally-sized exporters and non-exporters.

In this paper, we build a multi-attribute firm-heterogeneity model that generates, as theoretical predictions, CEP for quality, output prices, input prices, average wages, and capital intensity. We also provide systematic empirical evidence of these CEP using firm-level data from India, the United States, Chile, and Colombia. While it is easy to build a model that generates variation in export status among equally-sized firms by introducing additional sources of heterogeneity into a standard single-attribute model (e.g. heterogeneity in fixed exporting costs), no existing multi-attribute model can generate all the CEP we document. The model we propose provides a novel and, we argue, relevant way of thinking about the determinants of firm performance and exporting behavior. In addition, we provide empirical evidence that supports the importance of the specific mechanisms through which the model predicts those determinants to affect firm outcomes.

We make a distinction between two types of productivity. On the one hand, we model "productivity" (φ) as is standard in the literature, i.e. as *process productivity* or the ability to produce output using fewer variable inputs. On the other hand, we model "caliber" (ξ) as *product productivity* or the ability to produce quality incurring lower fixed outlays. Product quality is endogenously determined and encompasses any tangible or intangible characteristic of the product that consumers value. Quality shifts out product demand but also increases marginal and fixed costs. Caliber, by reducing the amount of fixed costs required to achieve a certain quality level, is a primary determinant of quality choice.

It has long been recognized (e.g. Shaked and Sutton 1983) that conceiving, designing, and producing a "high-quality" good that consumers are willing to pay extra for entails incurring fixed expenses associated with firm activities such as research, product development, advertising, and quality con-

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[3]In contrast to this prediction, Figure 1 – described later in more detail – shows the prevalence of equally sized exporters and non-exporters across the size distribution.

trol. It has also been widely recognized in the management and marketing literature that not all firms base their success on an efficient management of the production process (high φ). Many firms, by contrast, thrive based on their ability to create goods that consumers value (high ξ) through product differentiation, quality leadership or customer satisfaction. Furthermore, organization research views these two approaches as potentially opposed competitive strategies that require different types of firm competencies (e.g. Levinthal and March 1993). In light of these literatures and our emphasis on the importance of quality for export performance, distinguishing caliber (or product productivity) as a different type of productivity from the standard (process) treatment of productivity in economics seems a natural and appealing modeling choice. Although at a cost in terms of parsimony, this distinction is critical for explaining the exporting behavior of firms.

In the model, the caliber of the firm plays a critical role in its exporting behavior because variable iceberg trade costs, $\tau(\lambda)$, are assumed to be a decreasing function of quality λ. Many studies document the finding that firms producing low-quality products are handicapped in the export market (e.g. World Bank 1999, WTO 2005, Brooks 2006, Verhoogen 2008, Iacovone and Javornik 2009, Artopoulos et al. 2011). The function $\tau(\lambda)$ succinctly captures the different channels through which low quality may impose constraints on exporting. First, it 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 other trade-related costs that decrease with quality such as costs of return, rework and repair (Feigenbaum, 1991), and costs related to information asymmetries that may arise in trading across great distances.[4] Finally, although less obviously, $\tau(\lambda)$ can be viewed as capturing differences in preference for quality across countries (Hallak 2006, 2010), which we show can be isomorphically expressed as an iceberg trade cost.[5]

The role of $\tau(\lambda)$ is crucial to generate CEP. If τ were independent of quality, a combined-productivity parameter $\eta = \eta(\varphi, \xi)$ would be a summary measure of firm size, profits, and export status, and the model would collapse into a single-attribute model isomorphic to Melitz (2003) with this parameter (η) as the single heterogenous attribute.[6] Therefore, distinguishing φ and ξ as two different types of productivities is only worth the parsimony loss if the dependence of trade costs on quality is acknowledged.

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[4]Ivkovich and Weisbenner (2005) for investing, and Agarwal and Hauswald (2010), for lending, make a similar point.

[5]In the case of exports to lower-income countries, this income effect on $\tau(\lambda)$ operates in the opposite direction, potentially overturning the assumption that $\tau(\lambda)$ decreases with quality. Our findings, however, suggest that this does not occur even in the case of the United States.

[6]Even in our model with $\tau(\lambda)$, $\eta(\varphi, \xi)$ plays this summary role for non-exporting firms.

In order to focus in the simplest possible way on the key features of the model that generate CEP, we first examine a stripped down "interim" version of the full model in which both quality λ and marginal cost c are treated as exogenous and heterogeneously distributed across firms – in the full model they are both jointly determined by φ and ξ. Heterogeneity in λ and c, combined with $\tau(\lambda)$, yields the main result of the paper: conditional on size (revenue), quality is higher for exporters than for domestic firms. The simple intuition behind this result is that, once we condition on firm size, exporters (and non-exporters) can only have an advantage in one of these parameters, not in both. Hence, since $\tau(\lambda)$ decreases with quality, firms with relatively high quality λ (but also high cost c) will be the ones to export because their higher quality gives them a relative advantage in the export market. It follows immediately from this result that high-cost exporters will set higher prices than equally-sized domestic firms, giving rise to CEP for price. We also derive predictions for supply-side CEP (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. In the full model, quality and marginal costs are endogenized as functions of φ and ξ. Since firms with relatively higher ξ (and lower φ) optimally choose a higher λ (and hence have a higher c), the results derived in the interim model still apply.

We simulate the model to illustrate its implications for the effects of trade liberalization. We compare the results with those of a benchmark model with constant iceberg costs τ. As stated above, this model collapses into a Melitz (2003) model with combined productivity η as a summary measure of firm heterogeneity. There are contrasting implications of these two models. First, rather than a threshold firm size, in our model firms across the size distribution enter the foreign market following trade liberalization. Since the foreign market rewards firm capabilities differently from the domestic market, some large domestic firms do not find the foreign market profitable while other smaller firms may become exporters. Second, a key implication of Melitz (2003) is a gain in aggregate productivity following trade liberalization due to reallocation of market shares toward more productive firms. In our model, trade liberalization induces market share reallocation towards firms with high ξ relative to those with high φ. More interestingly, while in the benchmark model aggregate (combined productivity) η increases following trade liberalization, exactly as in Melitz (2003), in our model aggregate η may decline – although welfare still goes up. The intuition behind this result is that, in the open economy, aggregate η does not take into account the new aggregate productivity gains associated with market share reallocations toward high-caliber firms, which by producing high-quality products economize on

trade costs.[7]

We test for CEP 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. While data from all four countries are used to test the predictions for average wage and capital intensity, only India has data for ISO 9000 adoption, and only India and the U.S. have data for output and input prices. Consistent with the model predictions, we find robust evidence of positive and significant CEP. This result holds across countries and outcome variables, and is robust to a number of alternative specifications that address concerns about measurement error in revenue and rule out potential alternative explanations.[8]

Finally, we undertake an empirical exploration of the underpinnings of the trade-cost dependence on quality using firm-level data on export shipments by destination for the U.S. and India. In particular, we examine how export prices relate to the two most important underlying channels emphasized in the literature: destination distance and (per-capita) income. We find that these two channels matter differently for the two countries. For India, the average income of firms' export destinations is the only significant factor explaining variation in export prices across exporters. For the U.S., both average distance and average income have a significant effect on export prices. Although average income significantly explains variation in export prices in both countries, the estimated magnitude of this effect for the U.S. is less than a third of the magnitude for India.

The implications of distinguishing between productivity and caliber (or between process and product productivity) should not be confined to the CEP predictions derived in this model. Distinguishing between these two types of productivity could be important in various areas beyond determinants of exporting behavior. In particular, it could help future work exploring deeper determinants of 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. The 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 differential importance of fostering the ability of firms to design and produce high-quality goods – those with lower constraints to be marketed internationally

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[7]Our model also has implications for traditional productivity measures, which we explore in a Web Appendix (Section 2) available online on the authors' websites. We also show how with suitable data (on fixed and variable costs, as well as on revenue and quantity), and under maintained parametric and cost-minimization assumptions, it is possible to recover all the parameters of the model, in particular productivity and caliber for all firms.

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

– relative to fostering efficiency in the production process.

The rest of the paper is organized as follows. Section 2 discusses studies documenting CEP and argues why this finding is inconsistent with single-attribute models. Section 3 presents the interim model with exogenous quality and marginal cost. Section 4 develops the full model and presents the simulation results on the effect of trade liberalization. Section 5 presents the empirical estimation of CEP and various robustness tests. Section 6 explores the role of destination distance and income as underlying channels for conditional exporter price premia. Section 7 concludes.

2   Exporter premia *conditional on size*

Empirical work has consistently documented the existence of various *exporter premia*. Firms that export are larger and 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 also charge higher prices for their output and pay higher prices for their material inputs (Iacovone and Javorcik 2009; Kugler and Verhoogen 2011) while they attain higher levels of product quality as proxied by ISO 9000 adoption (Verhoogen 2008). 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.

Theoretical underpinnings for exporter premia are provided by heterogeneous-firm models of international trade. Melitz (2003), as many subsequent models, explains why exporters are larger and more productive as it predicts that more productive – and hence larger – firms self-select into the export market. Verhoogen (2008) and Kugler and Verhoogen (2011) extend the Melitz model allowing for endogenous quality choice and also predict that more productive firms self-select into exporting. In these models, in addition, more productive firms charge higher output prices and pay higher prices for their inputs as they have more incentives to invest in quality upgrading, which raises requirements of skilled labor and input quality.

While the correlation of export status with productivity, average wage, capital intensity, input and output prices, and product quality observed in the data is consistent with the economic mechanisms that those models highlight, the systematic differences exhibited by exporters could simply be due to their larger size rather than a result of their exporting activity. For example, it is well-known that larger firms pay higher wages (Brown and Medoff 1989). To disentangle between size and exporting as the underlying driver of the observed exporter premia, researchers have customarily appealed to

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the intuitive approach of estimating *conditional exporter premia* (CEP), estimated by adding size controls (measured by firm revenue or number of employees) to the regressions described above. For example, Bernard and Jensen (1995, 1999), Isgut (2001), Van Biesebroeck (2005), De Loecker (2007), and Bernard et al. (2007), among others, find CEP for average wages and capital intensity, while Kugler and Verhoogen (2011) find CEP for output and input prices.

The presence of CEP in the data cannot be interpreted through the lenses of "single-attribute" models of firm heterogeneity. These models are based on the notion of a single heterogeneous attribute – in all cases productivity – as the sole driver of behavior and performance differences across firms. Single-attribute models deliver the result that firm size monotonically increases with firm productivity and that a threshold productivity – and hence size – level determines whether firms export. This result implies that firms that have the same size should be equally productive and hence have the same export status. Figure 1 plots, for each of the four countries in our sample, the fraction of exporters in each of 40 size quantiles (defined by industry). In contrast to the above prediction, this figure shows the prevalence of equally-sized exporters and non-exporters across the size spectrum. The figure sets the following puzzle: if the exporter is inferred to be more productive, what is the compensating advantage that allows the non-exporter to match the exporter's size via larger domestic sales? Single-attribute models do not answer this question as they cannot explain differences in export status for equally-sized firms in the first place. Thus, in a regression framework an exporter dummy should have no explanatory power once firm size is (properly) controlled for.[9] To correctly interpret CEP, we need to identify the compensating advantage of non-exporters and understand how it affects export status and other firm outcomes.

In this paper, we model this compensating advantage by introducing a second source of firm heterogeneity. While it is easy to explain Figure 1 with additional sources of heterogeneity, here we build a model that not only can explain variation in export status between equally-sized firms, as displayed in Figure 1, but also yields the following CEP as predictions:

CEP 1. Conditional on size, exporters attain higher quality

CEP 2. Conditional on size, exporters charge higher prices

CEP 3. Conditional on size, exporters pay higher intermediate input prices

CEP 4. Conditional on size, exporters pay higher average wages

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[9]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 the correlation between size and export status. In our tests below, we allow for flexible size controls, and also check robustness to measurement error in size.

CEP 5. Conditional on size, exporters use physical capital more intensively

Some of these CEP have already been documented in the empirical literature. In Section 5, we evaluate these predictions systematically as a test of our model, using plant-level data from India, the United States, Chile, and Colombia.

3   An interim model with exogenous marginal costs and quality

This section presents a simple "interim" model. The model has two distinguishing features. First, firms are heterogeneous in their marginal cost (c) and in the quality of their products (λ). These parameters are exogenously drawn from a bi-variate probability distribution with support $[\underline{c}, \infty) \times [0, \overline{\lambda}]$.[10] Second, a trade discount factor $\tau(\lambda)$ summarizes exporting constraints associated with the (lack of) product quality. These two features are embedded in an otherwise standard setup a la Melitz. We develop this interim model first for analytical transparency. By temporarily treating marginal costs and quality as exogenous without modeling the supply side, we can show that a set of conditions on these outcomes is sufficient to generate CEP 1-5. The next section endogenizes marginal costs and quality in a model in which these two outcomes are determined by more fundamental firm attributes.

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

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

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 a price aggregator (defined in Appendix 1), and stars denote foreign variables.[11] Foreign demand is only available for a firm that pays a fixed exporting cost f_x, in which case the indicator function I_x takes a value of 1.

Foreign demand is adjusted by the trade discount factor $\tau(\lambda)$. This factor is a critical element of our theoretical framework. While it is treated formally as an iceberg trade cost in the model, we

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[10]The closed-economy model of Sutton (2007) also includes exogenous heterogeneity in these two outcomes.

[11]P is inversely related to product prices. $P^{1-\sigma}$ is the cost-of-utility index for a CES utility function.

interpret this factor more broadly as capturing export constraints associated with product quality. A substantial amount of evidence suggests that lack of quality hinders exports. Brooks (2006) finds that Colombian firms in sectors with larger quality gaps relative to G-7 countries tend to export a smaller fraction of their output. Verhoogen (2008) finds that Mexican firms invest in quality upgrading in response to export opportunities created by the Peso devaluation. Iacovone and Javorcik (2009) find that Mexican firms increase their average prices two years before they start exporting, which suggests a process of quality upgrading in preparation to export. Evidence of export quality requirements is also provided by studies in international management that document firms' need to upgrade quality as a crucial requirement to access foreign markets.[12] Policy-oriented research also emphasizes the existence of quality requirements for exports as part of a broader concern about the impact of standards on market access (World Bank 1999, Maskus et al. 2005, WTO 2005).

The trade discount factor can be written as $\tau(\lambda) = \frac{t(\lambda)}{\lambda^\delta}$ to highlight the main two underlying channels through which quality might introduce a wedge between foreign and domestic demand. In the numerator, $t(\lambda)$ represents iceberg transport costs, assumed to be decreasing in quality. In the presence of per-unit charges, transport costs represent a smaller proportion of price for high quality 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.[13] A second possible interpretation of $t(\lambda)$ relates to costs of return shipping. For complex products (e.g. industrial machinery), repair, rework and warranty related costs (classified as "external failure costs" of quality by Feigenbaum 1991, p 111) can be significantly higher over long distances, increasing net transaction costs for lower quality products as defective items may require expensive return shipments to the origin country. A final interpretation of $t(\lambda)$ relates to asymmetric information problems in export transactions, which are likely to be higher across greater distances.[14] Higher quality encoded through quality certification such as ISO 9000 can alleviate information asymmetry problems due to its quality-signaling, common-language, and conflict-setting properties (Guler et al. 2002, Hudson and Jones 2003, Terlaak and King 2006, Clougherty and Grajek 2008).

In the denominator of $\tau(\lambda)$, the term λ^δ captures differences across countries in the intensity of preference for quality. Higher-income countries tend to demand goods of higher quality (Hallak 2006,

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[12]See Weston 1995 (U.S.), Erel and Ghosh 1997 (Turkey), Mersha 1997 (Africa), Anderson et al. 1999 (Canada and U.S.), and Corbett 2006 (9 mostly-developed countries).

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

[14]Asymmetric information affecting transactions over longer distances has been documented for lending (e.g. Agarwal and Hauswald, 2010) and investing (Ivkovich and Weisbenner 2005).

2010) and also 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 Dixit-Stiglitz utility function augmented with preferences for quality as in Hallak (2006) and Lugovskyy and Skiba (2011). Under this framework, differences in the intensity of preference for quality across countries can be isomorphically expressed as an iceberg trade cost.[15] In the remainder of the paper, we assume that $\tau(\lambda)$ decreases with quality:[16]

A.1 $\lambda_1 > \lambda_2 \Rightarrow \tau(\lambda_1) \leq \tau(\lambda_2)$

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 implies that the influence of transport costs outweighs the effect of income.

Firms may need to pay a quality-related fixed cost $F(\lambda)$ but, since quality is exogenous, this cost will not affect their pricing or exporting decisions. Therefore, firm j chooses price to maximize operating profits $\pi^o(c_j, \lambda_j)$. Given CES demand, the standard constant mark-up applies: $p(c_j, \lambda_j) = \frac{\sigma}{\sigma-1} c_j$, and we can readily compute firm j's optimal revenue as

$$r(c_j, \lambda_j) = \left(\frac{\sigma}{\sigma - 1}\right)^{1-\sigma} (\lambda_j/c_j)^{\sigma-1} W_j. \tag{2}$$

For a domestic firm, $W_j = E/P$. Thus, revenue in equation (2) depends only on the ratio of quality to marginal cost (λ/c) and not on the value of these two parameters independently. As operating profits $\pi^o(c_j, \lambda_j)$ are a constant fraction ($1/\sigma$) of firm revenue, they also depend only on λ/c. By contrast, W_j varies across exporters according to their quality. Hence, quality induces an "indirect" advantage in the export market via $\tau(\lambda)$. This feature of our model is critical for breaking the monotonicity between revenue and export status.

This simple set up, together with ancillary assumptions about input requirements for the production of quality, generates all the conditional exporter premia described in section 2. The following proposition provides the key prediction of the model (and explains CEP 1):

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

Proof. Let a and b be two firms such that $\bar{r} = r(c_a, \lambda_a) = r(c_b, \lambda_b)$. Consider *w.l.o.g.* that a exports while b does not. Then, by equation (2):

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

[16]A particular case of this assumption is the existence of a minimum export quality requirement, as modeled in an earlier version of this paper (see Hallak and Sivadasan, 2009).

$$\bar{r} = \left(\tfrac{\sigma}{\sigma-1}\right)^{1-\sigma}(\lambda_a/c_a)^{\sigma-1}\left(\tfrac{E}{P}+\tau(\lambda_a)^{1-\sigma}\tfrac{E^*}{P^*}\right) = \left(\tfrac{\sigma}{\sigma-1}\right)^{1-\sigma}(\lambda_b/c_b)^{\sigma-1}\tfrac{E}{P}$$

which directly implies that

$(I) \qquad (\lambda_a/c_a)^{\sigma-1} < (\lambda_b/c_b)^{\sigma-1}$.

Since fixed costs are independent of the firm's exporting decision, this decision is governed by the comparison of the potential operating profits the firm would make in the export market (π_x^o) and the fixed exporting cost (f_x). Therefore, since a exports while b does not, it has to be true that $\pi_{xa}^o \geq f_x > \pi_{xb}^o$, or

$$\pi_{xa}^o = \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\left(\frac{\lambda_a}{c_a}\right)^{\sigma-1}\tau(\lambda_a)^{1-\sigma}\frac{E^*}{P^*} \geq f_x > \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\left(\frac{\lambda_b}{c_b}\right)^{\sigma-1}\tau(\lambda_b)^{1-\sigma}\frac{E^*}{P^*} = \pi_{xb}^o \quad (3)$$

The above inequalities imply that

$(II) \qquad (\lambda_a/c_a)^{\sigma-1}\tau(\lambda_a)^{1-\sigma} > (\lambda_b/c_b)^{\sigma-1}\tau(\lambda_b)^{1-\sigma}.$

Dividing (II) by (I), we obtain $\tau(\lambda_a)^{1-\sigma} > \tau(\lambda_b)^{1-\sigma}$. Since $\tau(\lambda)$ decreases with λ, this inequality proves that $\lambda_a > \lambda_b$. Also, since both firms achieve the same revenue, Proposition 1 implies that $c_a > c_b$. Moreover, using (I) we obtain $\lambda_a/c_a < \lambda_b/c_b$. $\square$

Proposition 1 provides a useful framework for solving the puzzle postulated in section 2. Due to its relative advantage in the export market, the firm endowed with a higher quality (firm a) is the one that exports. Its higher quality would also imply that, other things equal, it should make higher domestic sales. But since we have conditioned on firm size, firm a cannot export *and* sell more domestically. Hence, firm b needs to have some compensating advantage, which here is a lower marginal cost. In sum, a is a high-quality/high-cost firm while b is a low-quality/low-cost firm. In fact, since $\lambda_b/c_b > \lambda_a/c_a$, b sells more than a in the domestic market. This domestic advantage compensates for its lack of exports, allowing it to match a's total revenue.

Two properties of the model are key to break the monotonicity between firm size and export status. On the one hand, $\tau(\lambda)$ introduces a wedge between the export and 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 monotonically depend on the ratio λ/c. In that case, we would never observe equally-sized firms with a different export status. Here, despite its relatively high λ_b/c_b, firm b chooses not to export because the high trade discount factor on its low quality product places it at a disadvantage in the export market where it would not recover the fixed exporting costs.

On the other hand, with only one source of heterogeneity $\tau(\lambda)$ alone would not be able to generate CEP. For example, if λ were the only heterogeneous parameter, it would be the sole determinant of

size and export status. Thus, proposition 1 would be vacuous since two firms with the same size but different export status could not possibly exist.[17]

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 $r(c_a, \lambda_a) = r(c_b, \lambda_b)$. Then, from Proposition 1, $\lambda_a > \lambda_b$ and $c_a > c_b$. Consequently, $p(c_a, \lambda_a) > p(c_b, \lambda_b)$. $\square$

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:

A.2 $\frac{dp^I(\lambda)}{d\lambda} > 0$, $\frac{dw(\lambda)}{d\lambda} > 0$, and $\frac{dk(\lambda)}{d\lambda} > 0$

In Web Appendix 1.A, we provide deeper fundamentals for these assumptions. Here, given our interim treatment of c and λ as exogenously drawn from a bi-variate distribution, we can note that A.2 is consistent with simply imposing that the conditional expectation $E(c|\lambda)$ of this bi-variate distribution satisfies $\frac{dE(c|\lambda)}{d\lambda} > 0$. Proposition 1 and A.2 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 firm a exports and firm b does not, then $\lambda_a > \lambda_b$. Then it follows directly from A.2 that $p^I(\lambda_a) > p^I(\lambda_b)$, $w(\lambda_a) > w(\lambda_b)$ and $k(\lambda_a) > k(\lambda_b)$. $\square$

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.

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[17]In fact, proposition 1 might still be vacuous if λ and $1/c$ are highly correlated and f_x is large.

Proposition 1 and corollaries 1, 2, 3 and 4 can be weakened to be stated in expected values. In section 5, we take these predictions to the data in that form.

4 Endogenous quality with heterogeneous productivity and caliber

The interim model of section 3 left the supply side largely un-modeled. In particular, quality and marginal costs were treated as exogenous to highlight the modeling features that are critical to generate the observed conditional exporter premia. In this section, we set forth the full model with quality and marginal costs as endogenous outcomes of deeper firm attributes.

4.1 Set up

Firms are characterized by two heterogeneous attributes, productivity (φ) and caliber (ξ), 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, productivity φ is modeled as the ability of a firm to produce a given output at low variable cost. Productivity enters the marginal cost function in the following form:

$$c(\lambda, \varphi) = \frac{\kappa}{\varphi} \lambda^{\beta} \ ; \qquad\qquad 0 \leq \beta < 1 \qquad\qquad (4)$$

where κ is a constant and β is the quality-elasticity of marginal costs, capturing requirements of higher-quality (and hence more expensive) inputs to produce higher-quality output.

Product quality also involves fixed costs, which are represented by the following function:

$$F(\lambda, \xi) = F_0 + \frac{f}{\xi} \lambda^{\alpha} \ ; \qquad\qquad \alpha > 0 \qquad\qquad (5)$$

where f is a constant and α is the quality-elasticity of fixed costs.[18] 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). Here, we introduce heterogeneity in the ability of firms to maximize quality with a given amount of fixed outlays. We refer to this ability as the *caliber* (ξ) of a firm. A high-caliber firm, for example, can be one that is effective at generating a work environment that fosters design creativity or that can rapidly translate evolving consumer tastes into

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

designs that appeal to their customers. It can also be a firm with an R&D department effective at generating and implementing innovative ideas for new products.[19]

Productivity and caliber can be interpreted as "process productivity" and "product productivity", respectively. The first is the standard interpretation that economists give to the term "productivity". By contrast, the second type of productivity is generally ignored or underemphasized. This is particularly true of the theory of productivity estimation, which typically assumes that the productivity of a firm only affects its variable costs.[20]

The wisdom of this asymmetric treatment of product and process productivity is questionable as effectiveness in obtaining marketable outcome from fixed expenditures is widely recognized as a key determinant of firm competitiveness. Strategy and marketing researchers have long distinguished product differentiation (also quality leadership or customer satisfaction) from cost leadership (or productivity) as alternative 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, debating whether the organizational structure, practices, and incentive systems that are conducive to increasing competence in cost leadership (i.e. increasing productivity/process productivity) are compatible with fostering competence in product differentiation (i.e. increasing caliber/product productivity).[21] Given the apparent limitations of the standard concept of productivity to capture critical determinants of firm performance, and since our framework emphasizes the role of product quality and the fixed costs required to attain it, allowing for heterogeneity in process productivity but not in product productivity does not seem to be an *a priori* obvious modeling choice. Furthermore, while in several contexts distinguishing these two types of productivity might not be worth the parsimony loss, making this distinction is crucial – as we argue here – for understanding standard evidence on firm sorting into export markets and explaining the specific features that characterize exporters' behavior and performance. In addition, making this distinction could also have important implications for research on deeper determinants of firm dynam-

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[19]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.

[20]Standard approaches to estimate total factor productivity recover only a single-dimensional measure. An interesting question is how this measure relates to the underlying parameters of our model, in particular φ and ξ. In Web Appendix 2, we show that the productivity residuals from a Cobb-Douglas OLS regression show almost no correlation with these underlying parameters, 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 productivity and caliber could be identified.

[21]See March 1991, Levinthal and March 1993, Anderson et al. 1997, Rust et al. 2002, Raisch et al. 2009.

ics, aggregate productivity, and policies aimed at fostering international competitiveness and export development.

The full model maintains the demand side of the interim model. We also keep the assumption that $\tau(\lambda)$ is decreasing in λ and impose that this function is continuous and twice differentiable.[22] Defining the quality-elasticity of trade costs as $\varepsilon(\lambda) = \frac{-\tau'(\lambda)\lambda}{\tau(\lambda)}$, we further assume that this elasticity is bounded from above (A.3) and decreasing in λ (A.4):

A.3 $\varepsilon(\lambda) < \frac{\alpha}{(\sigma-1)} - (1-\beta)$

A.4 $\frac{d\varepsilon(\lambda)}{\partial\lambda} < 0$

These conditions guarantee a solution for the profit-maximization problem of the firm. In section 4.4 we simulate the model in the symmetric case $(\delta = 0)$ using $\tau(\lambda) = \tau_0 + \tau_1\lambda^{-\gamma}$, $\tau_0 \geq 1$, $\tau_1 \geq 0$, and $0 < \gamma < \frac{\alpha}{(\sigma-1)} - (1-\beta)$. The remainder of this section characterizes firms' optimal choices and describes the main features of the industry equilibrium. We show the existence of a free-entry industry equilibrium in Web Appendix 1.B.

4.2 Firms' optimal choice of price and quality

Firms choose price and quality to maximize post-entry profits, π, given by the difference between operating profits and fixed costs. Post-entry profits can be expressed as

$$\pi(c_j, \lambda_j) = \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}(\lambda_j/c_j)^{\sigma-1}W_j - F(\lambda_j) - I_x f_x. \tag{6}$$

The optimal price is given by the standard CES solution for *fob* prices: $p = \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\lambda^\beta$. 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 steps. First, we find the optimal quality for a firm that decides to serve only the domestic market ("domestic" case). Then we find the optimum for a firm that decides to export ("exporting" case). 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

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

where $\alpha' \equiv \alpha - (1-\beta)(\sigma-1)$ and $\alpha' > 0$ due to A.3 and the fact that $\varepsilon(\lambda) > 0$ by A.1. The solution for λ_d shows that both productivity (φ) and caliber (ξ) have a positive impact on quality choice as they reduce marginal and fixed costs of production, respectively.

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[22]With endogenous quality, assumption A.1 imposes constraints on $\overline{\varphi}$ and $\overline{\xi}$ so that λ is bounded.

Using equation (7), the optimal price can be expressed as

$$p_d(\varphi,\xi) = \left(\frac{\sigma}{\sigma-1}\right)^{\frac{\alpha-\beta-(\sigma-1)}{\alpha'}} \left(\frac{\kappa}{\varphi}\right)^{\frac{\alpha-(\sigma-1)}{\alpha'}} \left[\frac{1-\beta}{\alpha}\frac{\xi}{f}\frac{E}{P}\right]^{\frac{\beta}{\alpha'}}. \tag{8}$$

Conditional on φ, high-ξ firms sell their products at a higher price because they produce higher quality and hence have a higher marginal cost. Instead, the effect of φ on price conditional on ξ is ambiguous. A direct effect lowers the marginal cost and thus the price. An indirect effect raises marginal cost and price via a higher quality choice. Whether one or the other effect dominates depends on the sign of $\alpha-(\sigma-1)$. Note that the price depends here on the value of two parameters. Therefore, unlike in quality-based models with a single heterogeneous factor (Baldwin and Harrigan 2011, Johnson 2011, Kugler and Verhoogen 2011) price is not monotonically related to size.

Firm size is still determined by equation (2) but the quotient λ/c is now endogenous. Its optimal value is given by:

$$\frac{\lambda(\varphi,\xi)}{c(\varphi,\xi)} = \left(\frac{1-\beta}{\alpha}\right)^{1-\beta} \left(\frac{\sigma}{\sigma-1}\right)^{\sigma(1-\beta)} \eta(\varphi,\xi)^{\frac{1}{\sigma-1}} \left(\frac{E}{P}\right)^{\frac{1-\beta}{\alpha'}}, \tag{9}$$

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".

Equation (9) shows that λ/c can be expressed as a monotonic function of η. Thus, revenue can also be expressed as a function of η:

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

In the full model, η is the summary determinant of size variation across domestic firms. Thus, it plays the same role that λ/c plays in the interim model. It is interesting to note that since price is monotonically related to marginal cost, firms with the same η charge the same quality-adjusted price $\widetilde{p}_j = \frac{p_j}{\lambda_j}$, and hence obtain equal revenue $r_j = \widetilde{p}_j^{1-\sigma} E/P$. Interestingly, fixed costs are also a function of η, which implies that profits are so as well:[23]

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

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[23]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.

The main implication of this property is that η is a summary statistic for φ and ξ in the revenue and profit functions. Thus, domestic firms with the same η obtain equal revenues and equal profits regardless of their particular combinations of φ and ξ.

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

$$\underline{\xi}(\varphi) = f \left(\frac{F_0}{J} \right)^{\frac{\alpha'}{\alpha - \alpha'}} \left(\frac{\varphi}{\kappa} \right)^{\frac{-\alpha}{1 - \beta}} \left(\frac{E}{P} \right)^{\frac{-\alpha}{\alpha - \alpha'}} . \tag{10}$$

Equation (10) shows that for each productivity φ, there is a minimum caliber $\underline{\xi}(\varphi)$ such that firms above this minimum earn non-negative profits. Figure 2 illustrates this cut-off function (firms on this curve have equal revenue and profits). In the figure, each firm is represented by a single point, i.e. a $\varphi - \xi$ combination. Firms above the curve $\underline{\xi}(\varphi)$ survive while those below this curve exit the market. The negative slope of $\underline{\xi}(\varphi)$ highlights a trade-off between productivity (φ) and caliber (ξ). For example, firms with more (less) efficient production processes may be less (more) effective at making designs. Since η is a summary statistic for revenue, profits, and export status, if all firms were domestic the model could be collapsed 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.[24] First, as shown in Appendix 2, the optimal choice of quality is higher if the firm decides to export: $\lambda_x(\varphi, \xi) > \lambda_d(\varphi, \xi)$. Intuitively, the firm has two additional incentives to invest in quality upgrading when exporting: a higher total demand and a trade discount factor that decreases with quality.

Another important difference with the domestic case is that η is no longer a sufficient statistic for revenue and profits. Due to the presence of quality-sensitive trade costs, profits in the exporting case are relatively more responsive to changes in ξ than to changes in φ compared to the domestic case. Consequently, as illustrated in Figure 3, iso-profit curves are flatter, at any point, in the exporting case than in the domestic case. This property is essential to generate exporters and non-exporters with the same size. If $\tau(\lambda) = \tau$, revenue and profits could be written as functions of η also for exporters, and the model would collapse again to a one-dimensional model isomorphic to Melitz (2003).

The export status decision After solving the domestic case and the exporting case, the firm compares profits in both cases and decides to export if $\Delta\pi(\varphi, \xi) \equiv \pi_x(\varphi, \xi) - \pi_d(\varphi, \xi) \geq 0$. Define the

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[24] A formal derivation of the properties of this graphical representation is provided in Web Appendix 1.C.

export cut-off curve $\underline{\xi}_x(\varphi)$ as the value of ξ that solves $\Delta\pi(\varphi,\xi) = 0$. Since $\Delta\pi(\varphi,\xi)$ is increasing in both arguments, this curve has a negative slope. Figure 4 displays this curve, which 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. Firms located above $\underline{\xi}_x(\varphi)$ export. Given that iso-profit curves in the exporting case are flatter than in the domestic case 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 for exporters and for non-exporters both increase.

4.3 Testable predictions

The full model developed here delivers all the theoretical predictions (CEP) of the interim model.[25] To understand why those results are also delivered by the full model, let us focus first on proposition 1. Since the demand side is the same as in the interim model, revenues are still described by equation (2). Therefore, inequality (I) still holds. In the full model, it is also true that $\pi_{xa}^o \geq f_x > \pi_{xb}^o$. As fixed costs of quality are independent of which markets are served, it has to be true that the operating profits made by exporter a in the foreign market (π_{xa}^o) are larger than the fixed cost of exporting (f_x). Analogously, the potential operating profits domestic firm b would make in the export market, keeping the same quality $\lambda(\varphi_b, \xi_b)$, should be less than f_x. Since operating profits are still a constant proportion of revenue, inequality (3), and hence (II), still hold. Therefore, proposition 1 holds.

Since proposition 1 holds, corollary 1 holds as well. In the case of corollaries 2, 3, and 4, they still require the ancillary assumption that quality production demands higher-priced inputs and higher capital-labor ratios (assumption A.2). In Web Appendix 1.A, we provide deeper fundamentals for this assumption (partially drawing from Verhoogen 2008), tying it consistently to equations (4) and (5).

The two critical properties of the interim model are also relevant in the full model. First, if $\tau(\lambda) = \tau$, $\Delta\pi(\varphi,\xi)$ would just depend on η. In that case, revenue and export status would be constant along an iso-profit curve. Second, if there were only one source of heterogeneity (φ or ξ), it would monotonically determine quality and size. Hence, size would be sufficient to predict export status.

In the full model, size and export status are not monotonically related. In particular, there are domestic firms and exporters that have the same size. Figure 5 displays a typical iso-revenue curve that contains both exporters and non-exporters.[26] The iso-revenue curve in the figure consists of two disjoint parts. All firms in the upper-left portion, such as firm a, are exporters. All firms in the

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[25]In Hallak and Sivadasan (2009) we further show that these predictions can be derived from any model satisfying a set of conditions on the (endogenous) relationship between foreign and domestic operating profits, and between revenue and operating profits.

[26]For sufficiently low (high) levels of revenue, all firms could be domestic (exporters).

bottom-right portion, such as firm b, are non-exporters. From proposition 1, we know that firms on the upper-left portion of the iso-revenue curve produce higher quality than those on the bottom-right portion. Also, it can be shown that quality increases with ξ within each of these parts. A noticeable feature of the iso-revenue curve is its discontinuity between points c and d, where the two parts intersect with the export cut-off curve $\underline{\xi}_x(\varphi)$. To understand this jump, consider the total revenue of firm c if it decided not to export. This total would be lower since the firm would not only lose its export revenue but also part of its domestic revenue due to a lower quality choice. Since domestic revenue increases moving right along $\underline{\xi}_x(\varphi)$, a domestic firm on that curve that can achieve the same revenue as firm c needs to be located to its right, as shown for a firm at point d that decides not to export. Compared to firm c, the higher productivity (and higher λ/c) of this latter firm generates the extra domestic sales to compensate for its lack of exports.[27]

4.4   Implications for the effects of trade liberalization

In this section, we simulate our model in the symmetric case ($\delta = 0$) to illustrate the implications for the effects of trade liberalization.

Simulating the model requires specifying functional forms and parameter values for $\tau(\lambda)$ and $v(\varphi, \xi)$. We assume that $\tau(\lambda) = \tau_0 + \tau_1 \lambda^{-\gamma}$, and $v(\varphi, \xi)$ is distributed log-normal with parameters $(\mu_\varphi, \mu_\xi, \sigma_\varphi, \sigma_\xi, \rho)$. The parameters of these two functions, together with f_x, are calibrated to match the fraction of exporters by size quantiles in India (see Figure 1). The value of all other parameters (presented in Table $A.1$ of the Web Appendix) is chosen based on the literature, constraints imposed by the model, or set without loss of generality. Appendix 3 provides further details of the simulation.

The implications of our model ("the full model") are compared with those of a single attribute model ("the benchmark model"). As discussed above, when $\tau(\lambda) = \tau$ our model collapses to a model isomorphic to Melitz (2003) with η as the single heterogeneous attribute. Hence, we use this model as a benchmark and calibrate τ to match the overall fraction of exporters (0.153) in the Indian data set.

In single-attribute models, it is the largest domestic firms that benefit from trade by accessing the foreign market. These models predict that a threshold size divides exporters from domestic firms as illustrated by the dark line in Figure 6. In our model, in contrast, as an economy opens up to trade it is not necessarily the largest firms (those with high η) that export. As our simulated results show (light-colored line), firms enter the export market across the size distribution and hence match more

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[27]The largest non-exporter could potentially obtain less revenue than the smallest exporter. To avoid this situation, we require a sufficiently large support for φ and ξ.

closely the patterns in the data (Web Appendix Figure A.1 displays the goodness of fit).

This result emphasizes the broader point that exporting success may require different firm capabilities than success in the domestic market. In particular, firms with relatively high caliber have a relative advantage to produce quality and hence can perform better in the export market. The existence of firm capabilities that matter differently domestically and abroad has crucial policy/strategy implications for export promotion efforts of government agencies and international organizations (e.g. UNCTAD and UNIDO). While the standard models suggest that the same factors that drive domestic success also determine export success, our model highlights the differential impact in the export market of improving firms' organizational structure, practices, and incentives to maximize their ability to efficiently design and develop high quality products.

Our model also has interesting implications for reallocation effects of trade liberalization on aggregate productivity and welfare. Table 1 shows changes in (revenue-weighted) average process (φ), product (ξ), and combined (η) productivity due to trade liberalization under our model (top panel) and under the benchmark single-attribute model implied by $\tau(\lambda) = \tau$ (bottom panel). In our model, since $\tau(\lambda)$ is decreasing in λ, we expect firms with relatively high ξ to gain more from trade liberalization than firms with relatively high φ. Accordingly, the results in the first two columns of Table 1 show that, in response to trade liberalization, average productivity grows relatively more for ξ than for φ under the full model than under the benchmark model.[28]

Average η grows unequivocally in the benchmark model (column 3, bottom panel). Consistent with Melitz (2003), in single-attribute models trade liberalization induces reallocations toward firms endowed with larger amounts of the single attribute, which makes them the largest firms in autarky and hence those predicted to become exporters. In contrast, in the full model average η may go down (column 3, top panel) although welfare – summarized by $P^{\frac{1}{\sigma-1}}$ – still increases (column 4, top panel). The intuition behind this result is that average η cannot predict welfare changes because it is not a relevant measure of aggregate productivity. In the open-economy, aggregate productivity gains also come from reallocating market shares to save on trade costs $\tau(\lambda)$, which involves reallocating them towards high-ξ firms, as they produce higher quality. We finally note that the small magnitude of the welfare gains is consistent with other estimates in the literature (e.g. Eaton and Kortum 2002) and is related to the fact that these estimates capture only static gains from trade. Trade could have potentially much larger effects on welfare by inducing innovation through learning and competition.

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[28]The negative aggregate change for φ under the full model and for ξ under the benchmark model are particular to our calibration. Alternative calibrations could yield positive changes for both.

5 Empirical evidence on Conditional Exporter Premia (CEP)

In this section, we use plant-level micro data sets from India, the U.S., Chile and Colombia to present evidence of the five CEP discussed in Section 2, which also test the predictions of our model. Section 5.1 describes data sources, key variables and methodology. Section 5.2 presents the baseline results and robustness tests. Section 5.3 addresses robustness of our model to alternative explanations.

5.1 Data, variable definitions and methodology

5.1.1 Data sources and definition of variables

Our empirical analysis utilizes establishment-level manufacturing data from India, the United States, Chile and Colombia. Because our theory hinges on a differentiated-product demand structure, following Rauch (1999) we focus on industries manufacturing those products in our baseline analysis. We discuss data sources briefly below; more specific description of data sources, data cleaning, and concordances is provided in the Web Data Appendix.

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.

For the U.S., 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 (e.g. Foster et al. 2008) 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).[29]

We use manufacturing censuses for Chile and Colombia to examine exporter premia only in average wage and capital intensity 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

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[29]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.

the 4-digit ISIC level. The coverage period is 1991-96 for Chile and 1981-91 for Colombia.[30]

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 5.2.1 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. Export status is captured by a dummy variable defined to equal one for establishments reporting positive exports. Revenue is total sales, labor is total employment and average wage is the ratio of total wages to total employment. Capital, in the case of 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 U.S., 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 2 present summary statistics for establishments in "differentiated" sectors in our final samples for India, 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, who 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.[31] Hence,

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[30]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.

[31]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 fixed effects. Because nominal variables (capital intensity and wage) enter regressions in logarithms, our results are invariant to deflating them

means and standard deviations reported in Table 2 correspond to standardized variables.[32] 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.

5.1.2 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

$$E\left[Y\left|_{r,D=1}\right.\right] > E\left[Y\left|_{r,D=0}\right.\right], \quad \forall r, \qquad Y = \left\{\lambda, p, p^I, w, k\right\}. \tag{11}$$

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:

$$y = g_Y(r) + \delta_Y D + u \tag{12}$$

which is the empirical framework used by the literature to obtain the various CEP discussed in section 2. In equation (12), $g_Y(r)$ 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 (12) using ordinary least squares. It is worth noting that the coefficients in (12) *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 (12). 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

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using industry level deflators.

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

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.[33] Nevertheless, we also report results using non-standardized variables.

5.2 Baseline results

5.2.1 Conditional exporter quality premium

Though we do not have direct measures of product quality, an extensive literature suggests that ISO 9000 certification may be a good proxy for it, 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 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 a number of governments and private companies require this certification from suppliers. There is also evidence that the certification helps improve measures of customer satisfaction (Buttle, 1997).[34]

Table 3 presents results from estimating equation (12) 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 2), and is statistically significant in all specifications at the 1 percent level. This finding supports the main theoretical prediction of the model.

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[33]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.

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

5.2.2   Conditional exporter output-price premium

To estimate CEP in output prices, we measure price as the unit value per product line. For multi-product establishments, we include one price observation per line of differentiated product but maintain establishment revenue as our size measure. Also, since information on exports is not disaggregated by product line, in our baseline analysis we assume that an establishment exports all of its product lines. Standard errors are clustered at the establishment level.

Panel 1 of Table 4 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 significant in all specifications.[35]

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 of quality production. As discussed earlier, this finding has been previously documented but lacked a theoretical framework that could explain it. We interpret it as empirical support of the two-factor model with quality dependent trade costs that 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, potential concerns relate to our assumption that

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[35]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 U.S.. Because export status is strongly correlated with size 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.

multiproduct exporters export all their products, and to our use of establishment sales as the size control. To address these concerns, we examine a sample restricted to single-product establishments, and also examine a sales-weighted index of standardized prices for each plant. The results show that, for the U.S., the magnitude and significance levels of the conditional premium estimates are very similar to the baseline. For India, the estimates are significant in both robustness exercises for the cubic-polynomial control for size but not for the one with size-deciles controls. However, the estimated magnitude of the exporter premia 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. 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 negative domestic prices in 14 cases (none significant). Finally, De Loecker and Warzynski (2009) find that exporters charge higher prices than non-exporters and interpret these results as implying that they charge higher mark-ups. However, they also find suggestive evidence that the estimated markups may be driven by quality differences rather than by greater market power.[36]

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[36]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

5.2.3 Conditional exporter input-price premium

To test whether exporters pay higher input prices we compute these prices as the unit value of each establishment input. 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 5 shows the results. The input price CEP is positive and significant in all specifications with standardized variables, both for India and for the U.S.. The exporter premium is also positive in all specifications with non-standardized variables although in two of the four specifications it is not significant.

We undertake similar robustness checks as in Section 5.2.2. 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 (Table A.4).

5.2.4 Conditional exporter wage and capital intensity premia

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). For brevity, for each of the four countries, we only present the preferred specifications with the cubic and size-decile controls for size. As in section 5.2.1, the unit of observation is the establishment.

Table 6 shows that the CEP for average wage is significantly positive for all countries in all specifications. In the standardized case, the estimated exporter premia 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.[37]

For capital intensity, the results in rows 3 and 4 of Table 6 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 indicate 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

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."

[37]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.

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.[38]

5.3 Robustness to alternate models/explanations

5.3.1 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 even 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. As Kugler and Verhoogen (2011) argue, sales may be measured with error, especially in developing countries such as India, for reasons related to avoidance of excise and income taxes, which are less likely to bias measurement of employment. Since, like revenue, employment is monotonically 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.[39] The estimated results show that rather than becoming smaller, as expected if measurement error was driving the results, the estimated CEP increase 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

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[38]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").

[39]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.

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 $A.9$).

5.3.2 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 CEP. 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).[40] 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. This model, hence, can explain a positive conditional exporter price premium. However, it cannot 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 yields the prediction of a negative conditional price premium 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 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.[41] To address this possibility, we estimated price CEP 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 $A.10$).

A different class of models introduces 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 CEP observed in the data.

We could think of two alternative sources of heterogeneity (in addition to productivity) that may explain some of our results. One, firms may be heterogeneous in access to financial capital. While the predictions of such a model would largely depend on assumptions about how financial constraints

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[40]Heterogeneity in variable costs would work analogously.

[41]We thank a referee for raising this possibility.

affect firm size and export status, we undertake a test to check that heterogeneous access to financing is not driving our results. Using the measure of dependence on external finance proposed by Rajan and Zingales (1998), we rerun the baseline price regressions excluding products above the median for this measure and found a positive and significant premium even in industries that are less dependent on external finance (Table A.11). Two, firms could be heterogeneous in their access to government officials. If less productive firms produce lower quality and sell at lower prices as in Kugler and Verhoogen (2011), heterogeneous access to government contracts might explain some of our results. 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 positive and significant exporter premium even in industries that are relatively less dependent on government purchases.

6   Sources of export quality constraints

A number of empirical studies (Maskus et al. 2005, Brooks 2006, Verhoogen 2008, Iacovone and Javorcik 2009) have documented constraints to exporting associated with product quality. Our modeling of export quality constraints via the function $\tau(\lambda)$ parsimoniously summarizes the underlying sources of those constraints. In this section, we exploit variation in export destinations across firms to explore the role of the two most prominent sources discussed in the literature: distance and income per capita.

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. Similarly, 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 average to richer countries.[42]

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 Data 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

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[42]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 5 and the ones we present here, however, indicate that this is not the case.

($\bar{d}$) 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 7. 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 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 two relevant sources of export quality constraints. The results also suggest that the underpinnings of those constraints may vary by level of development, with distance-related factors more important for a high-income country like the U.S., 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 these underlying sources of quality constraints.

7 Conclusion and discussion

We develop a model of international trade with product productivity ("caliber") and process productivity ("productivity") as two distinct dimensions of firm heterogeneity. Product quality is endogenous and variable trade costs vary (inversely) with quality. The model predicts conditional exporter premia (CEP) for quality, output and input prices, average wage and capital intensity, and hence rationalizes evidence of CEP in the empirical literature that so far could not be properly interpreted. We also

test for CEP 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 will become exporters. Because trade costs go down with quality, firms with high caliber across the size distribution benefit from trade liberalization. As a result, resources reallocate toward those firms, which are not necessarily the largest ones. 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 from economizing on trade costs by producing high quality.

This model highlights the importance of distinguishing caliber from productivity as a different, but essential, source of competitiveness. In particular, it emphasizes the fact that the export market rewards one type of firm capability relatively more than the other. Distinguishing the two has important implications beyond the analysis made here on the determinants of exporting behavior and performance. This distinction can be helpful for identifying deeper determinants of productivity growth and dynamics, and hence for public policies aimed at fostering economic growth.

References

[1] Agarwal, S., and R. Hauswald, 2010. Distance and Private Information in Lending. *Review of Financial Studies* 23: 2757-2788.

[2] Alchian, A. and W. Allen, 1964. *University Economics: Elements of Inquiry.* Belmont, California: Wadsworth.

[3] Anderson, S., Daly, J. and M. Johnson, 1999. Why Firms Seek ISO 9000 Certification: Regulatory Compliance or Competitive Advantage?. *Production and Operations Management*, 8 (1): 28-43.

[4] Anderson, E.W., Fornell, C. and D. R. Lehmann, 1994. Customer Satisfaction, Market Share, and Profitability: Findings from Sweden. *The Journal of Marketing*, 58(3): 53-66.

[5] Arkolakis, C., 2010. Market Penetration Costs and the New Consumers Margin in International Trade. *Journal of Political Economy*, 118 (6): 1151-1199.

[6] Armenter, R. and M. Koren, 2010. Economies of Scale and the Size of Exporters. Mimeo.

[7] Artopoulos, A., Friel, D. and J.C. Hallak, 2011. Lifting the Domestic Veil: The Challenges of Exporting Differentiated Goods Across the Development Divide. NBER WP 16947.

[8] Aw, B.Y., Batra, G. and M. Roberts, 2001. Firm Heterogeneity and Export- Domestic Price Differentials: A Study of Taiwanese Electronics Products. *Journal of International Economics*, 54(1): 149-169.

[9] Baldwin, R. and J. Harrigan, 2011. Zeros, Quality, and Space: Trade Theory and Trade Evidence. *American Economic Journal: Microeconomics*, 3(2): 60-88.

[10] Bernard, A. and J.B. Jensen, 1995. Exporters, Jobs, and Wages in U.S. Manufacturing: 1976-1987 *Brookings Papers on Economic Activity. Microeconomics*, 67-119.

[11] Bernard, A. and J.B. Jensen, 1999. Exceptional exporter performance: Cause, effect, or both? *Journal of International Economics*, 47(1): 1-25.

[12] Bernard, A., Eaton, J., Jensen, J.B. and S. Kortum, 2003. Plants and productivity in international trade. *American Economic Review*, 93(4): 1268-1290.

[13] Bernard, A., B. Jensen, S. Redding and P. Schott, 2007. Firms in International Trade. *Journal of Economic Perspectives*, 21(3): 105-130.

[14] Bernard A., S. Redding., and P. Schott. 2011. Multi-product firms and trade liberalization. *Quarterly Journal of Economics*, forthcoming.

[15] Brooks, E., 2006. Why don't firms export more? Product quality and Colombian plants. *Journal of Development Economics*, 80(1): 160-178.

[16] Brown, C. and J. Medoff, 1989. The Employer Size-Wage Effect. *Journal of Political Economy*, University of Chicago Press, 97(5): 1027-1059, October.

[17] Brown, A., T. van der Wiele, and K. Loughton, 1998. Smaller Enterprises Experiences with ISO 9000. *International Journal of Quality & Reliability Management*, 15 (3): 273-285.

[18] Bustos, P., 2011. Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinian Firms. *American Economic Review*, 101(1): 304-340.

[19] Buttle, F., 1997. ISO 9000: Marketing Motivations and Benefits. *International Journal of Quality & Reliability Management*, 14(9): 936-947.

[20] Chaney, T., 2008. Distorted Gravity: The Intensive and Extensive Margins of International Trade. *American Economic Review*, 98(4): 1707-1721.

[21] Clougherty, J. and M. Grajek, 2008. The Impact of ISO 9000 Diffusion on Trade and FDI: A New Institutional Analysis. *Journal of International Business Studies* 39(4): 613–633.

[22] Corbett, C., 2006. Global Diffusion of ISO 9000 Certification through Supply Chains. *Manufacturing and Service Operations Management*, 8(4): 330-350.

[23] Das, S., M. Roberts, and J. Tybout, 2007. Market Entry Costs, Producer Heterogeneity and Export Dynamics. *Econometrica*, 75(3): 837-873.

[24] De Loecker, Jan, 2007. Do exports generate higher productivity? Evidence from Slovenia, *Journal of International Economics*, Elsevier, 73(1): 69-98.

[25] De Loecker, J. and F. Warzynski, 2009. Markups and Firm-Level Export Status. CEPR WP 7450.

[26] Eaton, J. and S. Kortum, 2002. Technology, Geography, and Trade. *Econometrica*, 70: 1741–1779.

[27] Eaton. J., S. Kortum, and F. Kramarz, 2008. An Anatomy of International Trade: Evidence from French Firms. Mimeo.

[28] Erel, E. and J. Ghosh, 1997. ISO 9000 implementation in the Turkish industry. *International Journal of Operations & Production Management*, 17(12): 1233-1246.

[29] Feigenbaum, Armand V., 1991. *Total Quality Control* (3 ed.), New York: McGraw-Hill.

[30] Ferrall, C., 1997. Routines to Maximize a Function in Stata. *Stata Technical Bulletin*, 38, July, 1997, 22-26.

[31] Foster, L., J. Haltiwanger and C. Syverson, 2008. Reallocation, Firm Turnover and Efficiency: Selection on Productivity or Profitability? *American Economic Review*, 98(1): 394-425.

[32] Guler, I., M. Guillén and J. Macpherson, 2002. Global Competition, Institutions, and the Diffusion of ISO 9000 Quality Certificates. *Administrative Science Quarterly*, 47: 207-232.

[33] Hallak, J.C., 2006. Product quality and the direction of trade. *Journal of International Economics*, 68(1): 238-265.

[34] Hallak, J.C. and J. Sivadasan, 2009. Firms' Exporting Behavior under Quality Constraints. International Policy Center WP 88.

[35] Hallak, J.C., 2010. A Product-Quality View of the Linder Hypothesis. *Review of Economics and Statistics*, 92(3): 453-466.

[36] Hudson, J. and P. Jones, 2003. International Trade in "Quality Goods": Signalling Problems For Developing Countries. *Journal of International Development*, 15: 999-1013.

[37] Hummels, D. and A. Skiba, 2004. Shipping the Good Apples Out: An Empirical Confirmation of the Alchian-Allen Conjecture. *Journal of Political Economy*, 112: 1384-1402.

[38] Iacovone, L. and B. Javorcik, 2009. Shipping Good Tequila Out: Investment, Domestic Unit Values and Entry of Multi-product Plants into Export Markets. Mimeo.

[39] Isgut, A., 2001. What's Different about Exporters? Evidence from Colombian Manufacturing. *Journal of Development Studies*, 37(5): 57-82.

[40] Ivkovich, Z. and S. Weisbenner, 2005. Local Does As Local Is: Information Content of the Geography of Individual Investors' Common Stock Investments. *Journal of Finance*, 60: 267-306.

[41] Johnson, R., 2011. Trade and Prices with Heterogeneous Firms. Mimeo.

[42] Kee, H.L. and K. Krishna, 2008. Firm Level Productivity and Demand Shocks: Evidence from Bangladesh. *American Economic Review* 98(2): 457-462.

[43] Klette, T.J. and S. Kortum, 2004. Innovating Firms and Aggregate Innovation. *Journal of Political Economy*, 112(5): 986-1018

[44] Kugler, M. and E. Verhoogen, 2011. Prices, Plant Size, and Product Quality. *Review of Economic Studies*, forthcoming.

[45] Lederman, D., M. Olarreaga and L. Payton, 2007. Export Promotion Agencies: What Works and What Doesn't. World Bank Policy Research WP 4044.

[46] Levinthal, D.A and J.G. March, 1993. The Myopia of Learning. *Strategic Management Journal*, Vol. 14, Special Issue: Organizations, Decision Making and Strategy, 95-112.

[47] Lugovskyy, V. and A. Skiba, 2011. How Geography Affects Quality. Mimeo.

[48] March, J.G., 1991. Exploration and Exploitation in Organizational Learning. *Organization Science*, 2(1), Special Issue: Organizational Learning: Papers in Honor of (and by) James G. March (1991), 71-87.

[49] Maskus, K., T. Otsuki and J. Wilson, 2005. The Cost of Compliance with Product Standards for Firms in Developing Countries: An Econometric Study. World Bank Policy Res. WP 3590.

[50] Melitz, M., 2003. "The impact of trade on intra-industry reallocations and aggregate industry productivity," *Econometrica*, 71(6): 1695-1725.

[51] Mersha, T., 1997. TQM implementation in LDCs: driving and restraining forces. *International Journal of Operations & Production Management*, 17(2): 164-183.

[52] Monahan, J., 1992. Longitidinal Research Database (LRD) Technical Documentation Manual. Internal Document, Center for Economic Studies.

[53] Motta, M., 1993. Endogenous Quality Choice: Price vs. Quantity Competition. *The Journal of Industrial Economics*. 41(2): 113-131

[54] Nguyen, D., 2011. Demand Uncertainty: Exporting Delays and Exporting Failures. Mimeo.

[55] Phillips, L.W., Chang, D. R. and R. D. Buzzell, 1983. Product Quality, Cost Position and Business Performance: A Test of Some Key Hypotheses. *The Journal of Marketing*, 47(2): 26-43.

[56] Porter, M.E., 1980, *Competitive Strategy*, New York: The Free Press.

[57] Raisch, S., Birkinshaw, J., Probst, G., and M.L. Tushman, 2009, Organizational Ambidexterity: Balancing Exploitation and Exploration for Sustained Performance. *Organization Science*, 20(4): 685-695.

[58] Rajan, R.G., Zingales, L., 1998. Financial dependence and growth. *American Economic Review* 88: 559-586.

[59] Rauch, J., 1999. Networks Versus Markets in International Trade. *Journal of International Economics*, 48(1): 7-35.

[60] Roberts, M. and J. Tybout. (Ed.), 1996. *Industrial Evolution in Developing Countries: Micro Patterns of Turnover, Productivity and Market Structure*. NY: Oxford University Press.

[61] Ruhl, K., 2008. The International Elasticity Puzzle. Mimeo.

[62] Rust, R., Moorman, C. and P.R. Dickson, 2002. Getting Return on Quality: Revenue Expansion, Cost Reduction, or Both? *The Journal of Marketing*, 66(4): 7-24.

[63] Shaked, A. and J. Sutton, 1983. Natural Oligopolies. *Econometrica.* 51(5): 1469-1483.

[64] Sivadasan, J., 2007. Productivity Consequences of Product Market Liberalization: Micro-evidence from Indian Manufacturing Sector Reforms. Mimeo.

[65] Sutton, J., 2007. Quality, Trade and the Moving Window: The Globalisation Process. *The Economic Journal*, 117: F469-F498.

[66] Terlaak, A. and A. King, 2006. The effect of certification with the ISO 9000 Quality Management Standard: A signaling approach. *Journal of Economic Behavior and Organization,* 60: 579-602.

[67] Van Biesebroeck, J., 2005, Firm Size Matters: Growth and Productivity Growth in African Manufacturing. *Economic Development and Cultural Change*, 53(3): 545-583.

[68] Verhoogen, E., 2008. Trade, Quality Upgrading and Wage Inequality in the Mexican Manufacturing Sector. *Quarterly Journal of Economics*, 123(2): 489-530.

[69] Weston, F., 1995. What do managers really think of the ISO 9000 registration process?. *Quality Progress*, 28(10): 67-73.

[70] Withers, B. and M. Ebrahimpour, 2001. Impacts of ISO 9000 registration on European Firms: A Case Analysis. *Integrated Manufacturing Systems*,12 (2): 139-151.

[71] World Bank, 1999. *World Development Report 1998/1999: Knowledge for Development*. New York: Oxford University Press.

[72] World Trade Organization, 2005. *World Trade Report 2005: Exploring the Links Between Trade, Standards, and the WTO.*

[73] Yeaple, S., 2005. A simple model of firm heterogeneity, international trade and wages. *Journal of International Economics*, 65(1): 1-20.

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 is the set of all varieties available in that market. Solving the consumer's problem yields market demand for quality j: $q_{j,k} = p_{j,k}^{-\sigma} \lambda_j^{\delta_k(\sigma-1)} \frac{E_k}{P_k}$, where $P_k \equiv \int_{j \in \Omega_k} p_j^{1-\sigma} \lambda_j^{\delta_k(\sigma-1)} dj$. Assume for simplicity that $\delta_d = 1$. Then, domestic revenue is given by $r_{j,d} = p_{j,d} q_{j,d} = p_{j,d}^{1-\sigma} \lambda_j^{\sigma-1} \frac{E}{P}$. Since preferences are CES, firms charge prices $p_{j,x} = t(\lambda_j) p_{j,d}$ in the foreign market. Thus, foreign revenue is $r_{j,x} = I_x t(\lambda)^{1-\sigma} p_{j,d}^{1-\sigma} \lambda_j^{\delta_x(\sigma-1)} \frac{E^*}{P^*}$. Defining $\delta \equiv \delta_x - \delta_d$, we can express foreign revenue as $r_{j,x} = I_x \left(\frac{t(\lambda)}{\lambda_j^\delta} \right)^{1-\sigma} p_{j,d}^{1-\sigma} \lambda_j^{(\sigma-1)} \frac{E^*}{P^*}$. Let $\tau(\lambda) = \frac{t(\lambda_j)}{\lambda_j^\delta}$. Then, we can write total revenue as: $r_j = p_{j,d}^{1-\sigma} \lambda_j^{\sigma-1} \left(\frac{E}{P} + I_x \tau(\lambda)^{1-\sigma} \frac{E^*}{P^*} \right)$. Equivalently, this demand system can be obtained from a Dixit-Stiglitz utility function defined in terms of quality-adjusted units of consumption, $\tilde{q}_{j,k} = q_{j,k} \lambda_{j,k}^{\delta_k}$, and quality-adjusted prices $\tilde{p}_{j,k} = \frac{p_{j,k}}{\lambda_{j,k}^{\delta_k}}$. Note, however, that the quality adjustment depends on the intensity of preferences for quality in market k.

Appendix 2. Quality is higher in the exporting case.
Proof. In the exporting case, the first order condition for optimal quality is:

$$\left(\frac{\sigma}{\sigma-1} \right)^{-\sigma} \left(\frac{\varphi}{\kappa} \right)^{\sigma-1} \left[(1-\beta) \frac{E}{P} \tau(\lambda)^{\sigma-1} + (1 - \beta + \varepsilon(\lambda)) \frac{E^*}{P^*} \right] - \frac{f \alpha \lambda^{\alpha'}}{\xi \tau(\lambda)^{1-\sigma}} = 0. \tag{13}$$

By assumption A.1, $\tau(\lambda)^{\sigma-1}$ decreases with quality. By assumption A.4, $\varepsilon(\lambda)$ also decreases with quality. By assumption A.3, $\frac{\lambda^{\alpha'}}{\tau(\lambda)^{1-\sigma}}$ increases with quality.[43] Thus, the left hand side of equation (13) decreases with quality. Evaluating it for $\lambda = \lambda_d(\varphi, \xi)$ yields:

$$\left(\frac{\sigma}{\sigma-1} \right)^{-\sigma} \left(\frac{\varphi}{\kappa} \right)^{\sigma-1} \left[(1 - \beta + \varepsilon(\lambda)) \frac{E^*}{P^*} \right] > 0 \tag{14}$$

Then, quality must increase to satisfy the first order condition. This means that $\lambda_x(\varphi, \xi) > \lambda_d(\varphi, \xi)$.

Appendix 3: Simulation and calibration of parameters Except for the parameters of the function $\tau(\lambda)$ and the joint distribution $v(\varphi, \xi)$, the rest of the parameters, presented in Panel 1 of Web Appendix Table A.1, were calibrated based on the literature, constraints imposed by the assumptions, or set without loss of generality. We set κ and f, which scale productivity (φ) and caliber (ξ) respectively, equal to unity without loss of generality. We set the demand elasticity σ equal to 4, within the range of estimates in the literature. We set $\beta = 0.9$ to retain a significant elasticity of marginal costs to quality without violating $\beta < 1$. The constant fixed costs parameter F_0 affects the domestic entry cutoff. We set it low enough (0.25) to ensure that sufficient number of domestic firms survive. Because real market size ($\frac{E}{P}$) in our model (like in Melitz 2003) has innocuous effects, we set it to unity. Then, we set $E = P = 50$, without loss of generality. As we consider a symmetric two-country case, we set $E^* = P^* = 50$ as well. The parameter γ moderates the dependence of variable trade costs on quality in our full model. We set this parameter to 0.7. Given these choices, Assumption A.3 imposes $\alpha > (1 - \beta + \gamma)(\sigma - 1) = 2.4$. We set $\alpha = 2.5$ to meet this criterion while restraining the influence of caliber on fixed costs.

The parameters of the $\tau(\lambda)$ function, τ_0 and τ_1, the fixed exporting cost f_x, and the five parameters of the joint log-normal distribution $v(\varphi, \xi)$, $\mu_\varphi, \mu_\xi, \sigma_\varphi, \sigma_\xi$, and ρ, are jointly calibrated using an efficient search

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[43]Compute $\left(\frac{\lambda^{\alpha'}}{\tau(\lambda)^{1-\sigma}} \right)' = \lambda^{\alpha'-1} \tau(\lambda)^{\sigma-1} \left[-(\sigma - 1)(-\frac{\lambda \tau'(\lambda)}{\tau(\lambda)}) + \alpha' \right]$. If condition A.3 is satisfied then the term in square brackets is positive. Thus, $\left(\frac{\lambda^{\alpha'}}{\tau(\lambda)^{1-\sigma}} \right)' > 0$.

(non-derivative) algorithm (Ferrall 1997), to match the overall fraction of exporters (0.153) and the fraction of exporters by size quantiles in the Indian data (calibrating for the U.S. yields similar results).[44] The calibrated parameters are presented in Panel 2 of Table $A.1$. Figure $A.1$ in the Web Appendix displays the fit of the calibrated full model to Figure 1. For the benchmark model, we set the parameters as in the full model except variable trade costs τ. Because τ does not depend on quality in the benchmark model, we set τ_1 to zero and calibrate τ_0 to match the overall fraction of exporters in the Indian data (0.153). We undertook a variety of checks using alternative parameter choices for $\sigma, \beta, F_0, \gamma$ and α, and verified that they did not affect the qualitative conclusions discussed in the text.[45]

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[44]Specifically, the objective function that is minimized is: $R = 40. \left(\frac{1}{N} \sum_{i=1}^{N} D_i^e - 0.153 \right)^2 + \sum_{k=1}^{40} \left(\sum_{i=1}^{N_k} D_i^e - \bar{D}_e^{\ k} \right)^2$, where D^e is a dummy for exporters, i indexes firms, k indexes the 40 size groups, and N (set to 5000) is the size of the simulated sample. Because the objective function is highly non-linear and does not satisfy the regularity conditions for a global minimum, the results and goodness of fit are sensitive to the choice of the starting point for the optimization algorithm. We use a three-step procedure to choose the starting point. First, we examine revenues for an initial choice of trade cost parameters over a finely divided $\varphi - \xi$ grid spanning the region $[0,10] \times [0,10]$. Second, since Figure 1 implies overlap between exporters and domestic firms all across the distribution, we identify the region in this grid with a significant overlap in revenues between exporters and non-exporters. Finally, we use the mean, standard deviation and correlation coefficient for this revenue overlap region, and the initial trade parameter values as the starting point for the optimization routine.

[45]The robustness of the comparative results is not surprising as these parameters (except for γ which is not operational in the benchmark model) are set the same for both the full and the benchmark models. Interested readers can verify the details of the calibration and simulations using the code available online on the authors' websites.

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.

Fraction exporters by size quantile
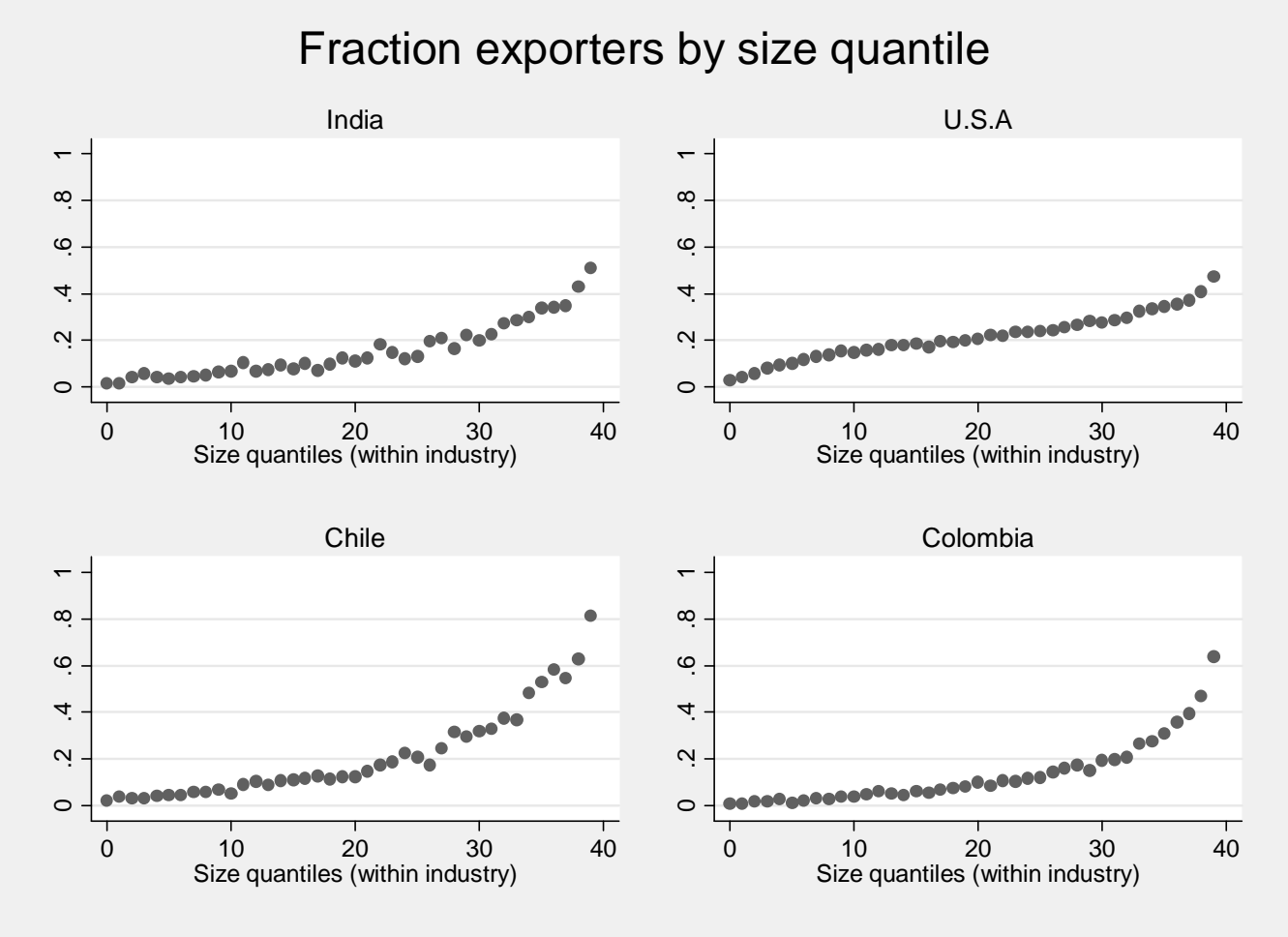
Figure 2: Survival cut-off function

$\underline{\xi}(\varphi)$: Survival cut-off function
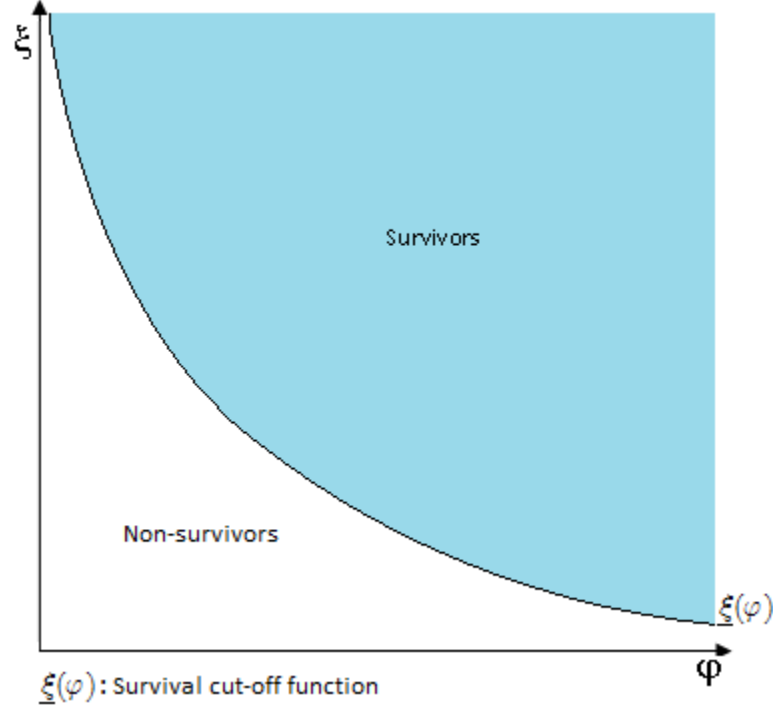
Figure 3: Isoprofit curves are flatter in the exporting case

$\underline{\xi}_{\pi_{d=k}}(\varphi)$: Domestic iso-profit curve

$\underline{\xi}_{\pi_{x=k'}}(\varphi)$: Exporting iso-profit curve
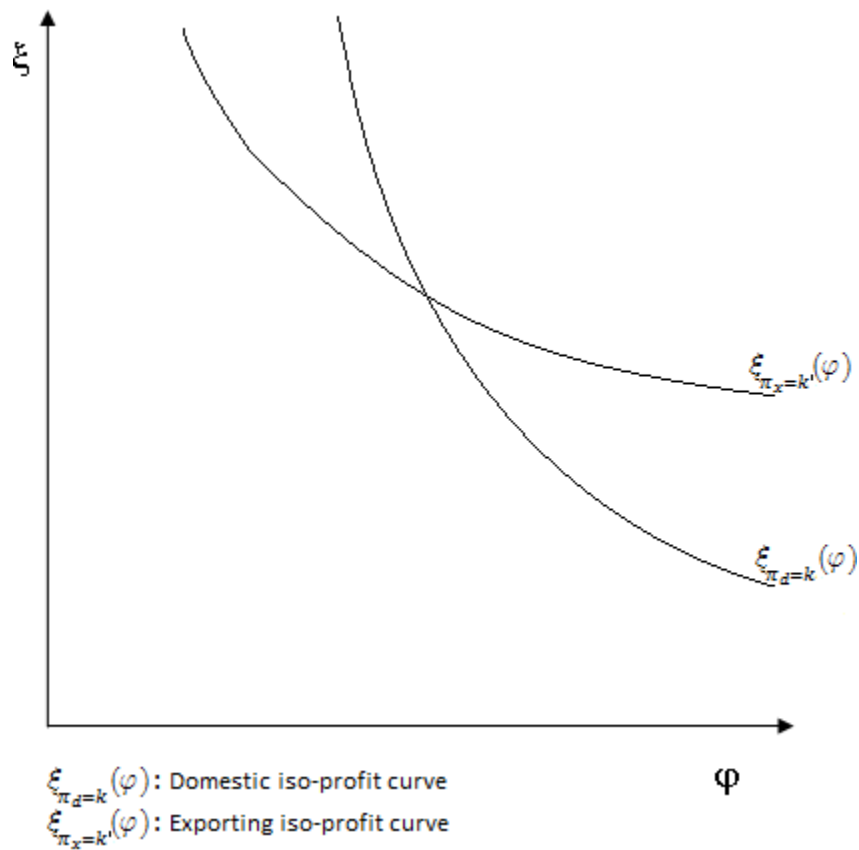
Figure 4: The export status decision

$\xi_x(\varphi)$: Export cut-off function

$\underline{\xi}(\varphi)$: Survival cut-off function
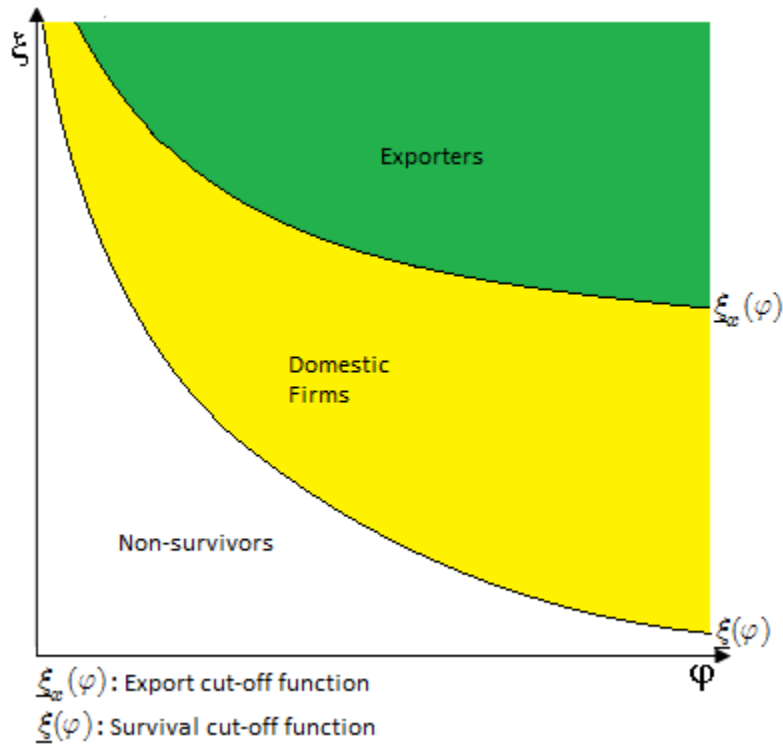
Figure 5: Firms with the same size and different export status

$\xi_x(\varphi)$: Export cut-off function

$\underline{\xi}(\varphi)$: Survival cut-off function

$\xi_{r=k}(\varphi)$: Iso-revenue curve
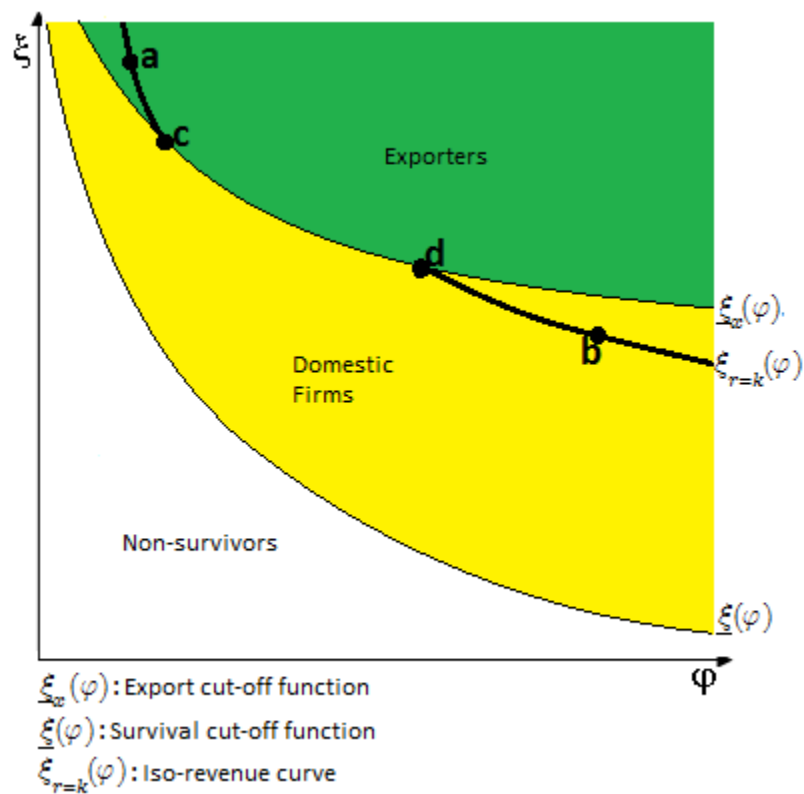
Figure 6: Autarky versus open economy case

Fraction exporters by size quantile
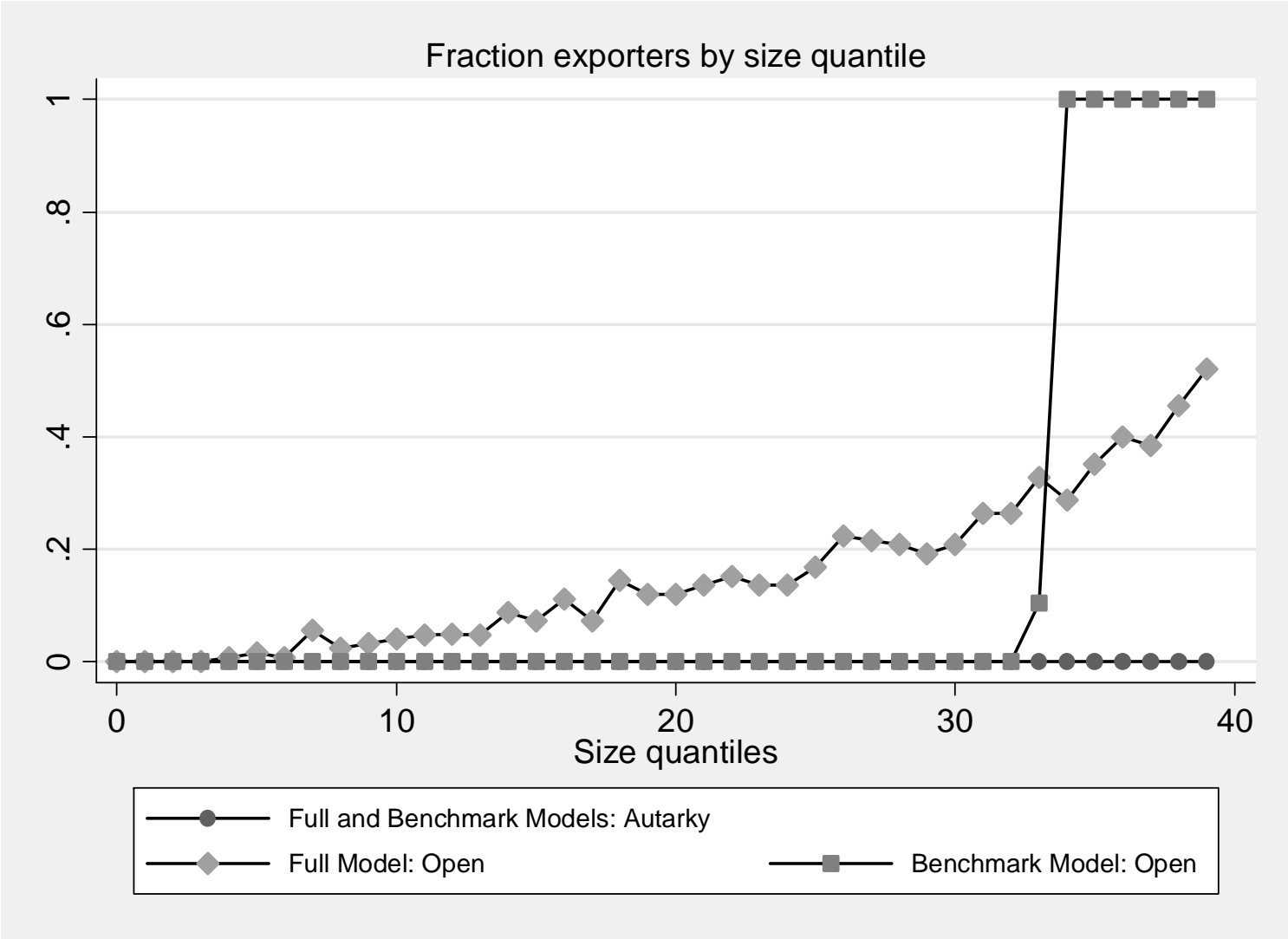
Table 1: Changes in welfare and aggregate productivity measures following opening up to trade

	Aggregate (revenue share weighted average) "physical productivity" (φ)	Aggregate (revenue share weighted average) "product productivity" (ξ)	Aggregate (revenue share weighted average) "combined productivity" (η)	Welfare per capita $\left(P^{\frac{1}{\sigma-1}}\right)$
	(1)	(2)	(3)	(4)
Full Model: Autarky	6.874	3.258	804.775	3.6808
Full Model: Open	6.860	3.424	803.204	3.6840
% Change following opening to trade	**-0.19%**	**5.08%**	**-0.20%**	**0.09%**
Benchmark Model: Autarky	6.874	3.258	804.775	3.6827
Benchmark Model: Open	6.886	3.221	807.874	3.6840
% Change following opening to trade	**0.17%**	**-1.15%**	**0.39%**	**0.04%**

Table 2: 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. Input prices are weighted by share of total costs.

Description	ALL ESTABLISHMENTS			NON-EXPORTERS			EXPORTERS		
	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	-.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 3: 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. Standard errors are clustered at the plant level; * 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 4: 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 5: 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 6: 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; * 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 (plants)	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 7: 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