FIRMS' EXPORTING BEHAVIOR UNDER QUALITY CONSTRAINTS

by

Juan Carlos Hallak *
Universidad de San Andres and NBER

and

Jagadeesh Sivadasan *
University of Michigan

CES 09-13 May, 2009

The research program of the Center for Economic Studies (CES) produces a wide range of economic analyses to improve the statistical programs of the U.S. Census Bureau. Many of these analyses take the form of CES research papers. The papers have not undergone the review accorded Census Bureau publications and no endorsement should be inferred. Any opinions and conclusions expressed herein are those of the author(s) and do not necessarily represent the views of the U.S. Census Bureau. All results have been reviewed to ensure that no confidential information is disclosed. Republication in whole or part must be cleared with the authors.

To obtain information about the series, see **www.ces.census.gov** or contact Cheryl Grim, Editor, Discussion Papers, U.S. Census Bureau, Center for Economic Studies 2K130B, 4600 Silver Hill Road, Washington, DC 20233, **Cheryl.Ann.Grim@census.gov**.

Abstract

We develop a model of international trade with export quality requirements and two dimensions of firm heterogeneity. In addition to "productivity", firms are also heterogeneous in their "caliber" {the ability to produce quality using fewer fixed inputs. Compared to single-attribute models of firm heterogeneity emphasizing either productivity or the ability to produce quality, our model provides a more nuanced characterization of firms' exporting behavior. In particular, it explains the empirical fact that firm size is not monotonically related with export status: there are small firms that export and large firms that only operate in the domestic market. The model also delivers novel testable predictions. *Conditional on size*, exporters are predicted to sell products of higher quality and at higher prices, pay higher wages and use capital more intensively. These predictions, although apparently intuitive, cannot be derived from single-attribute models of firm heterogeneity as they imply no variation in export status after size is controlled for. We find strong support for the predictions of our model in manufacturing establishment datasets for India, the U.S., Chile, and Colombia.

JEL codes: F10, F12, F14,
Keywords: Productivity, quality, exports, ¯rm heterogeneity

* Juan Carlos Hallak thanks the National Science Foundation (grant #SES-05550190) and Jagadeesh Sivadasan thanks the NTT program of Asian Finance and Economics for supporting this work. We also thank the Center for International Business Education (CIBE) for support. Part of the research in this paper was conducted by Jagadeesh Sivadasan as a Special Sworn Status researcher of the U.S. Census Bureau at the Michigan Census Research Data Center. Support for this research at the Michigan RDC from NSF (ITR-0427889) is also gratefully acknowledged. Any opinions and conclusions expressed herein are those of the author(s) and do not necessarily represent the views of the U.S. Census Bureau. All results have been reviewed to ensure that no confidential information is disclosed. We thank Carlo Altomonte, In¶es Armendariz, Paula Bustos, Mariana Colaccelli, Alan Deardo®, Rob Feenstra, David Hummels, Jim Levinsohn, Diego Puga, Kim Ruhl, Eric Verhoogen and Federico Weinschelbaum for their comments and suggestions. We also thank seminar and conference participants at Berkeley, Columbia, Georgetown, LSE, Michigan, Missouri, Oregon, Oxford, Princeton, San Andres, San Diego, Santa Cruz, Stanford, The World Bank, UBC, U. Montevideo, UT-Austin, UTDT, CREI (Spain), ELSNIT (Italy), LACEA (Colombia), NBER Summer Institute, RIEF (Italy), and UNIBO (Argentina). Santiago Sautua, Bernardo D. de Astarloa, Xiaoyang Li and Alejandro Molnar provided excellent research assistantship.

1 Introduction

Understanding what determines firms' export behavior and performance is one of the most important open questions in international trade. At a policy level, the impressive export performances of rapidly-growing developing countries (World Bank 1987, 1993) suggests that export growth might play a key role in helping countries attain high income levels. Also, as governments increasingly view export development as an important objective that justifies policies aimed at fostering it, understanding what makes firms export should help enhance the effectiveness of such policies.[1] More generally, identifying determinants of firms' exporting behavior is critical for answering the question of what determines trade patterns across countries, the field's core question in the last two centuries.

While work in international trade has traditionally focused on determinants of trade operating at the sector level, a growing new literature emphasizes the role played by factors operating at the level of the firm. In this literature a single attribute, heterogeneously distributed across firms, is usually modeled as the sole determinant of firms' ability to conduct business successfully, both domestically and abroad. This attribute is often modeled as productivity (e.g. Bernard et al. 2003, Melitz 2003, Chaney 2008, Arkolakis 2008), or alternatively as the ability to produce quality (Baldwin and Harrigan 2007, Johnson 2008, Verhoogen 2008, Kugler and Verhoogen 2008). In either case the models share the property that the endowment of this attribute perfectly predicts firms' revenue (henceforth our measure of firm size) and export status. Moreover, the models predict a threshold firm size above which all firms export – and below which none do.

Although these models parsimoniously explain the salient fact that exporters tend to be large (Clerides et al. 1998, Bernard and Jensen 1999), the prediction of a threshold firm size for export, common to single-attribute models, is contradicted in the data by a large number of "anomalous" firms. Notable among them are "born globals" – small and recently established firms with a strong export orientation (Oviatt and McDougall 1994, Rialp et al. 2005), and "local dynamos" – large firms that are successful in their domestic markets but do not sell abroad (Boston Consulting Group 2008). More generally, the models leave much of the observed relationship between firm size and export status unexplained. As a preview of the data we will describe later in more detail, 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).[2] Though this fraction increases with size, there are still many

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

[2] To be consistent with our model, Figure 1 uses data for differentiated products. Appendix figure A.1 shows a

exporters among the smallest firms as well as a substantial fraction of firms with no export activity even among firms at the top of the size distribution.

This paper develops a partial-equilibrium heterogeneous-firm model with endogenous product quality that can explain the lack of a one-to-one relationship between firm size and export status observed in these graphs.[3] The model embeds two sources of heterogeneity: "productivity" is the ability to produce output using fewer variable inputs – as is typically modeled in the literature; "caliber" is the ability to produce quality with fewer fixed outlays. Product quality shifts out product demand but increases marginal costs of production and fixed costs of product development. Although caliber is the primary determinant of quality choice, productivity also affects this choice by reducing the impact of quality on marginal costs. Therefore, both caliber and productivity increase firm's optimal choice of quality.

We describe and analyze the equilibrium in a trade environment with export quality constraints. In the presence of these constraints, high-productivity low-caliber firms are large in size, but refrain from exporting because they find the cost of satisfying the export quality constraint excessively onerous. In turn, low-productivity high-caliber firms are active in the export market despite being small. More generally, the model implies that export success might depend critically on firm capabilities that are not as essential for domestic success.

We first solve for the industry equilibrium in the closed economy and in a benchmark case of an open economy with no export quality constraints. In both cases, productivity (φ) and caliber (ξ) can be combined into a single "ability" parameter η ($\eta = \eta(\varphi, \xi)$) such that key variables of interest can be expressed in terms of this scalar parameter. For example, regardless of the particular combinations of φ and ξ, firms with the same value of η have identical revenue, profits, and export status (though they choose different quality levels and charge different prices). Furthermore, the model allows for a representation isomorphic to Melitz's (2003) model. A threshold ability level ($\underline{\eta}$) determines survival, while another threshold ability level ($\underline{\eta}_u$) determines firms' participation in the export market. The isomorphism with Melitz' model is appealing as it makes the case with no export quality constraints a transparent benchmark.

Next we analyze the full model, where we assume that firms are required to meet a minimum quality requirement to export.[4] Although simplistic, this assumption captures a wealth of evidence

similar pattern including all industries.

[3] We later discuss alternative dimensions of heterogeneity that could also explain the patterns observed in Figure 1 but not all the remaining predictions of the model.

[4] A similar assumption is made by Rauch (2007) in a model with homogenous firms.

suggesting that export success is associated with firms' ability to satisfy quality constraints.[5] While different reasons – discussed later – can be invoked to justify the existence of these constraints, our aim in this paper is not to identify their particular source but rather to identify their presence by examining its impact on firms' exporting behavior.

In the presence of export quality constraints, our model implies that the size of a firm is no longer sufficient information to infer its export status. In particular, a firm that does not export (high φ, low ξ) might have equal sales revenue as an exporting firm (low φ, high ξ). Because of its high productivity, the former firm can compensate its lack of foreign revenue with higher domestic sales. This prediction can explain the heterogeneity in exporting behavior within size groups observed in Figure 1.

While a variety of economic forces different from those we propose here can potentially explain Figure 1, our assessment of the model's empirical relevance relies on empirically testing the distinct set of additional predictions it delivers. In particular, our model predicts systematic differences between exporters and non-exporters *conditional on firm size*. Specifically, conditional on firm size exporters are predicted to produce higher quality and sell at higher prices than non-exporters. Also, to the extent that production of quality goods requires more intensive use of skilled labor and capital, exporters should pay higher average wages and be more capital intensive. In sum, the model predicts *conditional exporter premia* in quality, price, average wage, and capital intensity. Thus, in a regression framework with quality, price, average wage or capital intensity as the dependent variable and size controls, the conditional exporter premia should manifest in a positive coefficient on an export dummy.

The prediction of *conditional* exporter premia in our model is conceptually very different from the *unconditional* exporter premia predicted by recently proposed single-attribute models with quality heterogeneity (Baldwin and Harrigan 2007, Johnson 2008, Kugler and Verhoogen 2008, Crozet et al. 2008). In those models, exporters are predicted to be systematically different

[5] The international management literature widely acknowledges quality as a key requisite to access foreign markets (e.g. Guler et al. 2002, Gosen et al. 2005). In particular, several studies based on firm-level surveys both in developed and developing countries (e.g. Weston 1995, Erel and Ghosh 1997, Mersha 1997, Anderson et al. 1999, Corbett 2005) document satisfying the demands of international buyers as a critical motivation for obtaining quality management certification (ISO 9000). Studies in international trade, using census or large firm–level datasets, find that quality strongly influences firms' ability to export (Brooks 2006, Verhoogen 2008, Iacovone and Javorcik 2008). Finally, international organizations emphasize the attainment of quality standards as a crucial requirement for export competitiveness (International Trade Center 2005, World Bank 1999).

from non-exporters, particularly in size. But since size, quality, prices, and export status are all monotonically-related variables, once size is conditioned upon there is no variation left in the other variables. As a result, in the regression specification described above the coefficient on the export dummy should be zero. While estimation of positive conditional exporter premia has been customary in the empirical literature (e.g. Bernard and Jensen 1999, Fajnzylber and Fernandes 2006, Iaccovone and Javorcik 2008, Kugler and Verhoogen 2008) our paper is the first to provide a framework that makes sense of this empirical finding.

We test the predictions of our model employing manufacturing firm-level data from four countries: India, the United States, Chile, and Colombia. Since quality is not observable, our main testable prediction is the conditional exporter *price* premium. This prediction is tested using data for India and the U.S. as these countries' datasets include product-level information on revenue and quantities that allows us to calculate unit values. For Chile and Colombia, the datasets do not include such information but contain data on firms' wages and capital that can be used to test the ancillary predictions of conditional exporter premia on factor use. Consistent with the model predictions, we find positive and significant conditional exporter premia for prices, average wage and capital intensity.[6] We find that the results are consistent across countries and robust to a number of alternative specifications. Also, our robustness analysis addresses potential concerns about measurement error in revenue and rules out potential alternative explanations of our results.

This paper is related to a growing literature proposing international trade models with more than one source of heterogeneity. In section 5.2.1, we reference the relevant studies and discuss why those models cannot account for the empirical facts we document here.[7]

The rest of the paper is organized as follows. Section 2 describes our theoretical model. Section 3 describes the data. Section 4 presents our baseline results. Section 5 performs several robustness checks. Section 6 concludes.

2 Productivity and quality in a two-factor heterogeneous-firm model

This section develops a two-factor heterogeneous-firm model. In section 2.1, we characterize the equilibrium in a closed economy. In section 2.2, we examine the case of a benchmark open economy with no export quality constraints. In section 2.3, we introduce minimum export quality

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

[7] Sutton (2007) allows for firm heterogeneity in "productivity" and "quality" in the close economy but not in the open economy.

requirements and analyze the open-economy equilibrium in the presence of those requirements.

2.1 The closed economy

2.1.1 Set up

The model is developed in partial equilibrium. We assume a monopolistic competition framework with constant-elasticity-of-substitution (CES) demand. The demand system here is augmented to account for product quality variation across varieties (as in Hallak and Schott 2008):

$$q_j = p_j^{-\sigma} \lambda_j^{\sigma-1} \frac{E}{P}, \qquad \sigma > 1, \tag{1}$$

where j indexes product varieties while p_j and λ_j are, respectively, the price and quality of variety j. Each firm produces only one variety, so j also indexes firms. E is the (exogenously given) level of expenditure, and the "price aggregator" P is defined as $P \equiv \int_j p_j^{1-\sigma} \lambda_j^{\sigma-1} dj$.[8]

Product quality is modeled as a demand shifter that captures all attributes of a product – other than price – that consumers value. The demand system (1) solves a consumer maximization problem with a Dixit-Stiglitz utility function defined in terms of quality-adjusted units of consumption, $\widetilde{q}_j = q_j \lambda_j$, and quality adjusted prices $\widetilde{p}_j = \frac{p_j}{\lambda_j}$. Thus, firm revenues, $r_j = p_j q_j = \widetilde{p}_j \widetilde{q}_j$, can be expressed as:

$$r_j = \widetilde{p}_j^{\,1-\sigma} \frac{E}{P}. \tag{2}$$

Equation (2) indicates that larger firms charge lower quality-adjusted prices.

The model allows for two sources of firm heterogeneity. Following standard models (Melitz 2003, Bernard et al. 2003), the first source of heterogeneity is "productivity", φ, which reduces variable production costs given quality. Productivity enters the marginal cost function in the following form:

$$c(\lambda, \varphi) = \frac{c}{\varphi} \lambda^{\beta}, \qquad 0 \leq \beta < 1, \tag{3}$$

where c is a constant parameter. β is lower than unity – i.e. marginal costs increase with quality but not excessively fast – to ensure concavity of the profit function. Also, marginal costs are assumed to be independent of scale and increasing in product quality (λ).

In addition to productivity, there is a second source of heterogeneity we denote "caliber" (ξ). Caliber indexes firms' ability to develop high quality products paying low fixed costs. Fixed costs are represented by the following function:

$$F(\lambda, \xi) = F_0 + \frac{f}{\xi} \lambda^{\alpha}, \qquad \alpha > (1-\beta)(\sigma - 1), \tag{4}$$

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

where F_0 is a fixed cost of plant operation and f is a constant.[9] Attaining higher quality requires paying higher fixed costs. Moreover, the condition that $\alpha > (1-\beta)(\sigma-1)$, imposed to ensure concavity, implies that fixed costs grow sufficiently fast with quality. Conditional on attaining a given quality level, the fixed costs are lower for high-caliber firms.[10]

2.1.2 Firm's optimal choice of price and quality

Firms choose price and quality to maximize post-entry profits, Π, which are the difference between operative profits, Π_0, and fixed costs. The first order condition with respect to price yields the standard constant mark-up result of CES demand: $p_d = \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\lambda_d^{\beta}$.[11] Using this result, the first order condition with respect to quality yields:

$$\lambda_d(\varphi,\xi) = \left[\frac{1-\beta}{\alpha}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\left(\frac{\varphi}{c}\right)^{\sigma-1}\frac{\xi}{f}\frac{E}{P}\right]^{\frac{1}{\alpha'}} \tag{5}$$

where $\alpha' \equiv \alpha-(1-\beta)(\sigma-1) > 0$. Both productivity ($\varphi$) and caliber ($\xi$) have a positive impact on quality choice since they reduce, respectively, marginal costs and fixed costs of quality production.

Using equation (5) to solve for the optimal price, we obtain

$$p_d(\varphi,\xi) = \left(\frac{\sigma}{\sigma-1}\right)^{\frac{\alpha-\beta-(\sigma-1)}{\alpha'}}\left(\frac{c}{\varphi}\right)^{\frac{\alpha-(\sigma-1)}{\alpha'}}\left[\frac{1-\beta}{\alpha}\frac{\xi}{f}\frac{E}{P}\right]^{\frac{\beta}{\alpha'}}. \tag{6}$$

Conditional on φ, high-ξ firms sell their products more expensively because they produce higher quality and hence have higher marginal costs. Instead, the effect of φ on price conditional on ξ is ambiguous. On the one hand, productivity lowers marginal costs and thus prices. On the other hand, it induces a higher quality choice, which in turn raises marginal costs and prices. Whether one or the other effect dominates depends on the sign of $\alpha-(\sigma-1)$. In equation (6), prices depend on the value of two parameters. Therefore, in contrast with the predictions of quality-based models with a single heterogeneous factor (Baldwin and Harrigan 2007, Johnson 2008, Kugler and Verhoogen 2008), prices here are not monotone functions of productivity and size.

[9] In Appendix 4, we derive c and f as a function of deeper parameters.

[10] This approach to modeling quality captures the trade-offs present in Yeaple (2005) and Bustos (2005), where the adoption of a superior technology reduces marginal costs but requires firms to incur a fixed cost. Under our demand assumptions, this type of investment would be isomorphic to one that shifts out the demand curve, but only in a world with no export quality constraints.

[11] Subindex d denotes "domestic" firms, those that only sell in the domestic market (all firms are d in this section).

2.1.3 The cut-off function

Substituting the solutions for quality and price into equation (2), we obtain firm revenue:

$$r_d(\varphi,\xi) = H\left(\frac{\varphi}{c}\right)^{\frac{\alpha(\sigma-1)}{\alpha'}}\left(\frac{\xi}{f}\right)^{\frac{\alpha-\alpha'}{\alpha'}}\left(\frac{E}{P}\right)^{\frac{\alpha}{\alpha'}}, \tag{7}$$

$H \equiv \left(\frac{\sigma-1}{\sigma}\right)^{\frac{(\alpha\sigma-\alpha')}{\alpha'}}\left(\frac{1-\beta}{\alpha}\right)^{\frac{\alpha-\alpha'}{\alpha'}}$, as an increasing function of productivity (φ) and caliber (ξ).

From standard results of CES demand we know that operative profits equal $\frac{r}{\sigma}$. Therefore, $\Pi_d = \frac{1}{\sigma}r_d - F_d$. Using equations (4), (5), and (7), firm profits can be expressed as

$$\Pi_d(\varphi,\xi) = J\left(\frac{\varphi}{c}\right)^{\frac{\alpha(\sigma-1)}{\alpha'}}\left(\frac{\xi}{f}\right)^{\frac{\alpha-\alpha'}{\alpha'}}\left(\frac{E}{P}\right)^{\frac{\alpha}{\alpha'}} - F_0 \tag{8}$$

where $J \equiv \left(\frac{\sigma-1}{\sigma}\right)^{\frac{\alpha\sigma}{\alpha'}}\left(\frac{1-\beta}{\alpha}\right)^{\frac{\alpha}{\alpha'}}\left(\frac{\alpha'}{\alpha-\alpha'}\right)$. Profits also are increasing in productivity and caliber.

Firms remain in the market only if they can make non-negative profits ($\Pi_d \geq 0$). Since profits depend on two variables, φ and ξ, this condition results in a survival cut-off *function*:

$$\underline{\xi}(\varphi) = f\left(\frac{F_0}{J}\right)^{\frac{\alpha'}{\alpha-\alpha'}}\left(\frac{\varphi}{c}\right)^{\frac{-\alpha}{1-\beta}}\left(\frac{E}{P}\right)^{\frac{-\alpha}{\alpha-\alpha'}}. \tag{9}$$

For each productivity level φ, there is a minimum caliber such that firms above this minimum earn non-negative profits. The cut-off function $\underline{\xi}(\varphi)$ is decreasing in φ, highlighting a trade-off for survival between φ and ξ: more (less) productive firms can afford to be of lower (higher) caliber. The function $\underline{\xi}(\varphi)$ is displayed in Figure 2. Each firm, characterized by a pair of draws (φ,ξ), can be represented in the figure by a single point. Firms above $\underline{\xi}(\varphi)$ survive while those below this curve exit the market.

A convenient way of summarizing information about firms' productivity and caliber is to define their "ability" η as (we include c and f in the definition of η only for notation compactness):

$$\eta(\varphi,\xi) \equiv \left[\left(\frac{\varphi}{c}\right)^{\frac{\alpha}{\alpha'}}\left(\frac{\xi}{f}\right)^{\frac{1-\beta}{\alpha'}}\right]^{\sigma-1}.$$

A property of the model is that both revenue and profits can be expressed as functions of η[12]

$$r_d(\eta) = \eta H\left(\frac{E}{P}\right)^{\frac{\alpha}{\alpha'}}, \qquad \Pi_d(\eta) = \eta J\left(\frac{E}{P}\right)^{\frac{\alpha}{\alpha'}} - F_0. \tag{10}$$

The main implication of this property is that η is a summary statistic for φ and ξ in both functions, which depend on these heterogeneous factors only through η. Thus firms with equal η, e.g. those

[12] This is also true for pure prices (see (2)). Firms with higher (lower) η charge lower (higher) pure prices.

along $\underline{\xi}(\varphi)$, obtain equal revenue and equal profits regardless of the particular combinations of φ and ξ. In Figure 2, this property implies that iso-ability curves are also iso-revenue curves and iso-profit curves. Due to this property, the model can be collapsed into a one-dimensional model iso-morphic to Melitz (2003). In particular, as in the latter model we can think of η as a single productivity draw that determines entry-exit decisions: firms survive *iff* η is above a cut-off value $\underline{\eta}$, determined such that $\Pi_d(\underline{\eta}) = 0$. This cut-off value satisfies $\underline{\eta} = \eta(\varphi, \underline{\xi}(\varphi))$.[13]

2.1.4 Free-entry and industry equilibrium

Before entering the industry, firms do not know their productivity or caliber. To learn them, they have to pay a fixed entry cost $f_e > 0$. Once they pay this cost, they draw φ and ξ from a bivariate probability distribution with density $v(\varphi, \xi) > 0$ on the support $[0, \overline{\varphi}] \times [0, \overline{\xi}]$. There is free entry into the industry. Firms pay f_e to learn their productivity and caliber only if the expected post-entry profits, $\overline{\Pi}$, are greater or equal than the entry cost. Since all firms are equal ex-ante, the free entry condition imposes:

$$\overline{\Pi}(P) = \int_0^{\overline{\varphi}} \int_{\underline{\xi}(\varphi,P)}^{\overline{\xi}} \Pi_d(\varphi, \xi, P)\, v(\varphi, \xi)\, d\xi d\varphi = f_e. \tag{11}$$

Equation (11) is the condition for industry equilibrium. Solving for P in a closed form would require assuming a particular shape of the bivariate distribution $v(\varphi, \xi)$. We prefer not to make such an assumption and keep the analysis general. In Appendix 1(i), we demonstrate that a solution for P in equation (11) exists and is unique.

Once P is determined, we can solve for the equilibrium prices, quality levels, revenues, profits, and cut-off values. The probability of surviving is given by $P_{in} = \int_0^{\overline{\varphi}} \int_{\underline{\xi}(\varphi,P)}^{\overline{\xi}} v(\varphi, \xi)\, d\xi d\varphi$. The productivity and caliber joint density function conditional on surviving is simply $h(\varphi, \xi) = \frac{1}{P_{in}} v(\varphi, \xi)$. P can be written as aggregating across productivity and (surviving) caliber levels rather than across firms. Making appropriate substitutions we obtain $P = \int_j p_j^{1-\sigma} \lambda_j^{\sigma-1} dj = M^{\frac{\alpha'}{\alpha}} H E^{\frac{\alpha-\alpha'}{\alpha}} (\widetilde{\eta})^{\frac{\alpha'}{\alpha}}$, where $\widetilde{\eta} \equiv \int_0^{\overline{\varphi}} \int_{\underline{\xi}(\varphi,P)}^{\overline{\xi}} \eta(\varphi, \xi) h(\varphi, \xi)\, d\xi d\varphi$ is the (weighted) average ability of surviving firms. Solving for

[13] This property stems from the fact that the two components of the profit function, $\Pi_0(\lambda)$ 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 operative profits, which implies that they are also proportional to revenue and post-entry profits.

M yields $M = HE^{\frac{\alpha'-\alpha}{\alpha'}} P^{\frac{\alpha}{\alpha'}} \widetilde{\eta}^{-1}$. Since the right-hand-side of this equation is increasing in P, in equilibrium tougher market competition is associated with a larger number of entrants.

2.2 The open economy with unconstrained export quality

To benchmark our full model, in this section we examine the open-economy equilibrium in a two-country world economy where export quality is unconstrained. Our analysis focuses on the equilibrium cross-sectional configuration of firm characteristics within a country rather than on differences across countries or the effects of trade liberalization. We find that, as in the closed economy, in this "unconstrained" open-economy case the model can also be collapsed into a model with only one source of heterogeneity à la Melitz (2003).

The industry has the same structure in the foreign country as in the home country. However, the foreign parameters F_0^*, c^*, f^*, f_e^*, and E^* are allowed to differ. The joint density function that generates the productivity and caliber draws is $v^*(\varphi, \xi) > 0$, defined on the support $[0, \overline{\varphi}] \times [0, \overline{\xi}]$. The (endogenously determined) price aggregator is P^*. We describe the equilibrium in the home country. The qualitative characteristics of the equilibrium in the foreign country are analogous.

In order to export, firms in the home and foreign countries need to pay fixed exporting costs, respectively f_x and f_x^*, and iceberg transport costs τ. Firms need to decide whether to become exporters or remain domestic. They choose to export if the marginal profits they would make in the foreign market outweigh the fixed exporting costs. Exporters face CES demand in both the domestic and the foreign markets and thus charge the same (factory gate) price at home and abroad. The maximization problem in this case is analogous to that in the previous section, except that here total demand ($q^w \equiv q + q^*$) is the sum of domestic and foreign demand, and is determined by $q^w = p^{-\sigma} \lambda^{\sigma-1} W$, where $W = \frac{E}{P} + \tau^{-\sigma} \frac{E^*}{P^*}$. Exporter's optimal quality, revenue, and profits are given by the following expressions:

$$\lambda_u(\varphi, \xi) = \left[\frac{1-\beta}{\alpha} \left(\frac{\sigma-1}{\sigma} \right)^{\sigma} \left(\frac{\varphi}{c} \right)^{\sigma-1} \frac{\xi}{f} W \right]^{\frac{1}{\alpha'}} \tag{12}$$

$$r_u(\eta) = \eta H W^{\frac{\alpha}{\alpha'}}, \qquad \Pi_u(\eta) = \eta J W^{\frac{\alpha}{\alpha'}} - F_0 - f_x. \tag{13}$$

Equations (12) and (13) are analogous to equations (5) and (10), which still determine quality, revenue and profits for firms that do not export. In particular, η is also a summary statistic for φ and ξ in the exporters' revenue and profit functions. Thus, iso-ability curves are also iso-revenue curves and iso-profit curves.

Define as $\Delta_u \Pi \equiv \Pi_u - \Pi_d$ the difference in profits between exporting and not exporting. Using (10) and (13), this difference can also be expressed as a function of η: $\Delta_u \Pi(\eta) = \eta J A - f_x$, where $A \equiv W^{\frac{\alpha}{\alpha'}} - \left(\frac{E}{P}\right)^{\frac{\alpha}{\alpha'}} > 0$. Firms choose to export if $\Delta_u \Pi(\eta) \geq 0$. Setting $\Delta_u \Pi(\eta) = 0$ and solving for η, we obtain an export cut-off value, $\underline{\eta}_u$, such that only firms with ability above this value export. This cut-off value also determines the export cut-off function

$$\underline{\xi}_u(\varphi) = \frac{f_x}{JA}^{\frac{\alpha'}{\alpha-\alpha'}} f \left(\frac{\varphi}{c}\right)^{-\frac{\alpha(\sigma-1)}{\alpha-\alpha'}}, \tag{14}$$

which satisfies $\underline{\eta}_u = \eta(\varphi, \underline{\xi}_u(\varphi))$. Since η is constant along $\underline{\xi}_u(\varphi)$, this cut-off function is also an iso-revenue curve and an iso-profit curve.

Figure 3 shows the equilibrium configuration of firms in the open economy with unconstrained export quality.[14] Firms with caliber below $\underline{\xi}(\varphi)$ ($\eta < \underline{\eta}$) exit the market. Firms with caliber between $\underline{\xi}(\varphi)$ and $\underline{\xi}_u(\varphi)$ ($\underline{\eta} \leq \eta < \underline{\eta}_u$) are active in the domestic market but do not export. Firms with caliber above $\underline{\xi}_u(\varphi)$ ($\eta \geq \underline{\eta}_u$) sell domestically and also export.

Since $r_d(\eta)$, $r_u(\eta)$, and $\Delta_u \Pi(\eta)$ are all monotone functions of η, firm size (revenue) is a perfect predictor of export status. In particular, all firms smaller than $r_d(\underline{\eta}_u)$ do not export while all firms larger than $r_u(\underline{\eta}_u)$ have positive foreign sales (no firm has sales between these two values). This stark prediction of the unconstrained model can be represented in a graph showing the fraction of exporters as a function of firm size. As Figure 4 shows, this fraction is a step function that jumps from 0 to 1. This prediction, also common to all single-attribute models of firm heterogeneity, implies that conditional on a given revenue level all firms have the same export status.

Finally, we note that quality decreases as we move down an iso-revenue curve. To see this, consider iso-revenue curve $\xi^k(\varphi)$, defined so that $r_u(\varphi, \xi^k(\varphi)) = k$. Solving for ξ and substituting into equation (12), we obtain $\lambda_u(\varphi, \xi^k(\varphi)) = B\left(\frac{\varphi}{c}\right)^{-\frac{\sigma-1}{\alpha-\alpha'}}$ (B is a function of constant parameters).

2.3 The open economy with constrained export quality

A substantial amount of evidence suggests that success in foreign markets is associated with firms' ability to attain high levels of product quality. Brooks (2006) finds that Colombian firms in sectors with lower quality gaps relative to G-7 countries tend to export a larger 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 (2008) find that Mexican firms

[14] We assume that $f_x > (F_0 A) / \frac{E}{P}^{\frac{\alpha}{\alpha'}}$ to ensure that $\underline{\xi}_u(\varphi) > \underline{\xi}(\varphi)$.

increase their average prices two years before they start exporting, which suggests a process of quality upgrading in preparation to export. Evidence of the existence of export quality requirements is also provided by studies in international management. Using firm-level surveys in developed and developing countries, these studies document firms' need to upgrade quality as a crucial requirement to access foreign markets.[15] Finally, 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, WTO 2005, Maskus et al. 2005).

The potential motives for the existence of export quality constraints are various. First, higher income countries tend to consume higher-quality goods (Hallak 2006, 2008) and therefore are likely to set higher minimum quality standards. Firms that ship their products to higher income countries should then find those standards more stringent. Second, transportation costs are proportionally higher for low-quality goods (Alchian and Allen 1964, Hummels and Skiba 2004). Therefore, below some minimum quality threshold they can be prohibitive. Third, export quality requirements might be related to management quality certification (e.g. ISO 9000) which, due to its quality-signaling, common-language, and conflict-setting properties, can alleviate the severe information asymmetry problems under which international transactions are often conducted (Guler et al. 2002, Hudson and Jones 2003, Terlaak and Kind 2006, Clougherty and Grajek 2008).

In our model, we capture the idea that entering the export market imposes more stringent quality constraints by simply assuming that firms need to attain a minimum quality level to gain access to the export market. We do not intend to uncover the particular source of these constraints in this paper. Rather, our aim is to assess their common implications for the exporting behavior of firms. Thus, we favor a modeling choice that, although very stylized, generates predictions that are robust to the various potential sources of export quality constraints.

2.3.1 Characterization of the equilibrium

We examine the open-economy equilibrium in a two-country world economy with minimum export quality requirements. Firms need to reach quality level $\underline{\lambda}$ to be able to export (the minimum is $\underline{\lambda}^*$ for foreign firms exporting to the home country). Except for the minimum export quality, the "constrained" environment maintains all features of the unconstrained one. We keep our focus on the cross-sectional configuration of firm characteristics within a country.

[15] See Weston 1995 (U.S.), Erel and Ghosh 1997 (Turkey), Mersha 1997 (Africa), Anderson et al. 1999 (Canada and U.S.), Corbett 2005 (9 mostly-developed countries).

The equilibrium is represented in Figure 5. We describe its main features here and leave its formal characterization to Appendix 2. As in the unconstrained equilibrium (see Figure 3), firms below $\underline{\xi}(\varphi)$ do not survive (region I) while firms between $\underline{\xi}(\varphi)$ and $\underline{\xi}_u(\varphi)$ are only active in the domestic market (region II). Similarly, firms with sufficiently high combinations of φ and ξ are (unconstrained) exporters (regions V.a and V.b). In the constrained equilibrium, however, there is a new set of firms that would otherwise export with quality $\lambda_u < \underline{\lambda}$ but now are forced to choose between upgrading their quality or not participating in the export market. Among those firms, some refrain from investing and remain domestic (region III) while others upgrade quality and export (region IV).

The curve $\underline{\xi}_u(\varphi)$ is no longer the export cut-off function. As firms' unconstrained choice of quality decreases along $\underline{\xi}_u(\varphi)$, quality is above the minimum requirement only on its left part – where it coincides with the new export cut-off function – but drops below the minimum once it reaches productivity $\varphi_{\underline{\lambda}}$. Similarly, firms' unconstrained quality choice is below the minimum for all firms in the shaded areas delimited by $\underline{\xi}_u(\varphi)$ and the isoquality curve for $\underline{\lambda}$, $\underline{\xi}_{\underline{\lambda}}(\varphi)$. Those firms would otherwise find it profitable to sell abroad but they are forced to upgrade quality if they wish to export in the presence of the export quality requirement.[16]

In case firms in that area decide to export, they invest just enough to reach quality $\underline{\lambda}$. Thus, their marginal cost is $\frac{c}{\varphi}\underline{\lambda}^{\beta}$ and their price is $p_c(\varphi) = \frac{\sigma}{\sigma-1}\frac{c}{\varphi}\underline{\lambda}^{\beta}$ (subindex c denotes "constrained" firms). Revenue and profits are, respectively,

$$r_c(\varphi) = \left(\frac{\sigma-1}{\sigma}\frac{\varphi}{c}\right)^{\sigma-1}\underline{\lambda}^{\alpha-\alpha\prime}W, \qquad \Pi_c(\varphi,\xi) = \frac{1}{\sigma}\left(\frac{\sigma-1}{\sigma}\frac{\varphi}{c}\right)^{\sigma-1}\underline{\lambda}^{\alpha-\alpha\prime}W - \frac{f}{\xi}\underline{\lambda}^{\alpha} - f_x - F_0 \quad (15)$$

Since ξ does not affect quality choice for constrained exporters, its value has no effect on marginal costs, prices, or revenues. However, it affects profits since attaining $\underline{\lambda}$ is less costly for firms with higher caliber. Define $\Delta\Pi_c \equiv \Pi_c(\varphi,\xi) - \Pi_d(\varphi,\xi)$. The export cut-off function $\underline{\xi}_x(\varphi)$ is now implicitly defined by $\Delta\Pi_c(\varphi,\underline{\xi}_x(\varphi)) = 0$. This function cannot be solved in closed form. However, in Appendix 2 we demonstrate that its slope is negative and it is located between $\underline{\xi}_u(\varphi)$ and $\underline{\xi}_{\underline{\lambda}}(\varphi)$. Firms in region III find that upgrading quality to satisfy the export requirement is too onerous. In contrast, firms located in region IV invest in quality upgrade to meet the export requirement. Those firms are the constrained exporters.

In the case of the foreign country the analysis is analogous. In Appendix 1(ii) we prove existence

[16] $\underline{\xi}_u(\varphi)$ can be thought of as the (hypothetical) export cut-off function for a single firm if the restriction were removed only for that firm (removing it for all firms simultaneously would change P and hence shift $\underline{\xi}_u(\varphi)$).

and uniqueness of the equilibrium in this world economy.[17]

2.3.2 Firm size and export status

The presence of the minimum export quality requirements breaks the sufficiency of η for predicting firm total revenue (firm size). It also breaks the sufficiency of revenue for predicting export status. In Figure 6, we add three representative iso-revenue curves, r_1, r_2, and r_3, to the equilibrium configuration of firms displayed in Figure 5. Curves r_1 and r_2 represent families of iso-revenue curves located, respectively, in region II and in the area below $\underline{r}_x$ in region III. As in the unconstrained case, along those curves the value of η is constant and all firms are domestic.

Iso-revenue curve r_3 requires more careful analysis. Its upper-left portion is located in region V. On this part of r_3, firms export and have identical η. Since quality decreases along the curve, at point A quality reaches the minimum level $\underline{\lambda}$. Then, r_3 goes straight down to point B, which is located on $\underline{\xi}_x(\varphi)$. Since φ is constant on this segment and all firms produce quality $\underline{\lambda}$, marginal costs, price, and revenues are also equal. At point B there is a discontinuity in r_3, which reappears further to the right — in region III — as shown in the figure. This last portion of the iso-revenue curve contains only domestic firms, which attain revenue level r_3 compensating their lack of exports with more voluminous sales in the domestic market (due to their higher η). The limit case of this set of iso-revenue curves is $\underline{r}_x$, the minimum possible revenue for an exporter.

In contrast to the predictions in the unconstrained case and of single-attribute models of firm heterogeneity, the family of iso-revenue curves represented by r_3 includes both exporters and non-exporters. Therefore, for revenue levels in this family the fraction of exporters is strictly between 0 and 1. This prediction is consistent with the evidence presented in Figure 1.[18] Revenue level (size) is not sufficient to predict export status.

2.3.3 Testable predictions

In addition to explaining the existence of exporters and non-exporters of the same size, the model also predicts systematic differences in quality and price. The following proposition establishes that, for firms on the same iso-revenue curve, exporters produce higher quality than non-exporters.

[17] Setting $\underline{\lambda} = \underline{\lambda}^* = 0$, the proof also demonstrates equilibrium existence and uniqueness for the unconstrained case.

[18] In general the fraction of exporters need not be monotonically increasing in revenue. Monotonicity, however, can be proved for a bivariate uniform distribution for $v(\varphi, \xi)$ (proof available upon request).

Proposition 1. *Conditional on size (total revenue), quality is higher for exporters than for domestic firms:*

$$\forall \overline{r},\ \lambda_x(\varphi_x, \xi_x)|_{r_x=\overline{r}} > \lambda_d(\varphi_d, \xi_d)|_{r_d=\overline{r}}, \qquad x = \{u, c\} \tag{16}$$

For $r < \underline{r}_x$, this proposition is vacuous since none of the firms exports.

Proof. See Appendix 3.

This result can be verified by visual inspection of Figure 6. Exporters are either firms located between points A and B, in which case they produce quality $\underline{\lambda}$, or firms located above A, in which case they produce quality above $\underline{\lambda}$. Instead, non-exporters are located to the right of C, and thus produce quality below $\underline{\lambda}$. Exporters are firms with relatively high caliber and low productivity while non-exporters are firms with low caliber but high productivity.

Since quality is unobservable, our empirical investigation relies on corollaries to proposition 1. Corollary 1 states that, holding size constant, exporters charge higher prices than non-exporters:

Corollary 1. *Conditional on size, exporters charge higher prices than domestic firms*

$$\forall \overline{r},\ p_x(\varphi_x, \xi_x)|_{r_x=\overline{r}} > p_d(\varphi_d, \xi_d)|_{r_d=\overline{r}}, \qquad x = \{u, c\} \tag{17}$$

Proof. With CES demand, $r_i = p_i q_i = p_i^{1-\sigma}\lambda_i^{\sigma-1}S_i$, where $S_i = \frac{E}{P}$ if $i = d$ and $S_i = W$ if $i = x = \{u, c\}$. Solving for p_i, we obtain $p_i = r_i^{\frac{1}{1-\sigma}}\lambda_i S_i^{\frac{1}{\sigma-1}}$. On the same iso-revenue curve, $r_x = r_d$. Then, since $W > \frac{E}{P}$ and $\lambda_x > \lambda_d$ (proposition 1), corollary 1 easily follows. *QED*

Proposition 1 is the basis of our empirical investigation. Corollary 1 is the main testable prediction. The predictions of conditional (on size) exporter premia we obtain here are novel. Models of firm heterogeneity with quality differentiation predict *unconditional* exporter premia for quality and price (Baldwin and Harrigan 2007, Johnson 2008, Verhoogen 2008, Kugler and Verhoogen 2008). However, those models do not predict exporter premia *holding size constant*, as they cannot account for variation in export status among firms of equal size in the first place.

So far we have assumed that fixed and variable production costs increase with quality, leaving the source of those costs unmodeled. An *a priori* appealing rationale is the presumption that producing higher quality goods requires more skilled-labor-intensive and more capital-intensive techniques. In that case, exporters, who produce higher quality than non-exporters – conditional on size – will also pay higher average wages and have a higher capital-to-labor ratio.[19] In Appendix 4, we provide

[19] Exporters will also pay higher average wages if quality production requires paying efficiency wages.

a background model of the deeper fundamentals that might drive a positive relationship between quality and fixed and variable costs using an approach that partially draws on Verhoogen (2008). That relationship, combined with proposition 1, delivers the following additional results:

Corollary 2. *Conditional on size, exporters pay higher average wages than non-exporters*

Proof. See Appendix 4.

Corollary 3. *Conditional on size, exporters are more capital intensive than non exporters*

Proof. See Appendix 4.

Finally, proposition 1 and corollaries 1, 2 and 3 can be weakened to be stated in expected values. We take these predictions to the data in this last form.[20]

3 Data

3.1 Data sources

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

For India, we use a cross-section of the Annual Survey of Industries (ASI), conducted by the Central Statistical Organization, for the year 1997-98. In addition to establishment-level information (classified by 4-digit NIC categories), this survey also includes more disaggregate information on output quantities and values at the product level, which allows us to construct product level prices (unit values). Also, it has information on whether plants have obtained ISO 9000 certification, which can be used as a direct proxy for quality. The ASI covers all registered industrial establishments (formal sector) employing more than 20 persons, divided into a "census" sector

[20] Another potentially testable prediction, which differs from those of single-attribute models of firm heterogeneity, is that trade liberalization should induce a reshuffling of size rankings in favor of firms with high caliber. Thus, firm size in the closed economy does not perfectly predict size or export status in the open economy. For example, consider an iso-revenue curve in Figure 6 that crosses regions III, IV, and V in autarky. Following trade liberalization, firms lying in regions IV and V of the curve would choose to export and hence expand, whereas those in region III would remain domestic. We leave the empirical analysis of this prediction for further research.

and a "sample" sector.[21] All factories in the census sector (employing more than 100 workers or located in designated backward areas) are surveyed. Factories in the sample sector are stratified and randomly sampled. Throughout our analysis, we appropriately adjust for sampling weights (called "multipliers").

For the US, we use data from the 1997 Census of Manufactures (CMF) collected by the US Census Bureau.[22] The CMF includes detailed information on establishment inputs and outputs classified at the 4-digit SIC level. Although it covers all manufacturing establishments that employ at least one paid worker, data for most small plants are collected from administrative records ("AR plants"). Because many variables for AR plants are imputed rather than directly collected, following the practice in the literature (e.g. Foster et al. 2008) we exclude them from our analysis. A distinctive feature of this paper with regard to CMF data is the use of seven-digit SIC product-specific information to derive product-level unit values (or prices).[23] One drawback of using unit values is that quantity data is unavailable for a large fraction of establishments and products. However, since our model's predictions relate to comparisons across establishments (firms) *within industries*, lack of information for entire products or industries should not bias our results.

We use manufacturing census for Chile and Colombia only to examine exporter premia in average wage and capital intensity as those datasets do not include product-level information. For Chile, we use the annual Chilean manufacturing census, which covers all manufacturing plants with more than 10 employees. We use data for the years 1991-96, the only period with available data on export activity. For Colombia, we use the Colombian manufacturing census for the years 1981 to 1991. The Colombian census also covers all plants with 10 or more employees. Both the Chilean and Colombian censuses classify establishments at the 4-digit ISIC level.[24]

3.2 Definition of variables and summary statistics

Testing the predictions of our theoretical model requires data on export status, revenue, potential proxies for quality, output price, average wage, and capital intensity (capital to labor ratio).[25]

Ideally, we would like to have a measure of quality that is directly consistent with λ in our

[21] The limit is lower (10 employees) for plants that use electric power for production.

[22] We also use the 1992 CMF for robustness checks.

[23] Foster et al. (2008) use unit values at the 7-digit level derived from the CMF for a small set of specific products.

[24] 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.

[25] In Section 5, as part of our robustness checks, we define and discuss a number of other variables.

model. While this ideal measure is unavailable, in the Indian dataset each plant reports if it has obtained ISO 9000 certification. We discuss in section 4.3 why the ISO 9000 quality management certification could be a good proxy for quality (λ).

All variables, except for price, 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, capital is measured as reported total fixed assets. The well-defined ownership links available in the U.S. dataset allows us to aggregate establishments into firms and thus perform robustness analysis defining variables at the firm level.

For India and the U.S., a product price is its unit value, computed as the ratio of output value to output quantity. While price information is available for each product line - so there are multiple price observations per establishment - data on export value are reported only at the establishment level. In our baseline analysis, we assume exporters export all their product lines. However, we also check robustness to alternative assumptions about which product lines are exported.

Panels 1, 2, 3 and 4 of Table 1 present summary statistics for establishments in "differentiated" sectors in our final samples for India, the U.S., Chile and Colombia, respectively. The fact that price data are not available for all establishments and product lines is evident from the lower number of product-level price observations than of establishment-level observations for other variables despite many establishments having multiple products.

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 is likely to overestimate the prevalence of exporting in the full sample. Subject to this caveat, for India exporters account for 26% of product-level price observations (1,681/6,494), 20% of establishment-level observations with average wage and capital intensity information, and 18% of establishment-level observations with information on ISO 9000 adoption. For the US, exporters account for 27% of price observations and 21% of wage and capital observations. The higher prevalence of exporting in the sample of product prices than in the sample of establishments is due to our assumption that an exporting establishment exports all product lines, coupled with the fact that larger firms, who are more likely to export, are also more likely to have multiple product lines. Finally, exporters account for 21% of establishment-year observations in Chile and 13% in Colombia.

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. When using price data, "industries" are product codes. Thus, means and standard deviations reported in Table 1 correspond to standardized variables.[26] The unconditional mean of (standardized) prices is higher for exporters than for non-exporters in both India (panel 1) and the U.S. (panel 2). Panel 1 also shows that ISO 9000 certification in India is much more common among exporters (17%) than among non-exporters (3%). Finally, in all four panels, the overall mean values for average wage and capital intensity are higher for exporters than for non-exporters.

4 Empirical analysis

This section tests the theoretical predictions of the model. In section 4.1 we describe our estimation strategy. In section 4.2 we test corollary 1, which is the model's main testable prediction. In section 4.3, we exploit information on ISO 9000 certification available for Indian establishments, using it as a proxy for quality to test proposition 1. In section 4.4, we test corollaries 2 and 3.

4.1 Estimation strategy

In equilibrium, price, quality, revenue, capital intensity, average wage, and export status are jointly determined as functions of the exogenous ability draws, φ and ξ. Proposition 1 and corollaries 1, 2, and 3 all impose restrictions on conditional expectations derived from that joint distribution.

Defining an indicator variable for export status, D, we can write the weak versions of proposition 1 and the corollaries as

$$E\left[Y\left|_{r,D=1}\right.\right] > E\left[Y\left|_{r,D=0}\right.\right], \quad \forall r, \qquad Y = \left\{\lambda, p, \frac{VK}{L}, w^L\right\}. \tag{18}$$

To test the above predictions, we assume that the conditional expectations take the linear separable form: $E\left[Y\left|_{r,D}\right.\right] = g_Y(r) + \delta_Y D$, where $g_Y(r)$ is a flexible control for size and δ_Y is the conditional exporter premium. Given this assumption, a realization of the dependent variable can be expressed as

$$y = g_Y(r) + \delta_Y D + u \tag{19}$$

[26] All our specifications using panel data from Chile and Colombia include industry/year fixed effects. Thus, since nominal variables (capital intensity and wage) enter regressions in logarithms, our results are invariant to deflating them using industry level deflators.

where u is a random component uncorrelated with the conditioning variables. In our case, u captures variation in the dependent variable across firms that have the same revenue and export status but different φ and ξ. We estimate (19) using a linear regression framework. It is worth noting that the coefficients in equation (19) *do not* capture causal relationships. In particular, the exporter premium δ_Y should be interpreted as the difference in the expected value of Y when we compare 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-products industries to estimate equation (19). 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 industry. Thus, the constant in the polynomial becomes an industry-specific fixed effect (note that "industries" are defined at the product-code level for testing corollary 1). Also, to flexibly capture non-linearities, we specify both a parametric (a third order polynomial) and a semi-parametric (industry-specific size decile fixed effects) form for $g_Y(r)$. In contrast to the coefficients of the size control function, we restrict the coefficient on the export dummy to be constant – but later relax this restriction by interacting the export dummy with various product characteristics. Second, we standardize both the dependent and the independent variables using industry-specific means and standard deviations to improve comparability across sectors. In particular, standardization prevents particular industries from driving the overall results.[27] Nevertheless, we also check robustness to using non-standardized variables.

4.2 Price results

Since quality is not directly observable, the model's main testable result is corollary 1, which predicts a positive conditional exporter premium for price ($\delta_p > 0$). In this section, we test this prediction using manufacturing data for differentiated products in India and the United States.

As explained in section 3.2, we measure price with unit values per product line. For multiproduct establishments, we include one price observation per line of differentiated product but maintain establishment revenues as our measure of size. Also, since information on exports is not disaggre-

[27] 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.

gated by product line, in our baseline analysis we assume that an establishment exports all of its product lines. To allow for arbitrary correlation between error terms for a given establishment, we cluster standard errors at the establishment level.

Table 2 presents the results of estimating equation (19) with price as the dependent variable. Each entry in the table displays the estimate of the exporter premium, δ_p, in the indicated specification. The first two columns mainly serve as benchmark. In column 1, we include only product-specific fixed effects and no controls for size while in column 2 we include a product-specific size polynomial of order 2. Columns 3 and 4 are our baseline (preferred) specifications. In column 3, we include a product-specific polynomial of order 3. In column 4, we include product-specific size-decile fixed effects. Panel 1 presents results for India; panel 2 presents results for the U.S.. In each panel, row 1 (row 2) displays results using standardized (non-standardized) variables.

The table shows a positive conditional exporter price premium 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 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 statistically significant in all specifications. In particular, the standardized price premium in the baseline specifications is 13.6% and 13.5%. These results confirm the main testable prediction of our model: exporters charge higher prices than non-exporters *conditional on size*.

We note that conditional exporter price premium regressions have been estimated in the literature (e.g. Fajnzylber and Fernandes 2006, Iaccovone and Javorcik 2008, Kugler and Verhoogen 2008) although lacking a theoretical framework under which the results could be properly interpreted. In fact, size summarizes all relevant information about a firm under single-attribute models. Thus, those models predict that once size is controlled for the exporter premium should be zero ($\delta_p = 0$). We interpret the positive conditional premia typically found by this literature as further empirical support for the predictions of our model.

Our baseline sample includes only differentiated products, which are those that most closely match the assumptions of the model. As a check that our theory applies primarily to differentiated products, we implement our empirical strategy also on non-differentiated products (homogeneous and reference-priced), where it is less obvious that the theory should apply. The results are presented in Table 3. The conditional exporter price premium is higher for differentiated goods in

both countries. In India, the premium is large and statistically significant for differentiated products, but insignificant (and negative) in the sample of homogenous products. In the U.S., even though there is still a price premium for homogeneous good exporters, the premium for exporters of differentiated goods is higher. These results justify our focus on differentiated products.

We perform several robustness checks. The results are available in Table A.1 of the appendix. First, we redefine the export dummy as equal to one only for those firms with export sales above 2% of total revenue. For India, the magnitude and significance of the export premium in the baseline specifications is slightly lower. For the U.S., magnitude and significance are mostly unchanged. Second, we retain only the largest product line for each establishment to check robustness to the possibility that establishments export their main line of products but not subsidiary product lines. For India, the export premium has the same magnitude and is statistically significant when we control for a cubic function of size (column 3). It is positive but not significantly different from zero when we control for size with size decile dummies. For the U.S. the results follow closely those of the baseline specification in all cases.

In a number of other (unreported) robustness checks, we found 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 US 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 our results could be spurious if firms charge higher mark-ups in the export market than in the domestic market. However, the available empirical evidence shows just the opposite. Das et al. (2007) use a structural model to estimate the ratio of foreign to domestic demand elasticities in three manufacturing industries in Colombia. They find demand elasticities in the foreign market to be almost twice as large as in the domestic market in two sectors, and no significant difference in the remaining 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).

4.3 ISO 9000 quality proxy results

Even 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 certification is correlated with direct measures of product quality (e.g. Brown et al. 1998, Withers and Ebrahimpour 2001). Second, consistent with our modeling assumption that upgrading quality is costly but shifts demand out, Guler et al. (2002) document that obtaining ISO 9000 involves a considerable monetary investment (about $125,000) and time effort (about nine months to two years), and impacts both local and international demand as a number of governments and private companies (particularly MNCs) require this certification from suppliers. There is also evidence that the certification helps improve measures of customer satisfaction (Buttle, 1997).[28]

Results from estimating equation (19) with ISO 9000 certification as the dependent variable are presented in Table 4. Since the dependent variable is a dummy, we do not use the standardized specification here. Also, the unit of observation here is the establishment since only at that level do we have information on ISO 9000 adoption. Accordingly, the size controls vary at the 4-digit industry level rather than at the product level. Consistent with the predictions of proposition 1, we find that exporters are much more likely to obtain ISO 9000 certification, conditional on size.

4.4 Wage and factor intensity results

In this section, we test corollaries 2 and 3 by examining conditional exporter premia 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 the previous section, the unit of observation is the establishment. For each dependent variable, the first row presents results using standardized variables while the second row presents results using non-standardized ones.

Table 5 shows that the conditional exporter premium for average wage is significantly positive for all countries in both 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.[29]

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

[29] Though wage rates better capture unobserved worker ability, we also analyzed the share of non-production workers in the total wage bill. This share is significantly higher for exporters in the U.S., Chile and Colombia but statistically

Next, we examine the empirical validity of Corollary 3. For India, Chile and Colombia, the results in rows 3 and 4 of Table 4 show a positive and significant conditional exporter premium in capital intensity 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.

The results for the U.S. are different. Conditional on size, capital intensity appears to be lower for exporters than for non-exporters. Given that this result is at odds with results previously reported in the literature using similar specifications (e.g. Bernard and Jensen 1999), we perform the same estimation using Census data for 1992 rather than 1997 (results are presented in Appendix Table A.3). We find an insignificant (almost zero) premium on capital intensity in the 1992 data. In contrast, the 1992 results for average wage and price are very 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.[30]

Note that these corollaries combine proposition 1 with ancillary assumptions about factor use of quality production. Thus, rejection of the corollaries need not imply rejecting proposition 1. Nevertheless, the evidence of this section as a whole supports both that proposition and the implications of our model for factor usage. Conditional on firm size, exporters hire more skilled workers (as reflected in higher average wages) and, except for the U.S., are more capital intensive.

5 Robustness to alternate models

In this section we evaluate the robustness of our results to alternate models. In section 5.1, we focus on single-attribute models of firm heterogeneity and address the possibility that the conditional exporter premia we find are merely driven by measurement error. In section 5.2, we address robustness against alternate multi-attribute models.

insignificant for India. Looking at the purely physical measure of non-production worker share of employment, we found a higher share for exporters in the U.S. and Colombia, but a statistically insignificant premium for India and Chile. These results are reported in Appendix Table A.2.

[30] One hypothesis could be that quality upgrading requires increasing the intensity of capital 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").

5.1 Robustness to single-attribute models

Our results show systematic differences between exporters and non-exporters *conditional on size*. In fact, empirical studies consistently find positive conditional (on size) exporter premia in price, average wages, and capital intensity.[31] As discussed in section 4.2, those results are at odds with the predictions of single-attribute models, which are in general – explicitly or implicitly – the theoretical framework underlying those studies. In any event, since firm size and export status are correlated variables, measurement error in the size control variable could lead to a spurious finding of a positive conditional exporter premium even when the true premium is zero. We address this concern in three ways.

First, we alternatively use employment as the measure of firm size. As Kugler and Verhoogen (2008) 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 alternative size control to test those models as the null hypothesis.[32] The estimated exporter premia are presented in panel A of Table 6. Rather than becoming smaller, as expected if due to measurement error, the estimated magnitudes increase.

Second, a source of error in the size measure could arise from the fact that we use *establishment* size rather than *firm* size in our analysis. This measure of size could be inappropriate 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 datasets – we aggregate establishments up to the firm level and re-estimate our baseline specification. Panel 1 of Appendix Table A.4 shows that the results are robust to the use of firm size as control. As an additional robustness check, in panel 2 we repeat the analysis using only single-establishment firms. The baseline results are robust to this check as well.

Third, we exploit the panel nature of the data for Chile and Colombia to control for transitional 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 data period – 1993-96

[31] Section 4.2 references empirical evidence on conditional exporter premia in price. For evidence on conditional premia in wages and capital intensity, see Bernard and Jensen (1999) and Bernard et al. (2007).

[32] Our model indicates that we should use revenue as size control. Thus, while using employment is appropriate to test single-attribute models as the null, under our framework as null it could yield biased estimates.

for Chile and 1988-91 for Colombia (we exclude firms that enter or exit export status during the period to avoid transitional dynamics). The results, presented in Appendix Table A.5, confirm the baseline results.

5.2 Robustness to alternate multi-attribute models

Our paper proposes a multi-attribute model in which firms are heterogeneous in productivity and caliber. In this section, we evaluate the relevance of this characterization of firms' heterogeneity to explain our results against alternate multi-attribute models. We follow two different but complementary strategies. In section 5.2.1, we analyze the extent to which other specific multi-attribute models, some explicitly proposed in the literature, can explain the facts we document here. In section 5.2.2, we identify industries where the economic mechanisms we emphasize are more likely to operate and evaluate whether the predictions of our model hold more strongly in those industries than in others.

5.2.1 Evaluation of specific alternate multi-attribute models

Several multi-attribute models have been proposed in the literature. Although in general built to explain other implications of firm heterogeneity, we can evaluate whether they can also account for our results. 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., Ruhl 2008, Eaton et al. 2008, Armenter and Koren 2009).[33] Under this framework, less productive exporters might be of equal size as more productive non-exporters if the former have lower export costs. In that case, the exporters' lower productivity would imply that they charge higher prices. While this model can explain conditional exporter price premia, it cannot explain why exporters pay higher wages, use capital more intensively, or are more likely to acquire ISO 9000 certification. Alternatively, combining Kugler and Verhoogen's (2008) framework (rather than Melitz') with heterogeneous trade costs yields the opposite predictions, in particular exporters charge lower prices than non-exporters, conditional on size. In either of these two cases, firms with equal productivity should have equal sales volume in the domestic market. Thus, controlling for domestic sales rather than total sales, we should not observe systematic differences between the prices domestic firms and exporters charge. In panel B of Table 6, we see that this is not the case: exporters charge higher prices even conditional on *domestic* sales.

[33] Heterogeneity in variable costs would work analogously.

A different class of models introduces variation in products' appeal across markets (e.g. Nguyen 2008, Demidova et al. 2008, Eaton et al. 2008, Bernard et al. 2009). While these models can naturally explain the facts documented in Figure 1, they cannot explain the existence of systematic conditional exporter premia, as documented here.

We could think of an alternative class of models in which firms are heterogeneous in their productivity and in their access to financial capital. While the predictions of such a model would largely depend on assumptions about how financial constraints affect firm size and export status, it is not *a priori* obvious that such a model would predict our facts. Nevertheless, we undertake a crude 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 (1996), we exclude products above the median for this measure and rerun the baseline price regressions. As the results in panel 1 of Appendix Table A.6 show, the exporter premium is positive and significant even in the industries that are less dependent on external finance.

Finally, in addition to productivity firms could be heterogeneous in their access to government officials. Then, large purely domestic firms could be those particularly able to secure government contracts. If less productive firms produce lower quality and sell at lower prices as in Kugler and Verhoogen (2008), heterogeneous access to government contracts might, in principle, explain our results. To address this concern, we construct 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 United States. Then, we run the baseline price regressions excluding products above the median for this measure. Panel 2 of Appendix Table A.6 shows that the exporter premium is positive and significant even in industries that are relatively less dependent on government purchases.

5.2.2 Channels: exploring sources of export quality constraints

A more general strategy for checking that our results are not driven by other multi-attribute models is to investigate whether they are stronger in industries where the economic mechanisms we emphasize are more likely to operate. In particular, since our model predicts conditional exporter premia only in the presence of export quality constraints, we assess the relative strength of the premia in industries more closely affected by the sources of the constraints hypothesized in section 2.3, i.e. income per capita, distance to destination, and informational asymmetries. We wish to stress that the data we use for this analysis is not ideal since, as we discuss below, we know

export destinations at the country level but not at the firm level. Thus, the analysis here should be construed as exploratory, more informative as a whole about the relevance of our model with export quality constraints than about the particular source of the constraints. Details of data construction and concordances are provided in the data appendix.

First, since export quality requirements could be related to the income per capita and distance to destination markets, we would expect firms exporting to rich and/or distant countries to have a higher quality, and hence price premium. Unfortunately, our data sets do not provide information on firms' exports by destination country. Thus, we test whether the exporter price premium is higher for products sent on average, at the country level, to richer or to more distant countries. To do that, we construct trade-weighted means of destination GDP per capita and destination distance for each Indian and U.S. 4-digit SITC category and then interact them, standardized, with the export dummy. Columns 1 to 4 of Table 7 display the results. In the case of India, the coefficients on both interactions are positive, as expected, but not statistically significant. For the U.S., the interaction terms are positive and significant for both GDP per capita and distance.

Export quality constraints could also arise to solve informational asymmetry problems. In this case, we would expect the export premium to be higher for more highly differentiated products, which tend to be more complex and more difficult to contract upon. We use estimates of elasticities of substitution from Broda and Weinstein (2006) as a measure of product differentiation. This measure, standardized, is interacted with the export dummy variable. The results are presented in columns 5 and 6 of Table 7. For India, consistent with this idea we find that the dummy interaction is negative, significantly so in the cubic specification. For the U.S., the interaction is negative but statistically insignificant.

Finally, columns 7 and 8 present results including all 3 interactions simultaneously. While in general the estimated coefficients on the interaction terms are not significant, in all cases their sign is consistent with the hypothesized source of the export quality constraint.

The evidence we present here suggests that all three hypotheses play some role as sources of export quality constraints. However, further research using firm-level data with export destinations is needed to pin down their relative importance.[34] We take the analysis here as exploratory. As a whole, the results are consistent with the mechanisms we emphasize and thus supportive of our characterization of firms' exporting behavior.

[34] The fact that it is not clear that one of these sources prevails over the others supports our choice of modeling the export quality constraint in a simplified yet general form.

6 Conclusion

In this paper, we present a model of international trade with two dimensions of firm heterogeneity: productivity and caliber. Quality choice is endogenous and a minimum threshold needs to be attained in order to export. The model predicts conditional exporter premia for quality, price, average wage and capital intensity, which we test using establishment-level data from India, the U.S., Chile and Colombia. We find strong support for the predictions of the model.

Our characterization of firms' exporting behavior has important implications beyond what we explore here. For example, while single-attribute models predict the largest firms to be the ones to 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. Thus, the export response to trade liberalization could be substantially lower than otherwise predicted. Similarly, the lack of a one-to-one relationship between firm size and export status implies different intensive-margin versus extensive-margin export responses to changes in trade costs (e.g. Arkolakis 2008, Chaney 2008, Ruhl 2008) as export volumes of new entrants in the export market might largely exceed those that cover the fixed export costs. More generally, we hope our model can be used as an alternative benchmark to evaluate, for example, the effects of exchange rate fluctuations, international price movements, or trade liberalization.

References

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

[2] 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.

[3] Arkolakis, C., 2008. Market Penetration Costs and the New Consumers Margin in International Trade. NBER WP 14214.

[4] Armenter, R. and M. Koren, 2009. Economies of Scale and the Size of Exporters. Mimeo.

[5] 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.

[6] Baldwin, R. and J. Harrigan, 2007. Zeros, Quality and Space: Trade Theory and Trade Evidence. NBER Working Paper 13214.

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

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

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

[10] Bernard A., S. Redding., and P. Schott. 2009. Multi-product firms and trade liberalization. Mimeo.

[11] Boston Consulting Group, 2008. The BCG 50 Local Dynamos. How Dynamic RDE-Based Companies Are Mastering Their Home Markets –and What MNCs Need to Learn from Them.

[12] Broda, C., and D. Weinstein, 2006. Globalization and the Gains from Variety. *Quarterly Journal of Economics*, 121(2), 541-585.

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

[14] 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.

[15] Bustos, P., 2005. The Impact of Trade on Technology and Skill Upgrading: Evidence from Argentina. Mimeo.

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

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

[18] Clerides, S., S. Lach, and J. Tybout, 1998. Is Learning by Exporting Important? Micro-Dynamic Evidence from Colombia, Mexico and Morocco. *Quarterly Journal of Economics*, 113(3): 903-947.

[19] Clougherty, J. and M. Grajek, 2008. The Impact of ISO 9000 Diffusion on Trade and FDI: A New Institutional Analysis. CEPR DP 6026.

[20] Corbett, C., 2005. Global Diffusion of ISO 9000 Certification through Supply Chains. Mimeo.

[21] Crozet, M., K. Head and T. Mayer, 2008. Quality Sorting and Trade: Firm-level Evidence for French Wine. Mimeo.

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

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

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

[25] Fajnzylber, P. and A. Fernandes, 2006. International Economic Activities and Skilled Labor Demand: Evidence from Brazil and China. Mimeo.

[26] Foster, L., J. Haltiwanger and C. Syverson, 2007. Reallocation, Firm Turnover and Efficiency: Selection on Productivity or Profitability? *American Economic Review*, 98(1): 394-425.

[27] Gosen, J., S. Babbar and S. Prasad, 2005. Quality and developing countries: the role of international and organizational factors. *International Journal of Quality & Reliability Management*, 22(5): 452-464.

[28] 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.

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

[30] Hallak, J.C., 2008. A Product-Quality View of the Linder Hypothesis. *The Review of Economics and Statistics*, forthcoming.

[31] Hallak, J.C. and P. Schott, 2008. Estimating Cross-Country Differences in Product Quality. NBER WP 13807.

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

[33] 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.

[34] Iacovone, L. and B. Javorcik, 2008. Shipping Good Tequila Out: Investment, Domestic Unit Values and Entry of Multi-product Plants into Export Markets. Mimeo.

[35] International Trade Center UNCTAD/WTO, 2005. *Innovations in Export Strategy: A strategic approach to the quality assurance challenge*. Geneva: ITC.

[36] Johnson, R., 2008. Trade and Prices with Heterogeneous Firms. Mimeo.

[37] Kugler, M. and E. Verhoogen, 2008. Product Quality at the Plant Level: Plant Size, Exports, Output Prices and Input Prices in Colombia. NBER WP 14418.

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

[39] 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.

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

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

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

[43] Nguyen, D., 2008. Learning Demands and Trade Failures. Mimeo.

[44] Oviatt, B. and P. Mc Dougall, 1994. Toward a theory of international new ventures. *Journal of International Business Studies* , 25(1): 45-64.

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

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

[47] Rauch, J., 2007. Development Through Synergistic Reform. NBER WP 13170.

[48] Rialp, A., Rialp, J. and G. Knight, 2005. The phenomenon of early internationalizing firms: what do we know after a decade (1993-20003) of scientific inquiry? *International Business Review*, 14: 147-166.

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

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

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

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

[53] Terlak, 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.

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

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

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

[57] World Bank, 1987. *World Development Report 1987: Barriers to Adjustment and Growth in the World Economy. Industrialization and Foreign Trade*. New York: Oxford University Press.

[58] World Bank, 1993. *The East Asian Miracle*. New York: Oxford University Press.

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

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

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

Appendix 1: Equilibrium existence and uniqueness in the closed and open economies

i. Existence and uniqueness in the closed economy. Since $\Pi_d(\varphi, \xi, P)$ and $\underline{\xi}(\varphi, P)$ are continuous and differentiable in P, $\overline{\Pi}(P)$ is also continuous and differentiable in P. Because $\overline{\Pi}(P)$ is continuous, to demonstrate existence we only need to show that it takes the value f_e at least once. Substituting equations (8) and (9) into (11) it is easy to see that $\lim_{P\to 0}\overline{\Pi}(P) = \infty$ and $\lim_{P\to\infty}\overline{\Pi}(P) = 0$. This implies that there exists at least one value of P such that $\overline{\Pi}(P) = f_e$.

Since $\forall(\varphi, \xi)$, $\frac{d\Pi_d(\varphi,\xi,P)}{dP} < 0$, application of Leibniz's rule implies that $\frac{d\overline{\Pi}(P)}{dP} < 0$, i.e. $\overline{\Pi}(P)$ is a strictly decreasing function of P. Therefore, $\overline{\Pi}(P)$ takes the value f_e only once. *QED*

ii. Existence and uniqueness in the open economy. To save notation, rename $\varphi = \widetilde{\varphi}/c$ and $\xi = \widetilde{\xi}/f$, letting $\widetilde{\varphi}$ and $\widetilde{\xi}$ denote the original productivity and caliber draws. Hence, φ and ξ combine technology and input cost and can be interpreted as "cost-adjusted productivity and caliber".

Ex-ante expected profits are given by

$$\overline{\Pi}(P, P^*) = \int_0^{\overline{\varphi}}\int_0^{\overline{\xi}} \Pi(\varphi, \xi, P, P^*)\, v(\varphi, \xi)\, d\xi d\varphi, \qquad P > 0, P^* > 0,$$

$$\Pi(\varphi, \xi, P, P^*) = \begin{cases} 0 & \text{if } (\varphi, \xi) \in r(I) \\ \Pi_d(\varphi, \xi, P) & \text{if } (\varphi, \xi) \in \{r(II), r(III)\} \\ \Pi_c(\varphi, \xi, P, P^*) & \text{if } (\varphi, \xi) \in r(IV) \\ \Pi_u(\varphi, \xi, P, P^*) & \text{if } (\varphi, \xi) \in \{r(V.a), r(V.b)\} \end{cases}$$

where $r(X)$ denotes region $X = \{I, II, III, IV, Va, Vb\}$ as depicted in Figure 5 and Π_d, Π_u, and Π_c are respectively given by equations (8), (13), and (15). At the regions borders firms are indifferent, so $\Pi(\varphi, \xi, P, P^*)$ does not jump. Thus, this function is continuous in (φ, ξ), though not differentiable at the limits of integration – of measure zero in R^2. The functions Π_d, Π_u, and Π_c are continuous and differentiable in P and P^*, as are also the limits of integration for each region. Therefore, the continuity and differentiability of the function $\overline{\Pi}(P, P^*)$ in P and P^* follows directly.

Since $\Pi(\varphi, \xi, P, P^*)$ is continuous in (φ, ξ), by application of Leibniz rule we can find the derivatives of $\overline{\Pi}(P, P^*)$ with respect to P and P^*. Since $\forall(P, P^*, \varphi, \xi) : \frac{\partial \Pi_i}{\partial P} < 0$, $i = d, u, c$, $\frac{\partial \Pi_i}{\partial P^*} < 0$, $i = u, c$, $\frac{\partial \Pi_d(\varphi,\xi,P,P^*)}{\partial P^*} = 0$, and the derivatives of the limits of integration cancel out, we can establish that $\forall(P, P^*) : \frac{\partial \overline{\Pi}(P,P^*)}{\partial P} < 0$ and $\frac{\partial \overline{\Pi}(P,P^*)}{\partial P^*} < 0$. Analogously, $\forall(P, P^*) : \frac{\partial \overline{\Pi}^*(P,P^*)}{\partial P} < 0$ and $\frac{\partial \overline{\Pi}^*(P,P^*)}{\partial P^*} < 0$ in the foreign country.

Free-entry in each country implies the following system of equations:

$$\overline{\Pi}(P, P^*) = f_e \tag{20}$$

$$\overline{\Pi}^*(P, P^*) = f_e^* \tag{21}$$

We want to show that an equilibrium pair (P, P^*) exists and is unique. First, we make the following assumption:

Assumption 1:

a.) $\lim_{P\to\infty} \overline{\Pi}(P, P^*) < \lim_{P\to\infty} \overline{\Pi}^*(P, P^*)$

b.) $\lim_{P^*\to\infty} \overline{\Pi}(P, P^*) > \lim_{P^*\to\infty} \overline{\Pi}^*(P, P^*)$

The two inequalities are analogous. When $P \to \infty$ there are no profits to be made in the Home market so firms only operate in the Foreign market. Then, the first inequality simply states that Foreign firms' expected profits in the Foreign market – for any P^* – are higher than Home firms' expected profits in that market. Analogously, the second inequality states that Home firms' expected profits in the Home market are higher than Foreign firms' expected profits there.

Proposition 2. *: Under Assumption 1, there exists a unique pair (P, P^*) that solves the system of equations (20) and (21).*

Since $\overline{\Pi}(P, P^*)$ is strictly decreasing in P^*, for any given P the value of P^* that solves equation (20) is unique and implicitly defines a function $P^* = P^{*^H}(P)$. Similarly, since $\overline{\Pi}(P, P^*)$ is strictly decreasing in P, we can obtain the inverse function $P = P^H(P^*)$. Using the Implicit Function Theorem and previous results, we establish that this function is downward sloping: $\frac{dP^*}{dP}\big|_H = -\frac{\partial\overline{\Pi}(P,P^*)/\partial P}{\partial\overline{\Pi}(P,P^*)/\partial P^*} < 0$. Analogously, equation (21) defines $P^* = P^{*^F}(P)$ and $P = P^F(P^*)$ with slope $\frac{dP^*}{dP}\big|_F = -\frac{\partial\overline{\Pi}^*(P,P^*)/\partial P}{\partial\overline{\Pi}^*(P,P^*)/\partial P^*} < 0$.

The existence proof is represented in Figure A.2. Assumption 1.a implies that $f_e = \lim_{P\to\infty} \overline{\Pi}\left(P, P^{*^H}(P)\right) < \lim_{P\to\infty} \overline{\Pi}^*\left(P, P^{*^H}(P)\right)$. Since $\overline{\Pi}^*(P, P^*)$ is decreasing in P^*, this inequality also implies that

$$\lim_{P\to\infty} P^{*^H}(P) < \lim_{P\to\infty} P^{*^F}(P). \tag{22}$$

Analogously, assumption 1.b implies that $f_e^* = \lim_{P^*\to\infty} \overline{\Pi}^*\left(P^F(P^*), P^*\right) < \lim_{P^*\to\infty} \overline{\Pi}\left(P^F(P^*), P^*\right)$. Together with the fact that $\overline{\Pi}(P, P^*)$ is decreasing in P, this inequality implies that

$$\lim_{P^*\to\infty} P^F(P^*) < \lim_{P^*\to\infty} P^H(P^*). \tag{23}$$

Since both $P^{*^H}(P)$ and $P^{*^F}(P)$ are decreasing, (22) and (23) imply that these two curves must cross at least once. Thus, an equilibrium exists.

To show uniqueness we only need to demonstrate that the two curves satisfy the *single crossing* property: $\left| \frac{dP^*}{dP}\big|_H \right| > \left| \frac{dP^*}{dP}\big|_F \right|$. These derivatives are given by the following expressions:

$$\left| \frac{dP^*}{dP}\big|_H \right| = \frac{A + \frac{E}{P^2}B}{\tau^{-\sigma}\frac{E^*}{P^{*2}}B}, \qquad \left| \frac{dP^*}{dP}\big|_F \right| = \frac{\tau^{-\sigma}\frac{E}{P^2}D}{C + \frac{E^*}{P^{*2}}D}$$

where the terms $A > 0, B > 0, C > 0$, and $D > 0$ are not displayed to conserve space. Using simple algebra, is can be shown that the single property holds $\forall(P, P^*)$. Thus, there is a unique equilibrium. *QED*

Appendix 2: Formal characterization of the constrained equilibrium

The distinctive feature of the constrained equilibrium is the appearance of firms, in regions III and IV, that face a binding export quality constraint.

The curve $\underline{\xi}_u(\varphi)$ is the solution to $\Delta_u\Pi(\varphi, \underline{\xi}_u(\varphi)) = 0$. Along this curve, firms' unconstrained choice of quality is monotonically decreasing in φ (see equation for λ_u in section 2.2). Thus, there is a value ($\varphi_{\underline{\lambda}}$) at which this choice is exactly $\underline{\lambda}$.[35] From equations (12) and (13), we can easily verify that both λ_u and $\Delta_u\Pi$ are increasing in ξ – conditional on φ. Hence, $\lambda_u > \underline{\lambda}$ and $\Delta_u\Pi > 0$ for firms in region V.a. Since the export constraint does not bind for those firms, their export choice is determined by the sign of $\Delta_u\Pi$. Thus, they prefer to export.

Equating (12) to $\underline{\lambda}$, we obtain the expression for iso-quality curve $\underline{\xi}_{\underline{\lambda}}(\varphi)$ to the right of $\varphi_{\underline{\lambda}}$:[36]

$$\underline{\xi}_{\underline{\lambda}}(\varphi) = \underline{\lambda}^{\alpha'} f \frac{\alpha}{1-\beta}\left(\frac{\sigma-1}{\sigma}\right)^{-\sigma}\left(\frac{\varphi}{c}\right)^{-(\sigma-1)} W^{-1}. \tag{24}$$

This curve is also monotonically decreasing in φ. Comparing (24) with (14), we can check that the two curves intersect at $\varphi_{\underline{\lambda}}$ and $\forall\varphi > \varphi_{\underline{\lambda}} : \underline{\xi}_{\underline{\lambda}}(\varphi) > \underline{\xi}_u(\varphi)$. Firms located above $\underline{\xi}_{\underline{\lambda}}(\varphi)$ spontaneously satisfy the export quality requirement, so their export decisions are also governed by the sign of $\Delta_u\Pi$. Thus, firms in region V.b, where $\xi \geq \underline{\xi}_{\underline{\lambda}}(\varphi) > \underline{\xi}_u(\varphi)$, also prefer to export.

Firms located between $\underline{\xi}_u(\varphi)$ and $\underline{\xi}_{\underline{\lambda}}(\varphi)$ are forced to upgrade quality if they wish to export. Those that do it just attain quality $\underline{\lambda}$. In section 2.3 we provide the expressions for marginal costs, price, revenue and profits for those constrained firms. We also define $\Delta\Pi_c \equiv \Pi_c(\varphi, \xi) - \Pi_d(\varphi, \xi)$, which is given by:

$$\Delta\Pi_c(\varphi, \xi) \equiv \frac{1}{\sigma}\left(\frac{\sigma-1}{\sigma}\frac{\varphi}{c}\right)^{\sigma-1}\underline{\lambda}^{\alpha-\alpha'}W - \frac{f}{\xi}\underline{\lambda}^{\alpha} - f_x - J\left(\frac{\varphi}{c}\right)^{\frac{\alpha(\sigma-1)}{\alpha'}}\left(\frac{\xi}{f}\right)^{\frac{\alpha-\alpha'}{\alpha'}}\left(\frac{E}{P}\right)^{\frac{\alpha}{\alpha'}}.$$

[35] The expression for $\varphi_{\underline{\lambda}}$ can be obtained using equations (12) and (14) to solve for φ in $\lambda_u(\varphi, \underline{\xi}_u(\varphi)) = \underline{\lambda}$.

[36] The iso-quality curve is discontinuous at $\varphi_{\underline{\lambda}}$. Its expression to the left of $\varphi_{\underline{\lambda}}$ is identical but for $\frac{E}{P}$ replacing W.

The export cut-off function $\underline{\xi}_x(\varphi)$ is implicitly defined by $\Delta\Pi_c(\varphi, \underline{\xi}_x(\varphi)) = 0$. Since $\Delta\Pi_c(\varphi, \xi)$ is continuous and strictly increasing in its two arguments, by application of the implicit function theorem, $\underline{\xi}_x(\varphi)$ is continuous and decreasing in φ. Its location is shown in the following lemma:

Lemma A.1. The export cut-off function $\underline{\xi}_x(\varphi)$ is flanked by $\underline{\xi}_u(\varphi)$ and $\underline{\xi}_{\underline{\lambda}}(\varphi)$:

$$\forall \varphi > \varphi_{\underline{\lambda}} : \underline{\xi}_{\underline{\lambda}}(\varphi) > \underline{\xi}_x(\varphi) > \underline{\xi}_u(\varphi)$$

Proof. As constrained firms are forced to deviate from their optimal (unconstrained) choice of quality, $\Pi_c(\varphi, \xi) \leq \Pi_u(\varphi, \xi)$. This implies that $\Delta\Pi_c(\varphi, \underline{\xi}_u(\varphi)) < \Delta\Pi_u(\varphi, \underline{\xi}_u(\varphi)) = 0$. Thus, firms located on $\underline{\xi}_u(\varphi)$ strictly prefer not to export. On the other hand, since the export restriction is (just) not binding for firms located on $\underline{\xi}_{\underline{\lambda}}(\varphi)$, $\Delta\Pi_c(\varphi, \underline{\xi}_{\underline{\lambda}}(\varphi)) = \Delta\Pi_u(\varphi, \underline{\xi}_{\underline{\lambda}}(\varphi)) > 0$. Therefore, firms located along $\underline{\xi}_{\underline{\lambda}}(\varphi)$ strictly prefer to export.

These two results, the continuity of $\Delta\Pi_c(\varphi, \xi)$, and the fact that this function is strictly increasing in ξ then imply that $\forall \varphi > \varphi_{\underline{\lambda}} : \underline{\xi}_u(\varphi) < \underline{\xi}_x(\varphi) < \underline{\xi}_{\underline{\lambda}}(\varphi)$. *QED*

Appendix 3: Proof of Proposition 1

Consider an iso-revenue curve with at least an exporter and a non-exporter. For simplicity, assume a sufficiently high upper bound on the caliber support ($\overline{\xi}$) so that there is an unconstrained exporter on the curve whenever there is an exporter. Since both firms are on the same iso-revenue curve $r_d(\eta_d) = r_u(\eta_u)$.

Exporters need to satisfy the export quality constraint; therefore $\lambda_u > \underline{\lambda}$. Comparing equations (10) and (13), $W > E/P$ and $r_d(\eta_d) = r_u(\eta_u)$ imply that $\eta_d > \eta_u$. Since exporting is a choice, $\Delta_u\Pi(\eta_u) \geq 0$. The function $\Delta_u\Pi$ is increasing in η. Thus, $\eta_d > \eta_u$ implies that $\Delta_u\Pi(\eta_d) > 0$. This last inequality means that the non-exporter would make positive marginal profits in the export market if unconstrained in his choice of quality, i.e. the reason for not exporting is that he does not attain $\underline{\lambda}$. Hence, $\lambda_d < \underline{\lambda}$. *QED*

Appendix 4: Factor input requirements of quality production

Production requires the use of two primary factors, labor and capital. There are H_L types of labor, indexed by $h = 1, ...H$, which earn market-determined wages w_h^L. There are also H_K types of capital, indexed by $h = 1, ..., H_K$, and V vintages of each type of capital, indexed by

$v = 0, ..., V-1$. A unit of capital of vintage v lasts $v+1$ remaining periods. All vintages of the same type of capital are perfect substitutes and equally productive. Therefore, they earn identical market-determined rental rate w_h^K. The price of a unit of capital of type h and vintage v is p_{hv} and equals the discounted future sum of rental rates: $p_{hv} = \sum_{t=0}^{v} \frac{w_{ht}^K}{\rho_t}$, where $\rho_t = \Pi_{t'=0}^{t}(1+\rho_{t'})$ and $\rho_{t'}$ is the one period interest rate.

Denote by L_h the units of labor of type h, by $K_h = \sum_{v=0}^{V-1} K_{hv}$ the units of capital of type h hired by the firm, and define $L = \sum_h L_h$ and $K = \sum_h K_h$. Then, the average wage the firm pays is $w^L = \frac{\sum_h w_h^L L_h}{L}$ and the average rental is $w^K = \frac{\sum_h w_h^K K_h}{K}$. Wages and rental rate gaps across types of factor inputs can be thought to reflect differences in relative productivity in an unmodeled "numeraire" industry. In the case of labor, relative productivity is assumed to depend on skills.

To produce quality λ, a firm needs to pay average wage $w^L = \underline{w}^L \lambda^{b_L}$ and average rental rate $w^K = \underline{w}^K \lambda^{b_K}$, $b_L > 0$, $b_K > 0$, where $\underline{w}^L$ and $\underline{w}^K$ are the least expensive types of labor and capital, respectively. This requirement applies to factor inputs associated both with fixed and with variable costs. Thus, producing higher quality requires hiring more skilled and higher-paid workers and more expensive types of capital.

The quantity of output only depends on the quantity of inputs used in production, not on their type. Output is produced using a constant returns to scale Cobb-Douglas production function: $Y = \varphi L^{\alpha_L} K^{\alpha_K}$, where $\alpha_L + \alpha_K = 1$. Combining this production function with the requirements of input quality described above yields the unit cost function postulated in equation (3):

$$c(\lambda, \varphi) = \frac{A}{\varphi} \left(w^L\right)^{\alpha_L} \left(w^K\right)^{\alpha_K} = \frac{c}{\varphi} \lambda^{\beta}$$

where $A = \frac{1}{\alpha_L^{\alpha_L} \alpha_K^{\alpha_K}}$, $c = A \left(\underline{w}^L\right)^{\alpha_L} \left(\underline{w}^K\right)^{\alpha_K}$, and $\beta = \alpha_L b_L + \alpha_K b_K$.

Analogously, we assume that the fixed cost part of quality production requires labor and capital combined in a Cobb-Douglas production function with the same exponents: $\lambda = \left(\xi L'^{\alpha_L} K'^{\alpha_K}\right)^{1/\kappa}$. These costs can be thought of as expenses related to the implementation of quality control systems, worker training, or product development.[37] In addition, the firm incurs other fixed costs F_0 (such as annual maintenance expenses or headquarter expenses) unrelated to quality. Accordingly, fixed costs, conditional on quality λ, are as defined in equation (4):

$$F(\lambda, \xi) = \frac{A}{\xi} \left(w^L\right)^{\alpha_L} \left(w^K\right)^{\alpha_K} \lambda^{\kappa} + F_0 = \frac{f}{\xi} \lambda^{\alpha} + F_0$$

[37] In this static framework, sunk and fixed costs are equivalent. In a dynamic setting, sunk costs could still be considered fixed costs by converting them into an equivalent stream of per-period fixed costs.

where $f = A\left(\underline{w}^L\right)^{\alpha_L}\left(\underline{w}^K\right)^{\alpha_K}$ and $\alpha = \kappa + \alpha_L b_L + \alpha_K b_K$.[38] These assumptions, together with the results of proposition 1, yield Corollaries 2 and 3.

Proof of Corollary 2. The assumption that average wages are monotonically increasing in quality, combined with proposition 1, implies that

$$\forall \overline{r},\ w^L(\lambda_x(\varphi_x, \xi_x))|_{r_x=\overline{r}} > w^L(\lambda_d(\varphi_d, \xi_d))|_{r_d=\overline{r}}. \qquad QED$$

Firm-level statistics do not report firms' capital as a simple count of "machine units". Instead, capital in the plant is aggregated using their relative prices. Thus, rather than K we observe $VK = \sum_{h=1}^{H}\sum_{v=1}^{V} p_{hv}K_{hv}$.

Proof of Corollary 3. To demonstrate corollary 3, we first substitute the pricing equation for capital goods into the definition of VK to obtain $VK = \sum_{h=1}^{H}\sum_{v=1}^{V}\sum_{t=0}^{v}\frac{w_{ht}^K K_{hv}}{\rho_t}$. We assume that relative prices of different types of capital do not change over time: $\forall h,\ w_{ht}^K = \upsilon_t w_h^K$. We also assume that, although firms' composition of capital across types of capital goods differs, it does not differ across vintages within types, i.e., $\forall h,\ K_{hv} = a_v K_h, \quad K_h = \sum_{v=1}^{V} K_{hv}$. Thus we can write:

$$VK = \sum_{h=1}^{H}\sum_{v=1}^{V}\sum_{t=0}^{v}\frac{\upsilon_t w_h^K a_v K_h}{\rho_t} = \gamma\sum_{h=1}^{H} w_h^K K_h = \gamma w^K K$$

where $\gamma = \sum_{v=1}^{V}\sum_{t=0}^{v}\frac{\upsilon_t a_v}{\rho_t}$. Variable costs are Cobb-Douglas, so cost shares are constant. Thus, $\frac{w^K K}{\alpha_K} = \frac{w^L L}{\alpha_L}$, which implies that

$$\frac{VK}{L} = \gamma\frac{w^K K}{L} = \gamma\frac{\alpha_K}{\alpha_L}w^L = \gamma\frac{\alpha_K}{\alpha_L}\underline{w}^L\lambda^{b_L}. \tag{25}$$

Since fixed costs are also Cobb-Douglas with identical coefficients, equation (25) applies to those costs as well. Thus, it also characterizes the capital intensity of the plant, i.e. including capital and labor associated with both fixed and variable costs.

It is easy to check that $\dfrac{d\left(\frac{VK}{L}\right)}{d\lambda} > 0$ if $b_L > 0$. This result, combined with proposition 1, immediately implies corollary 3.[39] *QED*

[38] Note that $\alpha = \kappa + \beta$. The assumption that $\alpha > (1-\beta)(\sigma - 1)$ then implies that $\kappa > \sigma(1-\beta) - 1$.

[39] Note that $b_L > 0$ implies that $\beta > 0$. Hence, while Proposition 1 and Corollary 1 hold even if quality does not drive up marginal costs ($\beta = 0$), this assumption is needed for quality to imply higher wages and capital intensity.

Data Appendix

The Indian Manufacturing Survey dataset (ASI 1997-1998) uses the National Industrial Classification (NIC) 1987 revision. Each establishment is classified under a 4-digit NIC code. Thus, establishment-level information, e.g. export status, wagebill, employment, and capital, is provided at this level of aggregation. Product-level information for deriving unit values (shipment value and quantity) is provided at the (5-digit) "item code" level. Unfortunately, item codes do not aggregate up consistently to the 4-digit NIC classification. We define "industries" at the 4-digit level and "products" at the 5-digit item code level. After data cleaning – explained below – we are left with 323 4-digit NIC codes and 976 item codes. Establishments in the U.S. Census of Manufactures database (CMF 1997) are classified under the 4-digit Standard Industrial Classification 1987-revision (SIC 87). Product information is provided at the 7-digit SIC level. We define "industries" and "products" at the 4-digit and 7-digit SIC levels, respectively. After data cleaning, there are 467 4-digit SIC codes and 2,069 7-digit SIC codes.[40] Finally, both the Chilean Manufacturing Census (1991-1996) and the Colombian Manufacturing Census (1981-1996) use the 4-digit ISIC industry classification. After data cleaning, we are left with 77 industries in Chile and 88 in Colombia.

As part of our data cleaning process, we drop observations with missing data for our size proxies (revenue and employment) or for variables required to form our dependent variables (capital intensity and average wages). When focusing on price information, we also drop products with missing revenue or quantity information. Also, because we control for size using industry-specific or product-specific polynomials of order 3, we exclude industries or products with less than 5 observations from our sample as well as those reporting no exporters. Further, to avoid the influence of outliers, we winsorize all variables by 1% on both tails of the distribution (within each industry). For India, we also drop codes for aggregate or miscellaneous categories (99920, 99930, and 99999) and products measured in unspecified units (unit code 999). As discussed in the text, all our analysis using the Indian dataset adjusts appropriately for sampling probabilities.

For India, price is defined as the "ex-factory value" of goods manufactured divided by the quantity manufactured. The "ex-factory value" excludes all distribution and transportation costs associated with the sale of the manufactured products.[41] For the U.S., product value of shipments

[40] While there is a total of about 13,000 distinct 7-digit product codes, quantity information is not available for product lines that "are not meaningful" (Monahan, 1992).

[41] In the 1997-98 survey, data on transportation and other distribution costs was collected at the plant level and then imputed to individual products in proportion to the gross sales value data collected for each product.

is defined as "net selling value, f.o.b. plant, of shipments, after discounts and allowances and exclusive of freight charges and excise taxes".

For various tests we perform, we need to concord our India and U.S. product-level data with the 4-digit SITC classification. For India, we construct a manual concordance between 5-digit item codes and 4-digit SITC Rev.3 categories. For the U.S., we construct a manual concordance between 5-digit SIC Rev.1987 codes and 4-digit SITC Rev.2 categories. We also construct a mapping from 4-digit SITC Rev.3 codes to 4-digit SITC Rev.2 codes (Rev.3 → Rev.2) using the concordances between 10-digit Harmonized System (HS) codes and those two classifications available at the the Center for International Data (CID) website.[42] Specifically, to map a given Rev.3 category into a Rev.2 category, we first identify all the 10-digit HS codes included in the first category. Then, we select the Rev.2 category into which most 10-digit HS codes are mapped. Thus, U.S. product codes are also mapped to the Rev.2 classification.

We also combine our data with other industry classifications as follows:

- *Rauch's classification (RC).* Rauch (1999) proposed a classification of 4-digit SITC Rev.2 categories into three classes: "homogenous", "reference-priced" and "differentiated" goods. We use his "liberal" version. For products, we apply RC directly to our earlier mapping of product codes into SITC Rev.2 categories. For the India dataset, we first manually concord 3-digit NIC codes to the 3-digit ISIC classification. Then, using a concordance between the 3-digit ISIC classification and the more disaggregate 4-digit SITC Rev.2 classification,[43] we define as "differentiated" any 3-digit ISIC code where more than half of 4-digit SITC Rev.2 codes that match it are differentiated according to RC. For industries in the U.S. dataset, 4-digit SIC codes are defined as differentiated if more than half of 5-digit SIC codes within a 4-digit SIC category are differentiated according to RC. For Chile and Colombia, "differentiated" 3-digit ISIC categories are identified as done for India.

- *Broda-Weinstein (BW) elasticity of substitution.* These estimates are available at the 4-digit SITC Rev.3 level.[44] For India, they can be directly applied to product codes, which are already mapped to that classification. For the U.S. we first map the elasticities to the 4-digit SITC Rev.2 classification using the Rev.3 → Rev.2 concordance described earlier.

- *Destination (average) GDP per capita.* Data on Indian and U.S. exports by 4-digit SITC

[42] http://cid.econ.ucdavis.edu/data/sasstata/usxss.html

[43] From http://www.macalester.edu/research/economics/page/haveman/Trade.Resources/.

[44] http://faculty.chicagogsb.edu/christian.broda/website/research/unrestricted/TradeElasticities/TradeElasticities.html.

Rev.2 categories for 1997 was downloaded from the CID website. For India, we convert this information into 4-digit SITC Rev.3 categories following our earlier concordance. Then, for each Rev.3 category for India and Rev.2 category for the U.S. we construct the (average) "destination GDP per capita" measure by weighting the GDP per capita of destination countries with the share of exports (CIF value) shipped to that destination. GDP per capita (in constant year 2000 $) for 1997 comes from the World Bank's World Development Indicators CD-ROM.

- *Destination (average) distance.* We follow the same procedure as outlined for destination GDP per capita. Here, bilateral distance data (rather than GDP per capita data) comes from the CEPII website.[45]

- *Measure of external financial dependence.* The Rajan-Zingales measure of dependence on external finance is available for 2-digit SIC 1987 categories. For India, we use the CID concordance to map those categories into the 4-digit SITC Rev.3 classification. The modal 2-digit SIC category is chosen as the unique match to any 4-digit SITC Rev.3 code. For the U.S., 7-digit SIC product categories are directly mapped to their classification.

- *Measure of dependence on the government.* The Bureau of Economic Analysis of the U.S. provides Input-Output (I-O) matrices for 1997 based on a 5-digit IO classification code.[46] For India, we combine BEA's IO-HS (10-digit) concordance with a HS-SITC (Rev.3) 4-digit concordance from the CID website to obtain a 4-digit SITC Rev.3 I-O matrix. For the U.S. we follow analogous procedure except for the use of a HS-SITC (Rev.2) 4-digit concordance to obtain a 4-digit SITC Rev.2 I-O matrix. We form a measure of dependence on the government as the ratio of total output consumed by the government to total output. For a handful of product codes with missing data, we imputed the fraction of output used by government for the corresponding 4-digit I-O codes.

[45] http://www.cepii.fr/anglaisgraph/bdd/distances.htm
[46] http://www.bea.gov/industry/io_benchmark.htm

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

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

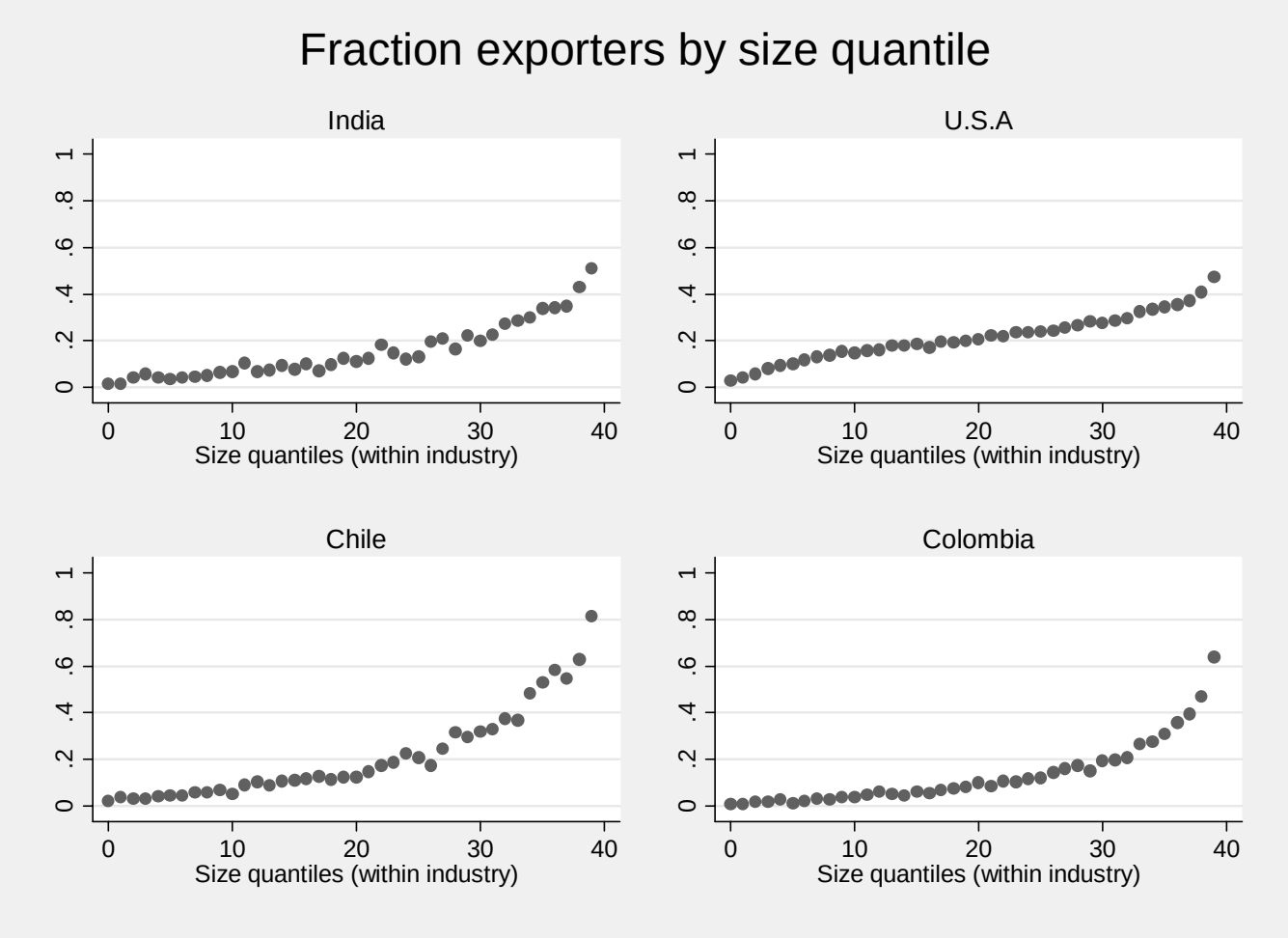
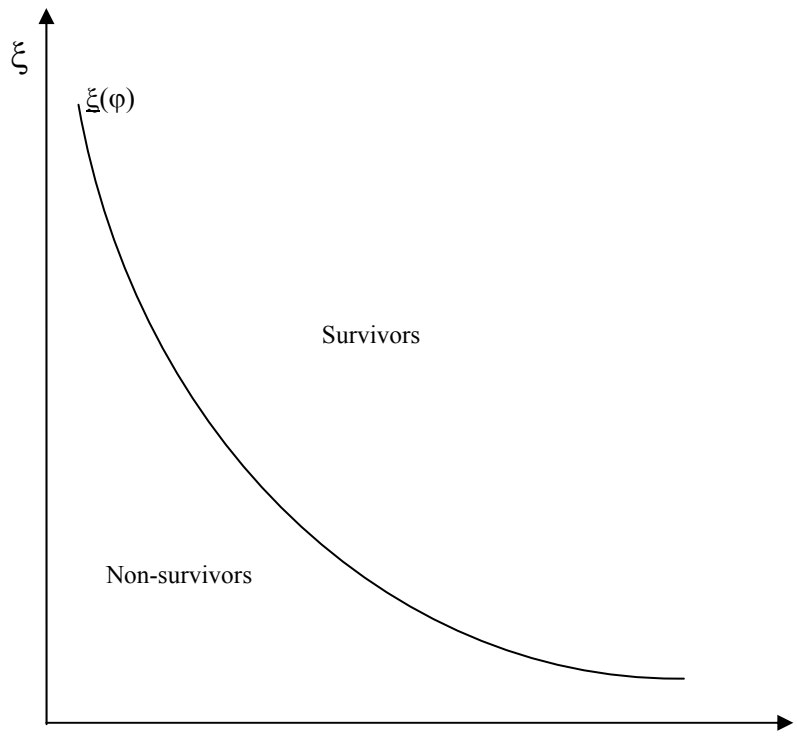
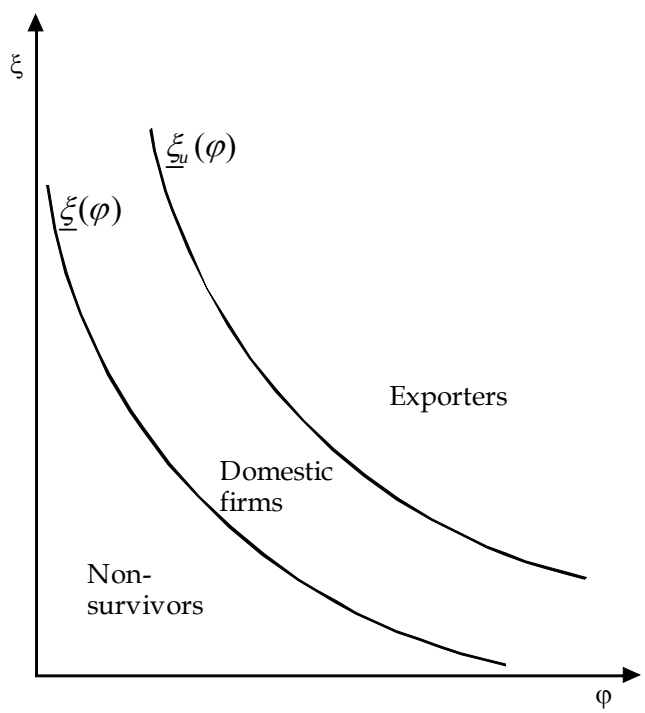


Figure 2: Equilibrium in the closed economy



$\underline{\xi}$ (φ): cut-off between survivors and non-survivors φ

Figure 3: Unconstrained export quality equilibrium



$\underline{\xi}$ (φ): cut-off between survivors and non-survivors

$\underline{\xi}_u$(φ): export cut-off in the <u>unconstrained</u> regime

Figure 4: Fraction of exporters as a function of revenue in the unconstrained export quality equilibrium

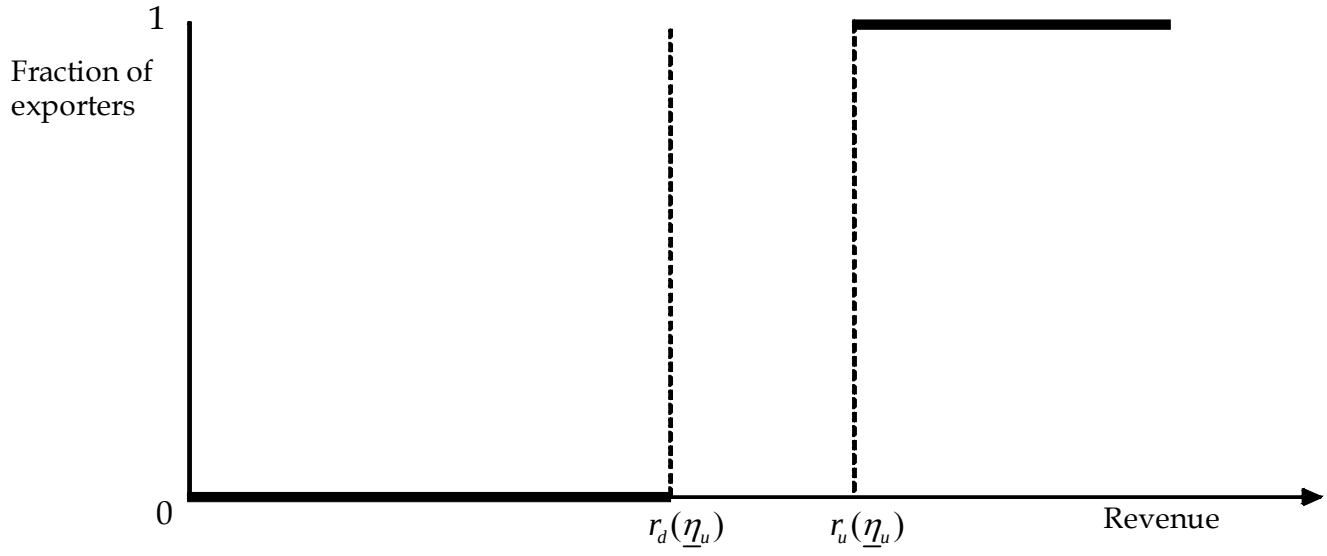
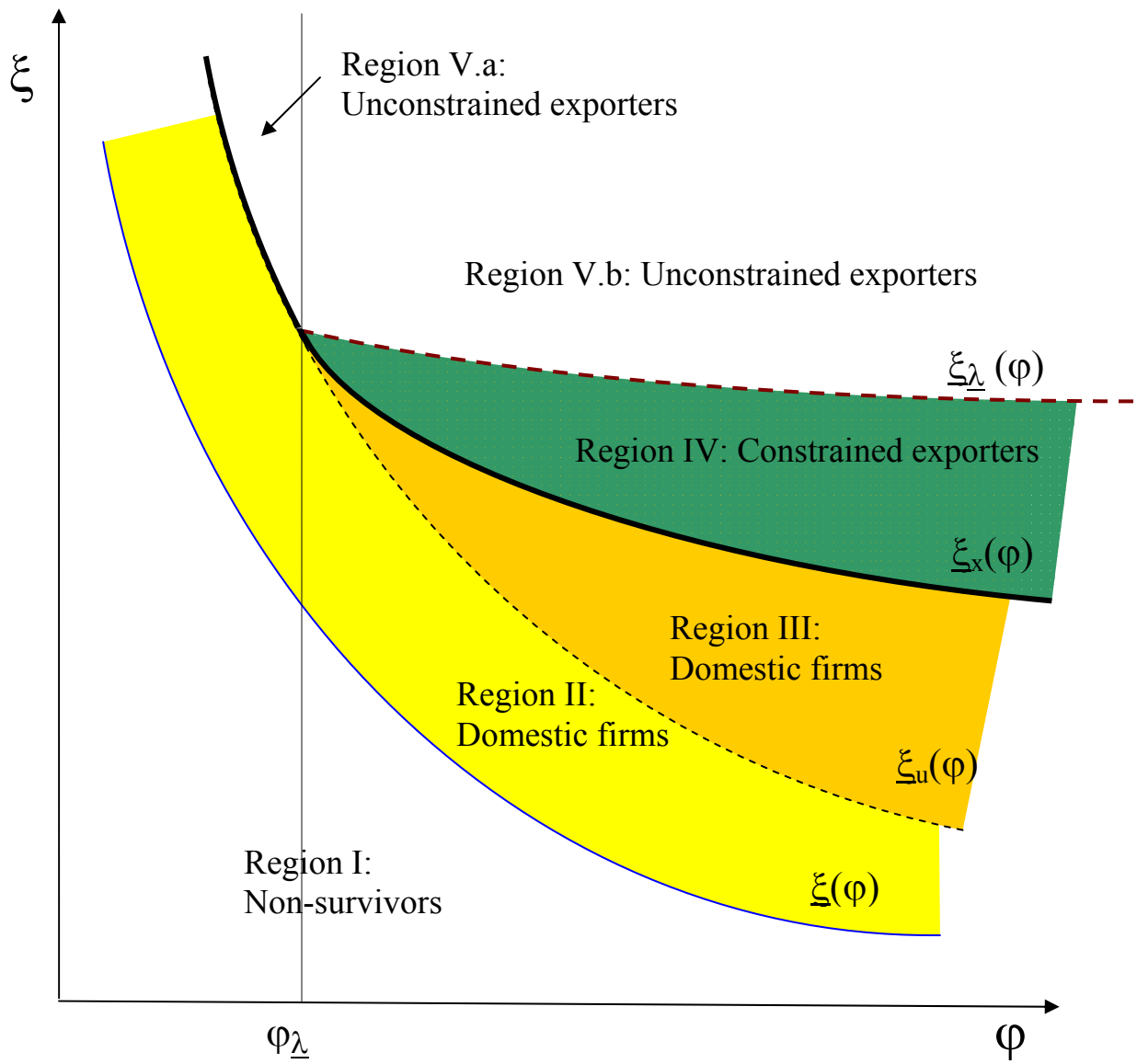


Figure 5: Constrained export quality equilibrium



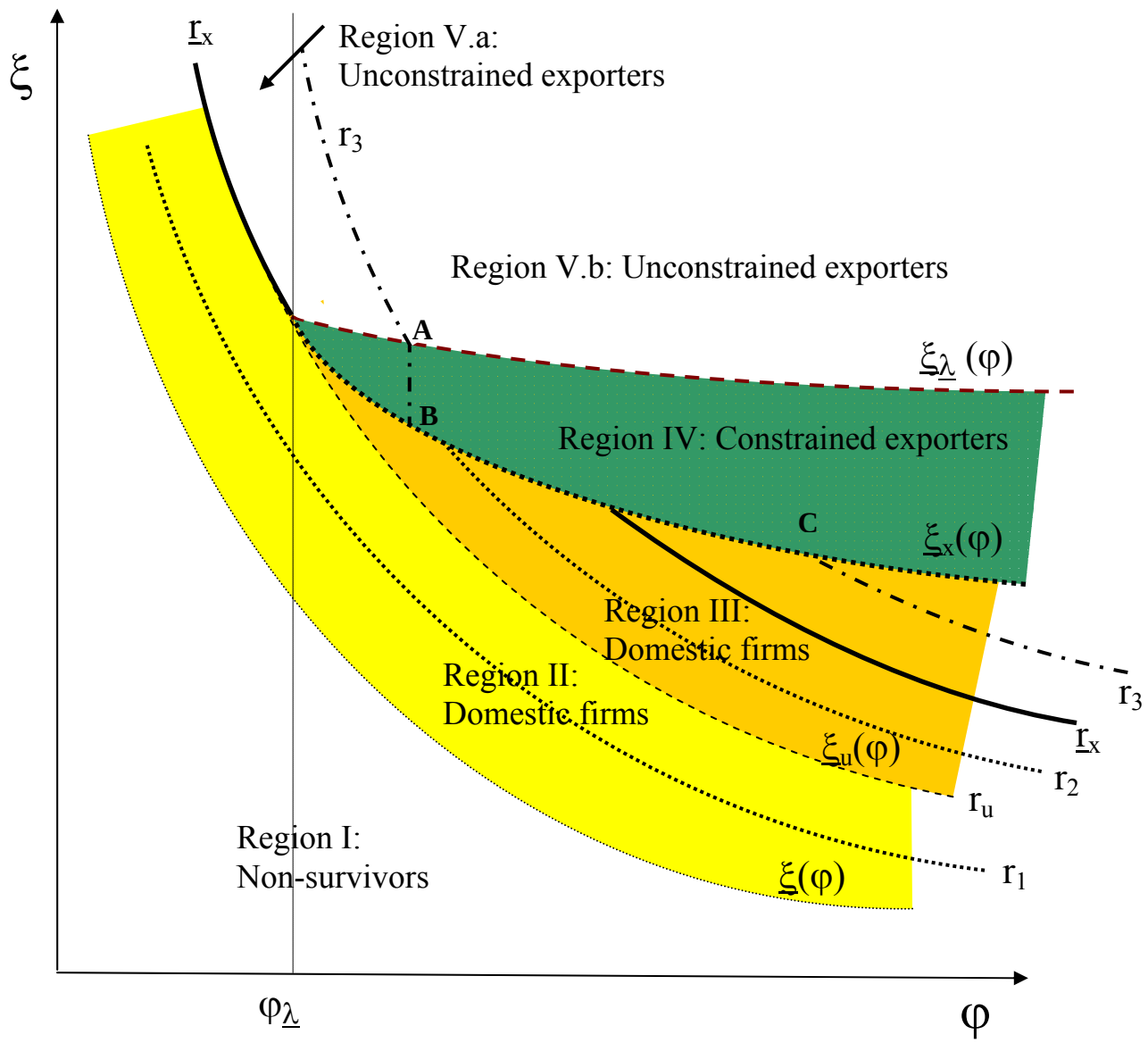
$\underline{\xi}$ (φ): cut-off between survivors and non-survivors

$\underline{\xi}_u$(φ): export cut-off in the <u>unconstrained</u> regime

$\underline{\xi}_{\underline{\lambda}}$(φ): iso-quality curve for threshold quality $\underline{\lambda}$

$\underline{\xi}_x$(φ): export cut-off in the <u>constrained</u> regime

Figure 6: Iso-revenue and iso-quality curves in the constrained export quality equilibrium



$\underline{\xi}$ (φ): cut-off between survivors and non-survivors

$\underline{\xi}_u$(φ): export cut-off in the <u>unconstrained</u> regime

$\underline{\xi}_{\underline{\lambda}}$(φ): isoquality curve for threshold quality $\underline{\lambda}$

$\underline{\xi}_x$(φ): export cut-off in the <u>constrained</u> regime

Table 1: Summary statistics

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

	ALL ESTABLISHMENTS			NON-EXPORTERS			EXPORTERS		
Description	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
Panel 1: India (1998)									
Standardized (log) price	6,494	0.00	1.00	4,813	-0.01	0.96	1,681	0.06	1.05
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) average wage rate	123,079	0.00	1.00	96,670	-0.06	1.03	26,409	0.21	0.86
Standardized (log) capital intensity (capital/labor)	123,079	0.00	1.00	96,670	-0.01	0.98	26,409	0.02	1.07
Panel 3: Chile (1991-96)									
Standardized (log) average wage rate	17,053	0.00	1.00	13,446	-0.17	0.96	3,607	0.62	0.87
Standardized (log) capital intensity (capital/labor)	17,053	0.00	1.00	13,446	-0.14	0.97	3,607	0.50	0.92
Panel 4: Colombia (1981-91)									
Standardized (log) average wage rate	39,990	0.00	1.00	34,714	-0.11	0.94	5,276	0.73	1.06
Standardized (log) capital intensity (capital/labor)	39,990	0.00	1.00	34,714	-0.07	0.99	5,276	0.43	0.89

Table 2: Log price: Baseline results

All reported figures are coefficients on an exporter dummy which equals 1 if the establishment reports positive exports. Price is defined as a unit value (product revenue/quantity). Standardized (log) price is (log) 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. 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 price (standardized)	0.112**	0.130**	0.177***	0.169**
	[0.050]	[0.060]	[0.063]	[0.073]
Dependent variable: Log 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
Number of products	296	296	296	296
Number of plants	4,933	4,933	4,933	4,933
Panel 2: USA (1997)				
Dependent variable: Log price (standardized)	0.082***	0.131***	0.136***	0.135***
	[0.018]	[0.019]	[0.019]	[0.020]
Dependent variable: Log 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
Number of products	860	860	860	860
Number of plants	18,373	18,373	18,373	18,373
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 3: Log price: Results for differentiated and homogenous goods sectors

All reported figures are coefficients on an exporter dummy which equals 1 if the establishment reports positive exports. Price is defined as a unit value (product revenue/quantity). Standardized (log) price is (log) price demeaned by the product-specific mean and divided by the product-specific standard deviation. Homogenous products include Rauch's (1999) "homogeneous" and "reference-price" sectors (liberal version). 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%.

	India (1997-98)				USA (1997)			
	Differentiated products		Homogenous products		Differentiated products		Homogenous products	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: Log price (standardized)	0.177***	0.169**	-0.0305	-0.0158	0.136***	0.135***	0.100***	0.100***
	[0.063]	[0.073]	[0.0361]	[0.0549]	[0.019]	[0.020]	[0.018]	[0.020]
Number of observations (plant-product)	6,494	6,494	18,541	18,541	49,203	49,203	49,499	49,499
Product fixed effects	Yes	No	Yes	No	Yes	No	Yes	No
Product-specific size polynomial (order 3)	Yes	No	Yes	No	Yes	No	Yes	No
Product-specific size-decile fixed effects	No	Yes	No	Yes	No	Yes	No	Yes

Table 4: Quality proxy – 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 5: Wage and capital intensity results

All reported figures are coefficients on an exporter dummy which equals 1 if the establishment reports positive exports. Standardized average wage is the wagebill 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		USA		Chile		Colombia	
	(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 6: Robustness checks: conditioning on employment and domestic sales

All reported figures are coefficients on an exporter dummy which equals 1 if the establishment reports positive exports. Establishment size is defined as log employment in panel A and log domestic sales in panel B. Only differentiated sectors are included. Standard errors are clustered at plant level; * significant at 10%; ** significant at 5%, *** significant at 1%.

	India		USA		Chile		Colombia	
Dependent Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Panel A: conditioning on employment								
Log price (standardized)	0.137**	0.170**	0.139***	0.133***				
	[0.0558]	[0.0694]	[0.019]	[0.020]				
ISO 9000 dummy	0.098***	0.106***						
	[0.009]	[0.009]						
Log average wage (standardized)	0.432***	0.435***	0.223***	0.234***	0.394***	0.395***	0.325***	0.360***
	[0.0347]	[0.0356]	[0.014]	[0.014]	[0.0324]	[0.0317]	[0.0315]	[0.0315]
Log capital intensity (standardized)	0.483***	0.507***	-0.090***	-0.084***	0.488***	0.492***	0.388***	0.387***
	[0.0362]	[0.0365]	[0.016]	[0.016]	[0.0370]	[0.0360]	[0.0322]	[0.0319]
Panel B: conditioning on domestic sales								
Log price (standardized)	0.202***	0.245***	0.138***	0.134***				
	[0.0589]	[0.0788]	[0.019]	[0.020]				
ISO 9000 dummy	0.093***	0.101***						
	[0.008]	[0.009]						
Log average wage (standardized)	0.349***	0.363***	0.133***	0.140***	0.224***	0.244***	0.209***	0.254***
	[0.0318]	[0.0332]	[0.012]	[0.013]	[0.0264]	[0.0269]	[0.0256]	[0.0268]
Log capital intensity (standardized)	0.323***	0.348***	-0.152***	-0.140***	0.301***	0.324***	0.197***	0.211***
	[0.0348]	[0.0357]	[0.014]	[0.014]	[0.0348]	[0.0345]	[0.0299]	[0.0295]
Product or industry-year fixed effects	Yes	No	Yes	No	Yes	No	Yes	No
Product or industry-year specific size polynomial (order 3)	Yes	No	Yes	No	Yes	No	Yes	No
Product or industry-year size-decile fixed effects	No	Yes	No	Yes	No	Yes	No	Yes

Table 7: Log price: Interaction results

The dependent variable is log standardized price. EXPDUM is an exporter dummy. DESTGDP is the standardized (value weighted) average GDP per capita of the destination countries to which a product is exported; DESTDIST is the standardized (value weighted) average distance. SIGMA is the (standardized) elasticity of substitution (from Broda and Weinstein, 2006). Only differentiated sectors are included. Standard errors are clustered at plant level; * significant at 10%; ** significant at 5%, *** significant at 1%.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel 1: INDIA (1997-98)								
EXPDUM	0.277***	0.263***	0.278***	0.278***	0.130**	0.122	0.210***	0.208**
	[0.0678]	[0.100]	[0.0689]	[0.102]	[0.0657]	[0.0975]	[0.0684]	[0.0998]
EXPDUM X DESTGDP	0.0248	0.0997					0.0513	0.0849
	[0.0604]	[0.0898]					[0.0839]	[0.120]
EXPDUM X DESTDIST			0.0284	0.115			0.0363	0.105
			[0.0729]	[0.111]			[0.102]	[0.144]
EXPDUM X SIGMA					-0.174***	-0.210	-0.0954	-0.143
					[0.0599]	[0.187]	[0.0757]	[0.189]
Observations	4,901	4,901	4,901	4,901	6,321	6,321	4,767	4,767
Panel 2: USA (1997)								
EXPDUM	0.113***	0.111***	0.147***	0.143***	0.135***	0.131***	0.119***	0.103***
	[0.019]	[0.020]	[0.019]	[0.021]	[0.019]	[0.020]	[0.021]	[0.022]
EXPDUM X DESTGDP	0.086***	0.087***					0.068***	0.090***
	[0.021]	[0.022]					[0.026]	[0.029]
EXPDUM X DESTDIST			0.065***	0.048**			0.029	0.001
			[0.019]	0.021			[0.025]	[0.027]
EXPDUM X SIGMA					-0.006	-0.020	-0.022	-0.041
					[0.031]	[0.035]	[0.031]	[0.034]
Observations	49,203	49,203	49,203	49,203	49,203	49,203	49,203	49,203
Product fixed effects	Yes	No	Yes	No	Yes	No	Yes	No
Product-specific size polynomial (order 3)	Yes	No	Yes	No	Yes	No	Yes	No
Product-specific size-decile fixed effects	No	Yes	No	Yes	No	Yes	No	Yes

Figure A.1: Percentage of establishments that are exporters, by size percentile

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

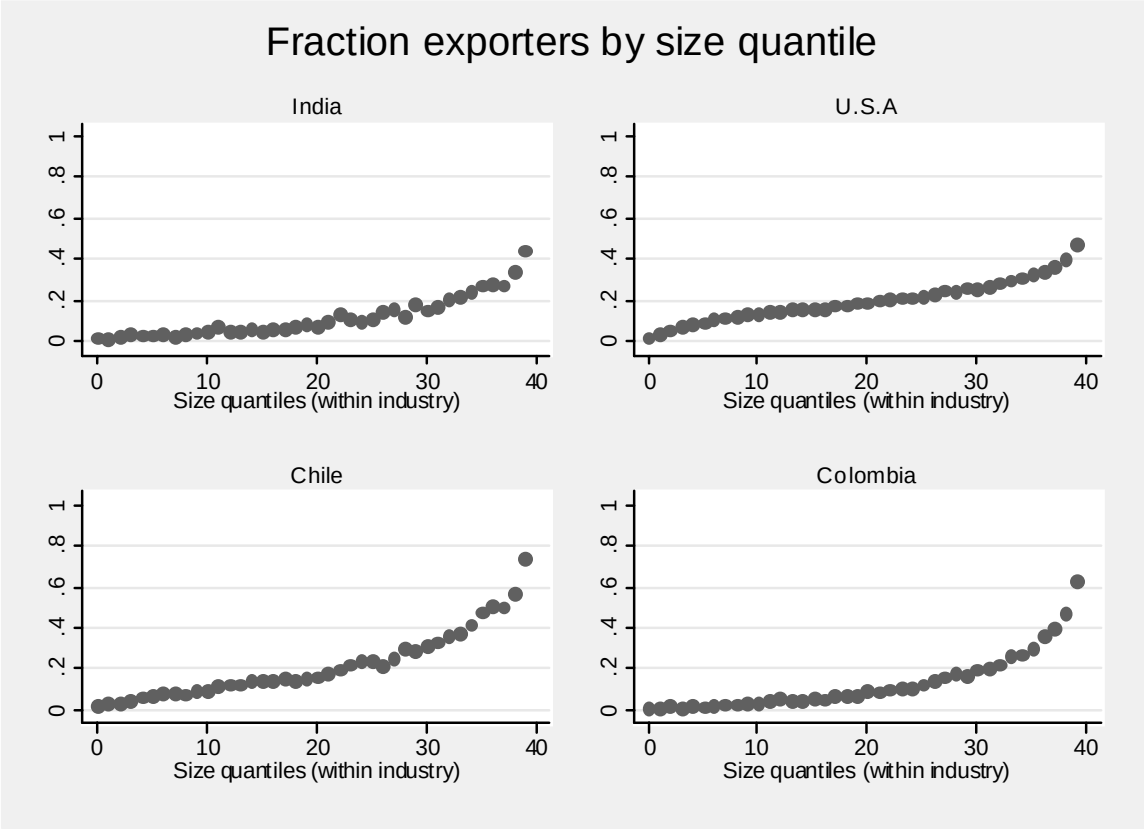


Figure A.2: Existence of equilibrium

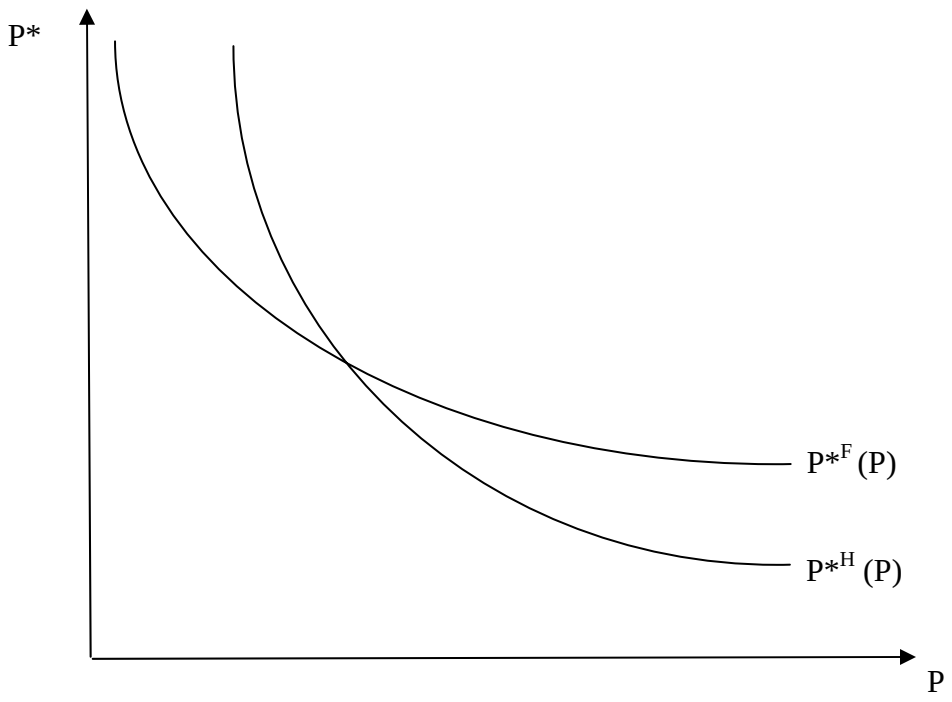


Table A.1: Log price: Robustness checks

All reported figures are coefficients on an exporter dummy. The exporter dummy equals 1 if the establishment reports positive exports, except for row 2 where it equals 1 if the establishment exports more than 2% of their total sales. Price is defined as a unit value (product revenue/quantity). Standardized (log) price is (log) price demeaned by the product-specific mean and divided by the product-specific standard deviation. Only differentiated sectors are included. Standard errors clustered at plant level; * significant at 10%; ** significant at 5%, *** significant at 1%.

	(1)	(2)	(3)	(4)
Panel 1: India (1997-98)				
Base case: Coefficient on exporter dummy from Panel 1 of Table 2	0.112**	0.130**	0.177***	0.169**
	[0.050]	[0.060]	[0.063]	[0.073]
Coefficient on dummy for export share >2%	0.151***	0.120*	0.161**	0.142*
	[0.056]	[0.064]	[0.068]	[0.079]
Coefficient on exporter dummy, main product line only	0.171**	0.125	0.179**	0.126
	[0.080]	[0.087]	[0.091]	[0.11]
Panel 2: USA (1997)				
Base case: Coefficient on exporter dummy from Panel 2 of Table 2	0.082***	0.131***	0.136***	0.135***
	[0.018]	[0.019]	[0.019]	[0.020]
Coefficient on dummy for export share >2%	0.096***	0.133***	0.136***	0.130***
	[0.021]	[0.021]	[0.022]	[0.024]
Coefficient on exporter dummy, main product line only	0.112***	0.122***	0.122***	0.121***
	[0.020]	[0.021]]	[0.021]	[0.025]
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 A.2: Skill intensity measures

All reported figures are coefficients on an exporter dummy which equals 1 if the establishment reports positive exports. The skilled share of the wage bill is the ratio of non-production worker wages to total wages. Skilled share of employment is the share of non-production workers in total employment. Both variables are standardized by using 4-digit industry-specific means and standard deviations. Only differentiated sectors are included. Standard errors are clustered at plant level; * significant at 10%; ** significant at 5%, *** significant at 1%.

	India		**USA**		**Chile**		**Colombia**	
Skilled share of the wage bill (standardized)	0.0166	-0.0147	0.244***	0.239***	0.110***	0.151***	0.121***	0.154***
	[0.039]	[0.041]	[0.016]	[0.016]	[0.036]	[0.036]	[0.034]	[0.032]
Skilled share of employment (standardized)	0.0096	-0.0149	0.192***	0.197***	-0.0228	0.0071	0.0678*	0.0929**
	[0.0403]	[0.0464]	[0.016]	[0.017]	[0.0391]	[0.0420]	[0.0351]	[0.0365]
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	Yes	Yes	Yes	Yes	Yes	Yes	Yes
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 A.3: Robustness checks: Using U.S. CMF 1992

All reported figures are coefficients on an exporter dummy which equals 1 if the establishment reports positive exports. The data covers the differentiated products/industries (defined per the Rauch 1999 classification) of the manufacturing sector for the US in 1992. For standardized log price, "product/industry" in the last four rows refers to 7-digit product codes; for other variables "product/industry" refers to 4-digit SIC (1987) code. Size is defined as log total sales of the establishment. Only differentiated sectors are included. Standard errors are clustered at plant level; * significant at 10%; ** significant at 5%, *** significant at 1%.

Dependent variable	**(1)**	**(2)**	**(3)**	**(4)**
Log price (standardized)	0.147***	0.117***	0.121***	0.131***
	[0.015]	[0.015]	[0.015]	[0.015]
Log average wage (standardized)	0.313***	0.100***	0.101***	0.112***
	[0.015]	[0.017]	[0.017]	[0.018]
Capital intensity (standardized)	0.233***	-0.001	-0.002	0.006
	[0.018]	[0.014]	[0.014]	[0.014]
Product/industry fixed effects	Yes	Yes	Yes	No
Product/industry-specific size polynomial (order 2)	No	Yes	No	No
Product/industry-specific size polynomial (order 3)	No	No	Yes	No
Product/industry size-decile fixed effects	No	No	No	Yes

Table A.4: Robustness checks: conditioning of firm sales and using single-establishment firms

All reported figures are coefficients on an exporter dummy which equals one for firms where at least one establishment exports. The data covers the differentiated products/industries (defined per the Rauch 1999 classification) for the U.S. manufacturing sector in 1997. For price, "product/industry" in the last 4 rows refers to 7-digit product codes; for other variables "product/industry" refers to 4-digit SIC (1987) code. In all cases, size is defined as the log firm sales. Average wage and capital intensity are defined using firm level aggregates. (Firm and establishment variables are the same for single-establishment firms in panel 2.) Only differentiated sectors are included. Standard errors are clustered at plant level; * significant at 10%; ** significant at 5%, *** significant at 1%.

Dependent variable	**(1)**	**(2)**	**(3)**	**(4)**
Panel 1: All variables defined at the firm level				
Log price (standardized)	-0.015	0.108***	0.121***	0.118***
	[0.017]	[0.020]	[0.021]	[0.023]
Log average wage (standardized)	0.321***	0.065***	0.074***	0.080***
	[0.016]	[0.016]	[0.015]	[0.018]
Capital intensity (standardized)	-0.014	-0.216***	-0.219***	-0.210***
	[0.018]	[0.016]	[0.017]	[0.016]
Panel 2: Sample restricted to single-establishment firms only				
Log price (standardized)	0.113***	0.149***	0.151***	0.168***
	[0.027]	[0.028]	[0.028]	[0.031]
Log average wage (standardized)	0.331***	0.068***	0.074***	0.090***
	[0.016]	[0.016]	[0.017]	[0.017]
Capital intensity (standardized)	-0.128***	-0.266***	-0.262***	-0.252***
	[0.023]	[0.019]	[0.019]	[0.019]
Product/industry fixed effects	Yes	Yes	Yes	No
Product/industry-specific size polynomial (order 2)	No	Yes	No	No
Product/industry-specific size polynomial (order 3)	No	No	Yes	No
Product/industry size-decile fixed effects	No	No	No	Yes

Table A.5: Robustness to using four-year means of variables

All reported figures are coefficients on an exporter dummy which equals 1 if the establishment reports positive exports. All variables are the 4 year mean values by establishment. Establishments that switched exporter status during the 4 year period, or have fewer than 3 observations in the four year period are excluded. Only differentiated sectors are included. Standard errors are clustered at plant level; * significant at 10%; ** significant at 5%, *** significant at 1%.

	Chile (1993-1996 mean)		**Colombia (1988-1991 mean)**	
	(1)	**(2)**	**(3)**	**(4)**
Dependent variable: Standardized average wage	0.180***	0.219***	0.124**	0.234***
	[0.0498]	[0.0531]	[0.0540]	[0.0604]
Dependent variable: Standardized capital intensity	0.311***	0.353***	0.164***	0.166***
	[0.0618]	[0.0671]	[0.0627]	[0.0633]
Number of observations (plants)	1,978	1,978	3,103	3,103
Industry-year fixed effects	Yes	Yes	Yes	No
Industry-year specific size polynomial (order 2)	No	Yes	No	No
Industry-year specific size polynomial (order 3)	No	No	Yes	No
Industry-year size-decile fixed effects	No	No	No	Yes

Table A.6: Robustness to excluding sectors dependent on external finance and government purchases

All reported figures are coefficients on an exporter dummy which equals 1 if the establishment reports positive exports. The dependent variable is standardized log per unit price, i.e. demeaned by the product specific mean and divided by the product specific standard deviation. Only differentiated sectors are included. Standard errors clustered at plant level; * significant at 10%; ** significant at 5%, *** significant at 1%.

	India		USA	
	(1)	**(2)**	**(3)**	**(4)**
Panel 1: Excluding products with above median dependence on Rajan-Zingales (2006) external finance measure				
Dependent variable: Standardized price	0.217**	0.263**	0.086***	0.083***
	[0.0874]	[0.121]	[0.030]	[0.033]
Panel 2: Excluding products with above median dependence on government purchases (based on US I-O table)				
Dependent variable: Standardized price	0.390***	0.424***	0.169***	0.174***
	[0.0983]	[0.148]	[0.033]	[0.036]
Product/industry fixed effects	Yes	Yes	Yes	No
Product/industry-specific size polynomial (order 2)	No	Yes	No	No
Product/industry-specific size polynomial (order 3)	No	No	Yes	No
Product/industry size-decile fixed effects	No	No	No	Yes