

Geography of Export Prices and Importer-Exporter Income Differences.

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Abstract

We develop a model of endogenous quality choice and trade that combines non-iceberg trade costs and non-homothetic preferences to capture the effect of importer-exporter income differences on geographic variation in quality and export prices. The differences in income substantially alter the effect of trade costs on quality. The incentive to trade high quality goods given high trade costs (the Alchian-Allen effect) is tempered by the increased remoteness from rich importers demanding high quality goods. The estimated effects of distance and contiguity in a sample of product-level imports to nine Latin American countries and the United States support our theory.

Keywords: quality, relative income, economic geography, Alchian-Allen effect, Linder, distance.

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1 Introduction

We develop a simple model of trade with endogenous quality choice that combines non-iceberg trade costs and non-homothetic preferences. New to the literature on quality and trade, we show how the effect of variable trade costs on export prices is determined by the differences in average per capita income between the exporter and importer countries.

In our model, the quality production function is introduced in a way similar to Flam and Helpman (1987); higher quality is accompanied by a higher marginal cost, and each firm produces single quality. On the demand side, following Linder (1961) we assume that richer consumers have stronger preferences for quality. The functional form of non-homotheticity is similar to Hallak (2006).

We propose a novel way to generalize the trade cost function to include both ad valorem and specific components, while preserving the high tractability of the model¹. This explicit decomposition enables us to highlight the importance of accounting for the functional form of trade cost when evaluating the effect of trade costs on a firm's choice of quality and export prices. Our predictions are very similar to the existing literature on the Alchian-Allen (AA) effect (see, e.g., Hummels and Skiba (2004)), which presents a convincing case that the functional form of trade costs is crucial to understanding their effect on export prices; specific trade costs increase export prices, while ad valorem trade costs act in the opposite direction. However, in our model, this is a result of a firm's endogenous quality and price choice (supply-side AA effect), while the existing literature relies on a compositional or demand-driven AA effect.

As in Flam and Helpman (1987), quality and export prices are affected by both domestic and foreign demands, and thus by both domestic and foreign preferences for quality. When both demands affect the choice of quality, the magnitude of the trade costs determines the relative importance of each market, and thus might have either a positive or negative effect on the quality choice of domestic firms. To illustrate the basic intuition behind this, consider a two-country world with traditional iceberg trade costs (in our model, it would mean that trade costs do not have a specific component). In this case, the intuition about the joint effect of income difference and trade costs on prices is straightforward. If the average income in the foreign market is higher than that at home, then the foreign demand for quality creates an incentive for the single-quality domestic producers to increase quality. An increase in the trade costs to the foreign market makes this incentive weaker, and as a result, the effect of trade costs on quality is negative if the importer is richer than the exporter. Naturally, if the foreign country happens to be poorer than the domestic country, the effect of trade costs on quality would be positive.

In a more general and empirically relevant case, the Alchian-Allen effect is likely to affect quality choice because the trade costs are not necessarily of iceberg form and variation in the magnitude of the trade costs can be related to the variation in their specific component. In this case, the

¹Hummels and Skiba (2004) and Hummels, Lugovskyy, and Skiba (2009) show that trade cost does indeed consist of both ad valorem and specific components.

Linder effect² tempers the AA effect, to trade higher quality goods at longer distances, as long as the average income of the importing country is higher than that of the exporter.

Our focus on the *joint* effect of trade costs and incomes on export prices and quality fills an important gap in the literature because these effects are usually treated as independent ones³, which can lead to biased estimates. This is because incomes, among other effects, affect *how* trade costs affect quality. In particular, when non-homotheticity is introduced at the same time as non-iceberg transportation costs, the Alchian-Allen effect can be reversed. This insight has important empirical implications because both effects contribute to the observed variation in export prices.

This paper’s focus on the income differences is also novel to the literature on quality and export prices. The effect of importer’s and exporter’s incomes on export prices has been recognized since Linder (1961), yet the importance of relative income went unnoticed in the related literature. While most papers agree that richer markets import more expensive goods and richer countries’ producers charge higher export prices, the difference between the incomes of the importer and exporter seems not to matter for export prices. Linder highlights the importance of relative income for trade volumes by predicting less trade between countries with different income levels, but this prediction does not invoke the effect of relative income on prices.

Our theory is strongly supported by the empirics (our main results are presented in Table 2). After controlling for the specific and ad valorem composition of trade costs, we find polarization in the effect of these costs on prices. The strength and even direction of this effect depend on the importer-exporter relative income. In particular, we find that distance decreases export prices to the destinations that are richer than the exporter and increases export prices to the destinations that are poorer than the exporter. The positive association between distance and unit values that is prevalent in the previous literature is restricted to the specification that does not account for either the Linder effect or product level trade barriers. The availability of the common border, on the other hand, decreases export prices to poorer destinations and increases them to richer destinations. These results hold for both the OECD and upper-middle income sets of exporters.

We contribute to the recent literature on trade barriers and export prices. Baldwin and Harrigan (2011) provide a variant of the Melitz (2003) model in which a higher marginal cost is associated with higher quality goods, and high quality firms are the most competitive ones. In line with theoretical predictions, they find that the United States export prices are positively related to trade distance. Given that the USA is one of the richest countries in the world, the predictions of our model are consistent with these findings, since we predict the prices to increase in trade barriers to poorer countries. However, in our sample with both poorer and richer (than exporter)

²Throughout the paper, we refer to the incentive to adjust quality based on consumer preferences as the Linder effect. According to Linder, “a whole array of forces influences the demand structure of a country. We shall, however, argue that the level of average income is the most important single factored that it has, in fact, a dominating influence on the structure of demand.”

³The origins of the literature on the effect of income on quality and prices can be traced to Linder (1961) (see Schott (2004); Hallak (2006); and Choi, Hummels, and Xiang (2009) for examples of more recent research). Hummels and Skiba (2004) use the Alchian-Allen effect to interpret variation in export prices. See also Goldberg and Knetter (1997) for an extensive review of the pricing-to-market literature.

destinations, the effect of distance on export prices is no longer monotonic. The same logic applies when exploring the effect of a common border on export prices. Sharing a border with a poorer export destination decreases export prices⁴, since exporters take into account weaker preferences for quality in the destination, while sharing a border with a richer destination has the opposite effect. Johnson (2012) extends the work of Baldwin and Harrigan (2011) by simultaneously estimating the export prices and export participation equations similarly to Helpman, Melitz, and Rubinstein (2008). Johnson (2012) notices that selection can drive the positive relationship between export prices and trade costs independently of their ad valorem or specific nature. This insight is common to the models of trade with heterogeneous firms. When selection is the main explanation for the variation in export prices, the nature of the trade costs is not relevant. The importer-exporter per capita income differences are equally secondary in the model with heterogeneous firms because it is the size of the destination market rather than the average income that affects selection by firms with different export prices. Furthermore, the selection into each market is independent. That is, as long as the fixed cost of production is covered, a firm exports to a destination if the revenues gained from selling to that destination cover the total costs. Our model instead highlights the importance of the nature of transportation costs and importer-exporter income differences, where all destinations matter to quality choice.

Several other papers rely on trade models with heterogeneous firms models to understand how productivity and quality are related to the firm’s decision to export; Verhoogen (2008) and Gervais (2010) are two notable examples. These papers use firm-level data to study the relationship between productivity and quality. Our approach is complementary to theirs because of our focus on the demand-side determinants of the quality of exports.

Relevant to the standard models of heterogeneous firms, our paper questions the assumption of the monotonic relationship between the marginal cost and profitability across firms⁵. The marginal cost with two parameters (a parameter for all quality types and one for quality upgrading) suggested by Flam and Helpman (1987) allows for the construction a model in which the ranking of firms’ profits depends on the income of the export destination. Lower quality firms might be the most profitable ones in poorer markets, while higher quality firms – might earn the most profits in richer markets. We illustrate this notion by providing a numerical example in Section 2.6.

Several recently published papers measure the quality of internationally traded goods. The most notable contributions are Khandelwal (2010), Hallak and Schott (2011), and Feenstra and Romalis (2012). Even though none of the methods are directly applicable for our purposes, our approach is complementary. Khandelwal (2010) estimates quality based on a discrete choice framework for US imports, which are available at a high level of disaggregation. Since our data contain US imports, we compare the conditional variation in the unit values used in our paper to Khandelwal’s estimates.

⁴This part is consistent with Harrigan, Ma, and Shlychkov (2011) who utilize the most dis-aggregated firm-product level US exports data and find a strong negative effect of the common borders with Canada and Mexico (both of which are poorer than the United States) on the US export unit-values.

⁵In Eaton and Kortum (2002), Melitz (2003), and Melitz and Ottaviano (2008), the low cost firms are the most productive firms. Baldwin and Harrigan (2011) allow for two cases, with either the low cost or the high cost firms to be the most competitive ones. However, conditional on the case, the relation between the marginal cost and competitiveness is monotonic.

The methodology of Hallak and Schott (2011) is similar in spirit to that of Khandelwal (2010). They extract quality estimates from the bilateral trade balances, but contrary to our main question they do not consider importer’s income. They are careful to acknowledge that an assumption of income not being related to the preference for quality is ”potentially strong”. Both papers estimate exporter-product quality shifters, even though, in the case of Khandelwal (2010), the estimates do not separately identify preference for quality, because there is just one importer, namely, the United States. Fortunately, it is not an issue in his application to the US labor market. Even though Feenstra and Romalis (2012) is more closely related to our paper, since they model both non-homothetic preferences and non-iceberg transportation costs, they focus on bilateral variation in unit values, not exporter-product quality shifters as the two aforementioned papers do.

We also explore the implications of our findings for gravity literature by estimating gravity with the Linder correction dummy. We find that the negative distance elasticity of trade is smaller in absolute value for the country pairs where the exporter is richer than the importer. This is consistent with the differential effect of distance on export prices.

Section 2 presents a simple two-country model of quality and trade. The conclusions of this simple model are verified for a multi-country setting. Section 3 presents evidence that supports our theory.

2 Theoretical Framework

There are two countries, Exporter and Importer, indexed by E and I , respectively. The main purpose of our model is to show that when Exporter is richer than Importer, trade costs decrease the quality of the goods shipped (from Exporter) to Importer, while the opposite is likely to happen when Exporter is poorer. To this end, we focus on modeling the quality choice of Exporter’s monopolistically competitive firms. The quality choice of each firm depends on each country’s preferences for quality, as well as the composition and magnitude of the trade costs.

2.1 Preferences

Preferences are symmetric across countries. A representative consumer in country $i \in \{E, I\}$ has a quasi-linear utility function across $G + 1$ differentiated composite goods:

$$U_i = x_{0i} + \sum_{g=1}^G \left(\Gamma_{giE}^{\frac{\sigma}{\sigma-1}} \frac{\varepsilon-1}{\varepsilon} + \Gamma_{giI}^{\frac{\sigma}{\sigma-1}} \frac{\varepsilon-1}{\varepsilon} \right) \quad \sigma > \varepsilon > 1, \quad (1)$$

where x_{0i} is the individual consumption of the numeraire; and the differentiated by country of origin goods Γ_{giE} and Γ_{giI} are CES composites of many symmetric varieties:

$$\Gamma_{giE} = \sum_{\gamma} \left(\lambda_{g\gamma E}^{\delta_{gi}} x_{g\gamma iE} \right)^{\frac{\sigma-1}{\sigma}} \quad \Gamma_{giI} = \sum_{\gamma} \left(\lambda_{g\gamma I}^{\delta_{gi}} x_{g\gamma iI} \right)^{\frac{\sigma-1}{\sigma}} \quad \delta_{gi}(\sigma - 1) < 1 \quad \forall g, i; \quad (2)$$

where $\lambda_{g\gamma e}$ is the quality level of differentiated variety γ of good g produced in country $e \in \{E, I\}$; δ_{gi} is the intensity of the preference for the quality of varieties of good g in country i ; and $x_{g\gamma ie}$ is i 's individual consumption of sector g 's variety γ produced in country e .

Similar to Hallak (2006), the preference for quality is destination-specific, where the strength of the preference for quality δ_{gi} depends on a country's income y_i :

$$\frac{\partial \delta_{gi}}{\partial y_i} > 0, \quad (3)$$

Intuitively, a good of the same quality is perceived differently across countries, and upgrading quality increases the marginal utility more so for richer countries.

2.2 Production

Labor is the only factor of production, and it is supplied inelastically. There are L_e consumers in country $e \in \{E, I\}$, and each is endowed with one unit of labor. The numeraire sector is characterized by perfect competition and constant returns to scale. One unit of labor can produce w_e units of the numeraire in country e . The numeraire good can be traded at zero cost. We assume that the numeraire sector is large enough for each country to have a strictly positive output of the numeraire. The introduction of the numeraire in the model simplifies the balance of the trade calculation and ties the wage to productivity in the numeraire sector.

Differentiated goods sectors are characterized by monopolistic competition. The variable cost function of sector g 's variety γ produced in country e is country and sector specific and is characterized by marginal labor requirement $b_{g\gamma e}(\lambda_{g\gamma e})$, which is a function of the chosen quality level $\lambda_{g\gamma e}$. In each sector, we assume that the technology is such that there exist maximum and minimum quality levels, $\underline{\lambda}_g$ and $\overline{\lambda}_g$, respectively. We do not limit a firm's choice to either high or low quality levels; rather, we allow for a continuous quality choice within the following range:

$$b_{g\gamma e}(\lambda_{g\gamma e}) = \frac{1}{B_{ge}} \exp(\lambda_{g\gamma e}/\beta_{ge}), \quad B_{ge}, \beta_{ge} > 0, \quad \lambda_{g\gamma ie} \in [\underline{\lambda}_g, \overline{\lambda}_g], \quad (4)$$

where higher B_{ge} lowers the marginal cost of production for all quality levels, while higher β_{ge} decreases the marginal cost of quality upgrading.⁶ We will refer to B_{ge} and β_{ge} as quantity and quality productivity parameters, respectively.

The fixed cost of production is sector and country specific and is denoted by C_{ge} . Every change in the characteristics of a product, including its quality, requires incurring the fixed cost. We assume that production takes some time. Thus, a firm first chooses the quality and later sets the optimal price.

⁶A similar marginal cost function was first introduced by Flam and Helpman (1987) and later used by Hummels and Klenow (2005).

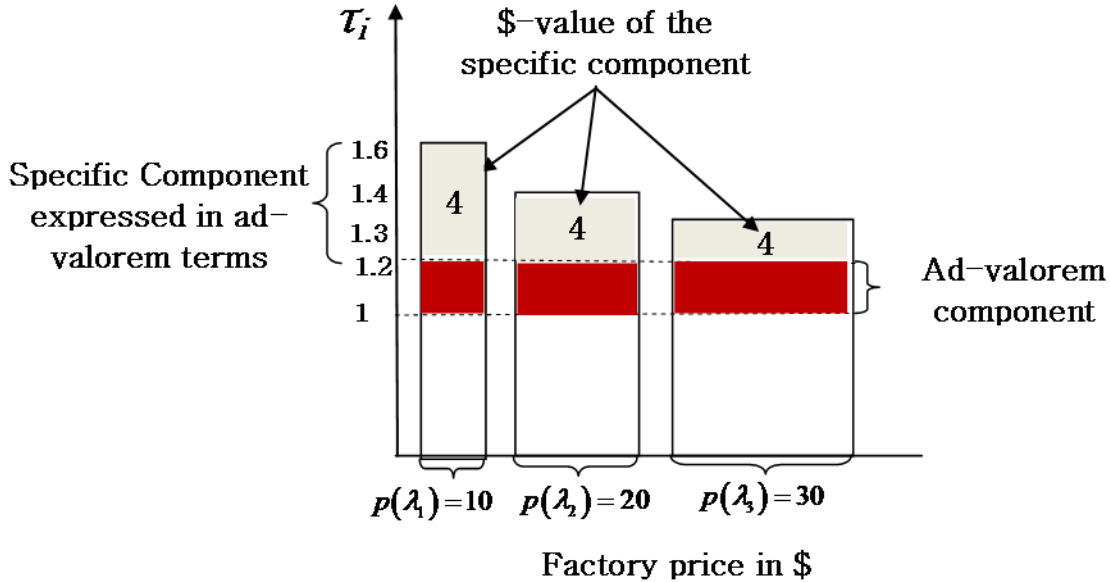


Figure 1: ad valorem and Specific Components in the Augmented Iceberg Trade Cost

2.3 Trade costs

International trade costs combine ad valorem tariffs and specific transportation costs. The ad valorem tariff of sector g 's varieties from e to i is denoted as a_{gie} and the corresponding specific transportation cost as s_{gie} . Internal trade costs are assumed to be equal to zero, $a_{gii} = s_{gii} = 0$. In our model, we attempt to preserve the analytical simplicity and tractability of the Samuelson iceberg functional form. To this end, we assume that transporters set the schedule of transportation costs in ad valorem terms, so that the total trade cost can be expressed as

$$\tau_{g\gamma ie}(\lambda_{g\gamma e}) = \eta_{ie} \left[1 + a_{gie} + \frac{s_{gie}}{p_{g\gamma ie}(\lambda_{g\gamma e})} \right] \quad \eta_{ie} \geq 1, \quad (5)$$

where $\tau_{g\gamma ie}(\lambda_{g\gamma e}) - 1$ is the amount of variety γ of quality $\lambda_{g\gamma e}$ required to export one unit of this variety from e to i , and $p_{g\gamma ie}(\lambda_{g\gamma e})$ is the factory-gate (i.e., net of transportation cost) price of this variety (see also Figure 1). η_{ie} is a scaling parameter that does not depend on quality and does not affect the relative shares of ad valorem and specific components of trade costs. The internal scaling parameter is set to unity: $\eta_{ii} = 1$.

The specific transportation cost is assumed to be lower than the factory-gate price in order to ensure that the second-order conditions hold in the market equilibrium:⁷

$$s_{gie} < p_{g\gamma ie}$$

⁷See Appendix for the proof of the second-order conditions.

The transportation sector is perfectly competitive, and transporters post their schedules before observing the actual prices. In particular, a transporter posts the transportation cost schedule for every quality level $\lambda_{g\gamma e}$. To achieve this goal, the transporter considers the best response of a producer, that is, how the producer will respond after observing the schedule of $\tau_{g\gamma ie}(\lambda_{g\gamma ie})$. The producer then takes the trade cost schedule as given and chooses the profit-maximizing delivered price $P_{g\gamma ie}$.

Finally, we assume that while better transportation infrastructure (e.g., the quality of ports, airports, etc.) lowers the transportation cost, the individual transporters take the level of infrastructure as given and have no control over it.

2.4 Market equilibrium and predictions

In this section, our main focus is on the equilibrium prices (as indicators of quality) of Exporter's goods shipped to Importer. For brevity, we omit exporter and sector subscripts.

We start with a profit-maximization problem of a firm producing variety γ . The firm first calculates the optimal price for a given quality level and corresponding transportation costs with respect to the vector of delivered prices to each destination $\{P_{\gamma E}, P_{\gamma I}\}$:⁸

$$\max_{P_{\gamma E}, P_{\gamma I}} \pi_\gamma = X_{\gamma E} [P_{\gamma E} - wb_\gamma \tau_{\gamma E}] + X_{\gamma I} [P_{\gamma I} - wb_\gamma \tau_{\gamma I}] - C, \quad (6)$$

where $X_{\gamma i}$ is the total delivered quantity of the differentiated variety γ to country $i \in \{E, I\}$ and $\tau_{\gamma i}$ is the corresponding iceberg trade cost. From the first-order conditions with respect to $P_{\gamma i}$,

$$\frac{\partial \pi_\gamma}{\partial P_{\gamma i}} = \frac{\partial X_{\gamma i}}{\partial P_{\gamma i}} (P_{\gamma i} - wb_\gamma \tau_{\gamma i}) + X_{\gamma i} = 0,$$

we obtain a standard expression à la Krugman (1980) for the delivered price:⁹

$$P_{\gamma i} = \frac{\sigma}{\sigma - 1} b_\gamma \tau_{\gamma i}, \quad (7)$$

which is a product of the monopolistic markup, marginal cost of production b_γ , and iceberg trade cost $\tau_{\gamma i}$. The corresponding factory-gate can be obtained by dropping the trade cost $\tau_{\gamma i}$, which makes the factory-gate price p_γ destination invariant:

$$p_{\gamma i} = p_\gamma = \frac{\sigma}{\sigma - 1} \frac{w}{B} \exp\left(\frac{\lambda_\gamma}{\beta}\right) \quad \forall i \in \{E, I\}. \quad (8)$$

It is important to note further that even though producers are free to charge destination specific

⁸Since the firm has to incur a fixed cost when choosing a new quality level, it chooses the same quality for both destinations rather than a destination-specific quality, which would require paying the fixed cost twice.

⁹The second order conditions hold for any quality level λ_γ , since (i) $\frac{\partial \pi_\gamma^2}{\partial^2 P_{\gamma i}} = -\frac{X_{\gamma i}}{P_{\gamma i}}(\sigma - 1) < 0$ and (ii) $\frac{\partial \pi_\gamma^2}{\partial^2 P_{\gamma E}} \frac{\partial \pi_\gamma^2}{\partial^2 P_{\gamma I}} - \left(\frac{\partial \pi_\gamma^2}{\partial P_{\gamma E} \partial P_{\gamma I}}\right)^2 = \frac{X_{\gamma E}}{P_{\gamma E}} \frac{X_{\gamma I}}{P_{\gamma I}} (\sigma - 1)^2 > 0$.

factory-prices (i.e., to price-discriminate across locations), the “no arbitrage” condition holds: for a given quality level, the equilibrium factory-price is independent of the trade cost and is the same across destinations. Therefore, despite the specific component of the trade cost, the analytical convenience of the Samuelson iceberg is preserved.¹⁰

By plugging the factory-gate price into equation (5), we solve for the equilibrium trade cost expressed as a Samuelson iceberg:

$$\tau_{\gamma I} = \eta_I \left[1 + a_I + \frac{\sigma - 1}{\sigma} \frac{s_I}{\frac{w}{B} \exp(\lambda_\gamma/\beta)} \right].^{11} \quad (9)$$

The above solutions (8) and (9) are unique for a given destination i and quality level λ_γ .¹²

The profit equation, given the profit-maximizing prices (see equation (7)), is now given by the following:

$$\pi_\gamma = X_{\gamma E} \frac{wb_\gamma \tau_{\gamma E}}{\sigma - 1} + X_{\gamma I} \frac{wb_\gamma \tau_{\gamma I}}{\sigma - 1} - C.$$

We next proceed with the first-order condition with respect to quality level λ_s :

$$\frac{\partial \pi_\gamma}{\partial \lambda_\gamma} = \frac{1}{\sigma - 1} \sum_{i \in \{E, I\}} \left[\frac{\partial X_{\gamma i}}{\partial \lambda_\gamma} wb_\gamma \tau_{\gamma i} - X_{\gamma i} w \left(\frac{\partial b_\gamma}{\partial \lambda_\gamma} \tau_{\gamma i} + b_\gamma \frac{\partial \tau_{\gamma i}}{\partial \lambda_\gamma} \right) \right] = 0.$$

Given the utility function (1), equilibrium prices (7) and (8), and trade cost (9), the above formula can be simplified as follows:

$$\sum_{i \in \{E, I\}} P_{\gamma i} X_{\gamma i} \left(\frac{\delta_i}{\lambda_\gamma} - \frac{1}{\beta} \frac{1 + a_i}{1 + a_i + s_i/p_\gamma} \right) = 0, \quad (10)$$

from which we find the equilibrium quality:¹³

$$\lambda_\gamma = \beta \frac{\sum_i (PX)_{\gamma i} \delta_i}{\sum_i (PX)_{\gamma i}} \left[\frac{\sum_i (PX)_{\gamma i} A_{\gamma i}}{\sum_i (PX)_{\gamma i}} \right]^{-1} \equiv \beta \frac{\bar{\delta}_i}{A_{\gamma i}}, \quad (11)$$

where

$$A_{\gamma i} \equiv \frac{1 + a_i}{1 + a_i + s_i/p_\gamma} \quad \forall i \in \{E, I\} \quad (12)$$

is the ad valoremness of trade costs from Exporter to country $i \in \{E, I\}$.

Since $P_{\gamma i}$, $X_{\gamma i}$, and $\tau_{\gamma I}$ depend on quality, the above result does not provide an explicit solution for λ_γ . However, it shows that the quality increases in the weighted average intensity of preference for quality $\bar{\delta}$, and decreases in the weighted average ratio of the ad valorem part of the iceberg over

¹⁰This property is achieved due to the assumption that producers take the transportation cost schedule as given.

¹¹Recall that the internal trade cost is set to zero, and thus $\tau_{\gamma E} = 1$.

¹²The factory-gate price is a monotonically increasing function of quality; thus, there is a unique factory-gate price for each quality. The expected factory price is unique for each λ for the same reason, which makes the equilibrium trade cost unique as well.

¹³The second-order conditions are provided in the Appendix.

the total iceberg transportation cost, $\overline{A_{\gamma i}}$.

Given that the upper-case utility function is of the quasi-linear utility functional from (1), the marginal utility gained from variety $\gamma'i$ is equal to its price:

$$\frac{1}{x_{\gamma'i}} \left(\lambda_{\gamma'i}^{\delta_i} x_{s'i} \right)^{\frac{\sigma-1}{\sigma}} \frac{\varepsilon-1}{\varepsilon} \left(\sum_{\gamma \in g} \left(\lambda_{\gamma}^{\delta_i} x_{\gamma i} \right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\varepsilon-\sigma}{\sigma\varepsilon-\varepsilon}} = P_{\gamma'i},$$

from which given the symmetry of all g 's firms in equilibrium, the equilibrium per-consumer quantity is given by

$$x_{\gamma'i} = \left(\frac{\varepsilon-1}{\varepsilon} \right)^{\varepsilon} P_{\gamma'i}^{-\varepsilon} N_g^{\frac{\varepsilon-\sigma}{\sigma-1}} \lambda_{\gamma'}^{\delta_i(\varepsilon-1)},$$

where N_g is the equilibrium number of firms in sub-sector g . Given the number of consumers in each country, we can find the per-country level of consumption of a representative variety γ ,

$$X_{\gamma i} = \left(\frac{\varepsilon-1}{\varepsilon} \right)^{\varepsilon} L_i P_{\gamma i}^{-\varepsilon} N_g^{\frac{\varepsilon-\sigma}{\sigma-1}} \lambda_{\gamma}^{\delta_i(\varepsilon-1)},$$

which we plug into equation (12) to get an updated expression:

$$\lambda_{\gamma} = \beta \delta_E \frac{1 + (K_I \tau_{\gamma I}^{1-\varepsilon}) \frac{\delta_I}{\delta_E}}{1 + (K_I \tau_{\gamma I}^{1-\varepsilon}) A_{\gamma I}}, \quad \forall \gamma \in g, \quad (13)$$

where $K_I = \frac{L_I}{L_E} \lambda_{\gamma}^{(\delta_I - \delta_E)(\varepsilon-1)}$. Note that quality crucially depends on Exporter-Importer's characteristics. Since factory price is a monotonic function of quality, Exporter's price is a function of the same parameters.

Proposition 1. *The quality of an exported (from Exporter to Importer) variety γ is affected by both the ad valoremness and magnitude of trade costs $\tau_{\gamma I}$. The ad valoremness decreases quality, while the effect of the magnitude of trade costs is positive if the relative importer-exporter preference for quality, $\frac{\delta_I}{\delta_E}$, is less than the ad valoremness $A_{\gamma I}$, and negative if $\frac{\delta_I}{\delta_E}$ is greater than the ad valoremness.*

Proof. The ad valoremness effect is evident from equation (13). For the net (of ad valoremness) effect of the magnitude of the trade costs $\tau_{\gamma I}$ on quality, please see the Appendix. \square

2.5 Multiple countries

While the effect of importer-exporter income differences on quality is most clearly seen in a two-country setting, it also exists in multi-country contexts, albeit with a slight modification. In this section, we show that the bilateral predictions formulated in Proposition 1 are robust to a multi-country setting. Theoretically, the crucial extension lies in adding a third country, which can be thought of as the "rest of the world". In particular, consider adding to our framework a third country, Other (indexed by O), which represents the rest of the world. Maintaining the set-up and

notation from the two-country model, it is easy to show that the pricing decisions of firms (given quality) will be the same as in the two-country model. The first-order conditions with respect to quality can be expressed as

$$\sum_{i \in \{E, I, O\}} P_{\gamma i} X_{\gamma i} \left(\frac{\delta_i}{\lambda_{\gamma}} - \frac{1}{\beta} \frac{1 + a_i}{1 + a_i + s_i/p_{\gamma}} \right) = 0 \quad \forall i \in \{E, I, O\}, \quad (14)$$

and the quality of goods exported from Exporter to both Importer and Other will be given by

$$\lambda_{\gamma} = \beta \delta_E \frac{1 + K_I \frac{\delta_I}{\delta_E} \tau_{\gamma I}^{1-\varepsilon} + K_O \frac{\delta_O}{\delta_E} \tau_{\gamma O}^{1-\varepsilon}}{1 + K_I A_{\gamma I} \tau_{\gamma I}^{1-\varepsilon} + K_O A_{\gamma O} \tau_{\gamma O}^{1-\varepsilon}}, \quad \forall \gamma \in g, \quad (15)$$

where $K_i = \frac{L_i}{L_E} \lambda_{\gamma}^{(\delta_i - \delta_E)(\varepsilon - 1)}$ and $A_{\gamma O} = \frac{1 + a_i}{1 + a_i + s_i/p_{\gamma}} \forall i \in \{I, O\}$. The predictions derived in the two-country model are now subject to additional constraints that take into account the rest of the world, represented by Other. Intuitively, it is desirable for the incomes of Exporter and Other to be on the same side of inequality, when compared to Importer's income, for the original predictions to hold in a three-country setting.

Proposition 2. *In a three-country model, the quality of variety γ sold from Exporter to Importer is affected by the trade costs from Exporter to Importer $\tau_{\gamma I}$, controlling for the ad valoremness of trade costs, $A_{\gamma I} = \frac{1 + a_I}{1 + a_I + s_I/p_{\gamma I}}$:*

(i) *the effect is positive if the relative Importer-Country_i preference for quality, $\frac{\delta_I}{\delta_i}$, is less than the corresponding relative ad valoremness $\frac{A_{\gamma I}}{A_{\gamma O}}$ for each country $i \in \{E, O\}$;*

(ii) *the effect is negative if $\frac{\delta_I}{\delta_i} > \frac{A_{\gamma I}}{A_{\gamma O}}$ for each country $i \in \{E, O\}$.*

Proof. See Appendix. □

2.6 Implications for heterogeneous firms models

In heterogeneous firms models with trade, firms are typically ranked by the distribution of marginal costs (of production) with the lowest marginal cost firms being the highest revenue and profit firms.¹⁴ Baldwin and Harrigan (2011), on the other hand, allow for the possibility of the higher cost firms to produce higher quality goods and thus to face stronger demand. As a result, in their augmented variant of the Melitz (2003) model, the lowest cost firms are not necessarily the most profitable ones.¹⁵ Importantly, in all of these models, there is only one marginal cost parameter, that differs across firms and thus determines the ranking of productivities.¹⁶

¹⁴See, for example, Eaton and Kortum (2002), Melitz (2003), and Melitz and Ottaviano (2008). An exception is Romer (1994), who ranks firms by the fixed cost of entering the market.

¹⁵The exact ranking depends on the strength of the correlation between cost and quality. For sufficiently high correlations, the higher cost firms are the most profitable ones.

¹⁶Baldwin and Harrigan (2011) use the same functional form of the marginal cost as in Melitz (2003), but they assume that a higher marginal cost might correspond to higher quality.

Our, à la Flam and Helpman (1987) cost function, on the other hand, contains two parameters (cost parameter for all quality types B , and quality upgrading parameter β) and allows for endogenous quality choice subject to preferences for quality from both the domestic and foreign markets. If used within the heterogeneous firms model, this cost function allows for more flexibility than traditional Melitz (2003) or Baldwin and Harrigan (2011) models, which predict a particular correlation between prices and profit levels. Below, we provide three observations that illustrate major deviations from the standard heterogeneous firms model obtained by using a more flexible cost function (4).

Observation 1. *Firms' quality levels and prices are positively correlated with the preferences for quality of the export destination.*

Observation 2. *The profit ranking of firms can change if the preferences for quality of a foreign country change.*

Observation 3. *The relationship between prices and profit levels is not necessarily monotonic for a given demand structure. As a result, the most profitable firms do not necessarily have to be outliers in terms of the prices they charge.*

In what follows, we demonstrate each of the above observations by means of a numerical example. We will consider two scenarios – *Poorer Importer* and *Richer Importer* – which differ only in terms of Importer's preference for quality (stemming from the difference in Importer's income), and are indexed by superscripts $-$ and $+$, respectively. In particular, $w_I^- = \delta_I^- = 2$, and $w_I^+ = \delta_I^+ = 4$.

All other parameters are the same for both scenarios. In particular, we assume $L_E = L_I$, $\varepsilon = 2$, $s = 0$, $\tau = 2$, and $w_E = \delta_E = 3$. In each scenario we consider two firms, with cost parameters given by $(B_1, \beta_1) = (20, \frac{1}{6})$ for the first firm and $(B_2, \beta_2) = (1, \frac{1}{2})$ for the second one.

By plugging the parameters into equation (13), we can find the equilibrium quality levels for both firms in each scenario:

$$\lambda_1^- = 0.41, \quad \lambda_2^- = 1.37, \quad \lambda_1^+ = 0.54, \quad \lambda_2^+ = 1.73.$$

From equation (8), the corresponding factory prices are as follows:

$$p_1^- = 1.7, \quad p_2^- = 46.1, \quad p_1^+ = 3.7, \quad p_2^+ = 95.8.$$

As we can see, both firms choose higher quality and charge higher prices when Importer has a greater preference for quality, which numerically confirms Observation 1.

Given that all firms charge the same markup and face the same fixed cost of production, the ranking of profits across firms is the same as the ranking of revenues, where using the results obtained in the section above, the equilibrium revenue of a firm is given as follows:

$$\sum_i P_i X_{\gamma i} = \left(\frac{\varepsilon - 1}{\varepsilon} \right)^\varepsilon N_g^{\frac{\varepsilon - \sigma}{\sigma - 1}} \left[L_E p_\gamma^{1 - \varepsilon} \lambda_\gamma^{\delta_E(\varepsilon - 1)} + L_I p_\gamma^{1 - \varepsilon} \lambda_\gamma^{\delta_I(\varepsilon - 1)} \right].$$

Then, the ratios of firms' revenues in each scenario are

$$\frac{\sum_{i=E,I} P_{1i}^- X_{1i}^-}{\sum_{i=E,I} P_{2i}^- X_{2i}^-} = 1.15 \qquad \frac{\sum_{i=E,I} P_{1i}^+ X_{1i}^+}{\sum_{i=E,I} P_{2i}^+ X_{2i}^+} = 0.52$$

As we can see, the profitability ranking changes between the scenarios, as predicted by Observation 2. Having poorer Importer as the export destination favors lower quality and lower-price Firm 1, while having richer Importer favors higher price Firm 2.

To illustrate Observation 3, let us introduce Firm 3 with cost parameters $(B_3, \beta_3) = (0.95, \frac{1}{2})$. In scenario $^+$, this firm charges the highest price, $p_3^+ = 48.5$. However, the highest profit will be earned by Firm 2, which charges the second highest price (both Firms 2 and 3 will produce the same quality, $\lambda_2^+ = \lambda_3^+ = 1.73$, but Firm 3 has a higher cost, and thus a lower profit).

Manova and Zhang (2012) emphasize and closely investigate variation in export prices across destinations in a model of trade with heterogeneous firms. Their estimation of how product-level export prices vary with the destination characteristics (Table II in their paper) is most closely related to our exercise. They report distance elasticities of export prices that are seemingly with odds with ours; negative for rich and positive for poor destinations. The discrepancy can be attributed to the differences in sample and specification used in our paper. By focusing on the within exporter variation the effect of distance on the f.o.b. price captures the “net effect of both the quality and mark-up adjustments.” Imperfect passthrough of distance-related trade barriers would lower f.o.b. price with distance, working against the Alchian-Allen effect. This effect is presumably stronger in the less competitive smaller markets of the poor destinations. The effect of the mark-up channel may also play a stronger role because they do not restrict products to the subsample of differentiated manufacturing goods.

3 Empirics

3.1 Data

Our main dataset combines import data for several Latin American countries with the US Census Imports of Merchandise for 2000–2005. The data include detailed product-level information on imports to nine Latin American countries (Argentina, Brazil, Chile, Columbia, Ecuador, Mexico, Peru, Uruguay, and Venezuela) and the United States from all exporters worldwide. The data are disaggregated by importer i , exporter e , and good g . We aggregate a good g to a Harmonized System 6-digit (HS6) category, with roughly 5,000 product categories. We observe value, weight, duties paid, and shipment charges. Since our main focus is on the cross-country differences in quality, we take the three-year averages of all variables. The averages are taken for the periods 2000-2002 and 2003-2005. We sum value, weight, duties, and shipment charges, and then divide the aggregates to obtain values and transportation charges per unit of weight. We refer to the

ratio of total value to the the total weight as unit values or exporter prices interchangeably. Each observation is identified by a unique importer-exporter-product-period combination and is indexed by *iegt*. The exporter-specific variables, like GDP and per capita GDP, are also averaged for the two three-year periods.

These data are uniquely suited for our research question. First, in order to study the effect of income differences, we need a data set that contains several importers of varying income levels. Second, at the 6-digit level, the goods are identified with adequate detail to mitigate changes in quality due to compositional effects. In other words, a high price of “PRINTING INK, BLACK” (HS6 category 321511) is a better indication of quality than, for example, a high price of the more aggregated “TANNING & DYE EXT ETC; DYE, PAINT, PUTTY ETC; INKS” (HS 2-digit category 32). The latter could arise from a shift in the composition of trade toward more expensive types of goods within a given HS 2-digit category. Third, our data contain several measures of importer-exporter product-specific trade barriers: transportation costs and duties paid. This is a rare feature of the data that is important for proper accounting for shifts in quality composition (this point is discussed in more detail below). The data on transportation costs are scant, and they are observable only for a small set of countries. Instead, distance often serves as a catch-all proxy for trade barriers between countries. Product-level barriers are important for constructing a measure of income differences that is consistent with Proposition 1. Fourth, the HS6 trade data cover many more exporters than the more specialized data sets. This coverage is critical because the effect of geography on vertical specialization is identified from across-exporter variation. Lastly, since we are not interested in the differences across producers *within* an exporter country, importer-exporter product level data represent precisely the appropriate statistical unit for studying the effect of importer-export income differences on quality. This is because we focus on systematic differences in incentives to produce quality for *all* producers that export to a given importer.

One important limitation of even the most detailed product-level trade data sets that rely on a standard classification, such as the one used in this study, is that even at the 6-digit level of disaggregation, categories subsume a substantial amount of variation in characteristics that are not captured by the classification category. Those features may include brand, fabric design, color, the navigation package in a car, or the printing speed of a printer. This limitation is explored by Sheu (2011) and Blonigen and Soderbery (2010) in some narrowly specialized and highly disaggregated data sets. Harrigan, Ma, and Shlychkov (2011) find the composition to be important even at the most disaggregated level. Using a highly disaggregated proprietary firm level data set of the US exporters, they separate the effect of changes in composition on the average export prices. Relevant to our analysis, those studies reveal that compositional effects are ubiquitous, and thus must be taken into account. In our case, we need to verify the robustness of our findings to possible variation in composition by explicitly accounting for variation in quality composition within a product category. To this end, in several specifications we use country-pair product-level duties and freight rates to control for compositional effects across exporters, as in Hummels and Skiba (2004).

The data on the value of bilateral trade for the rest of the world come from the World Integrated

Trade Solution (WITS) data set for the years 2000–2005. These data are used for the estimation of gravity equations, the calculation of export-weighted GDP per capita, and the number of destinations for every exporter and product. The data on the GDP and population size are from the World Development Indicators. The population-weighted distances between trading partners are from Head and Mayer (2002).

The assumptions embedded in our theory apply to vertically differentiated products. The relevant data set is accordingly restricted to the Rauch-differentiated categories within manufacturing industries (see Rauch (1999)). It is customary to concentrate on these industries because of their presumed potential for vertical differentiation. Manufacturing industries correspond to HS 2-digit codes in the 30–38 and 42–97 intervals. We use Rauch’s conservative classification to select differentiated products (the differentiation indicator value of “n” in his dataset).

There is also a potential exporter dimension to vertical product differentiation, which presumably requires a certain degree of technological sophistication. To keep only relevant exporters, we restrict our sample to the OECD and upper-middle income exporters. The designation of the countries is taken from the World Bank classification of country groups. There are 31 high-income OECD member countries. According to the World Bank, the upper-middle income economies are those with a Gross National Income between \$4,036 and \$12,475. This category contains 54 countries. We do not use high-income non-OECD countries, such as Andorra, Bahamas, Kuwait, and Slovenia.

Starting with these data, we apply further screening. First, it is common to censor small-value observations to limit noise. We restrict trade flows with a value lower than \$5,000 (in current dollars). Second, we retain only those importer-product-year categories with at least five exporters. We also keep only exporters that serve at least five destinations with the HS6 category in a given year. Third, for some specifications, we rely on product-country-pair trade costs¹⁷; therefore, some observations are omitted due to a lack of data. Table 1 illustrates the result of the restriction on the composition of our data set.

Table 1: Sample Description and Effect of Data Screening

Sample	Import value, %	HS6 products	Product-importer-year combinations	Importers
Unscreened sample	100.00	2,389	44,421	10
Value screen	99.96	2,388	41,423	10
Variation screen	99.95	2,387	41,272	10
Product level country-pair barrier screen	81.05	2,386	32,140	8

Notes. The screening is performed on the dataset that contains OECD and Upper-Middle Income exporters with non-missing observations for unit values. The information on collected duties is available for: Argentina, Brazil, Chile, Colombia, Ecuador, Peru, Uruguay, USA, and is not available for Mexico and Venezuela.

¹⁷For example, freight rate, tariff, and bilateral air-transportation instruments described in the next section.

3.2 Methodology

Our empirical exercise contributes to the understanding of the geographic variation in the unit values of traded goods. Our focus is on two widely used geographic proxies for trade costs: distance and contiguity. Similar to other research in this field, we use the theory of vertical product differentiation to interpret the results of the export-price regressions. This approach is based on the premise that the export prices contain information about quality. The connection between quality and prices has been acknowledged frequently in the literature on consumer price indexes and has received attention in the trade literature. However, in addition to quality, the unit values can differ for a variety of other reasons. Chief among them, are those related to the producer’s pricing decisions in the presence of market power. Price-setting producers can charge different factory prices across geographically segmented markets because of both price discrimination and pricing-to-market. For these reasons, we explicitly control for market-related variation in the unit values and concentrate on the across-exporter variation in the bilateral quality shifters. To this end, in all export-price specifications, we control for product-importer-period unobserved heterogeneity with fixed effects, thus confining our estimation to the variation within a given destination market.¹⁸

Figures 2 and 3 illustrate the main idea of our approach. Keeping in mind that the associations demonstrated in the figures are univariate and unconditional, we use these figures to justify the expected results. The figures present data for specific markets defined by the importer-product-period combinations. It is precisely this type of variation in the unit values that we explore in the empirics.

Figure 2 plots the unit values of US imports in two categories: men’s shirts and beauty products.¹⁹ In both cases, distance has a negative effect on unit value in the case of the relatively rich importer, the United States. This association fits well with our theoretical prediction. The farther the exporter is from the richer US market (observations denoted by $D = 0$ to match the notation used in the rest of the empirics), the stronger is the influence of the exporter’s own domestic market with a lower demand for quality. The US case of the US is apparent from the simple bivariate plots, because the US market is both large and rich.

Unfortunately, the opposite case, where the exporter is richer than the importer (denoted by $D = 1$ in the figure), cannot be effectively illustrated on the US import data because there are only few exporters that are richer than the United States (e.g., Luxembourg, Norway, Japan). Figure 3 shows a similar exercise for Brazilian imports of t-shirts and Mexican imports of refrigerators.²⁰ For these importers the number of both relatively rich and relatively poor exporters is sufficient to illustrate the polarization of the distance effect on export prices. For the relatively rich exporters,

¹⁸The fixed effects also control for unobserved market-specific product-level factors that can affect prices but might not necessarily be related to quality differences. Among them are differences in market structure, taxation, level of protection, and domestic production.

¹⁹More specifically “MEN’S OR BOYS’ SHIRTS, NOT KNIT, OF COTTON” and “BEAUTY & SKIN CARE PREPARATION, NESOP”, respectively. The first product was used as an example in Schott (2004)

²⁰More specifically “T-SHIRTS, SINGLET, TANK TOPS ETC, KNIT ETC COTTON” and “COMBINED REFRIGERATOR-FREEZERS W SEPARATE DOORS”, respectively.

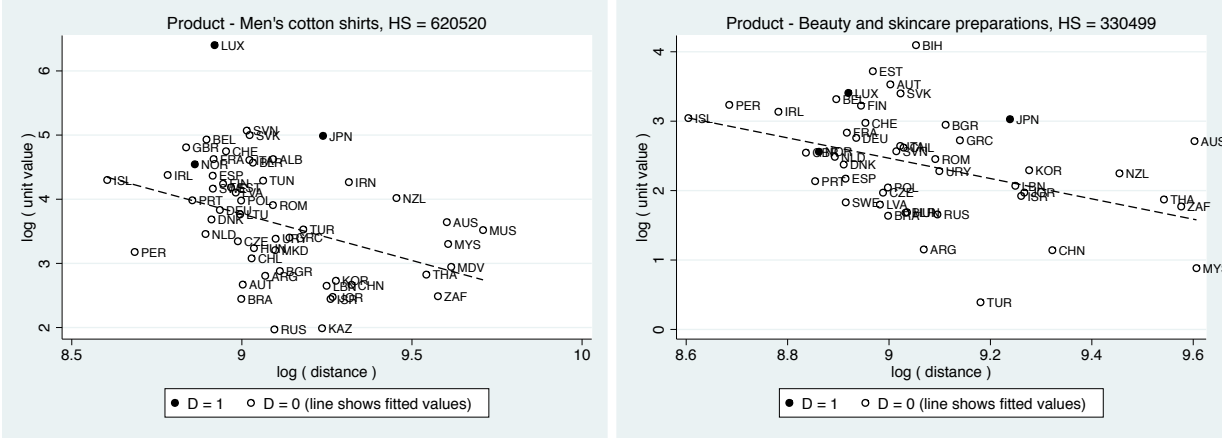


Figure 2: Unit value of US imports and distance.

Notes. D reflects importer-exporter income difference; $D = 1$ corresponds to the case of relatively rich exporter, otherwise $D = 0$. The unit values are calculated in current dollars per Kg. The imports are for 2003-2005. The distances are censored at $\ln(\text{dist}) = 8.5$. The labels correspond to ISO country codes of the exporter. $D = 1$ for Luxembourg, Norway, and Japan. The exporters include OECD and upper-middle income economies.

remoteness increases prices, since both Linder and Alchian-Allen effects work in the same direction. The remoteness from the low income importer does not have the same detrimental effect on quality as it does in the case of the United States. Note that in both panels of Figure 3, the overall effect hides the substantial polarization in the relationship between distance and unit value. The basic insight from these illustrative examples is confirmed by the econometric specifications.

By concentrating on the variation within the market, we are effectively interpreting deviations in unit values from the market mean as measures of quality. In order to validate the use of within-market variation in unit values as a measure of quality, we compare unit values with direct estimates of exporter-product quality preference parameters from Khandelwal (2010). Exploiting variation in the US import shares within exporter-product groups, Khandelwal develops a discrete choice methodology to estimate exporter-product demand shifters. Product quality is measured as the US-specific exporter-product demand shifter²¹. We denote it by $\hat{\lambda}_{eg}$ to match the notation of Khandelwal's paper (referred to as $\lambda_{1,ch}$ in his paper). Here and in what follows, index i denotes country importer; e , country exporter; g , HS6 good; t , period. Following Khandelwal's methodology, we re-estimate $\hat{\lambda}_{eg}$ parameters for an extended data set that includes US imports from 1989 to 2006 and thus overlaps with our dataset. Details of the estimation can be found in Khandelwal (2010) or Levchenko, Lewis, and Tesar (2011). The application of the discrete choice methodology relies on the effective control for product characteristics and is therefore estimated with the most disaggregated fixed effects available. We aggregate the obtained estimates to HS6 by simple averaging.

The estimates of quality exhibit substantial dispersion within each product. In order to limit the effect of outlying estimates, we eliminate the top and bottom 1% of $\hat{\lambda}_{eg}$ for each HS6 product category. Further, we consider only those HS6 categories with at least 1,000 observations in the US imports data set that was used to estimate the quality parameters. Finally, we scale $\hat{\lambda}_{eg}$ by

²¹Khandelwal (2010) also estimates the time component, which we do not use in our cross-sectional comparison.

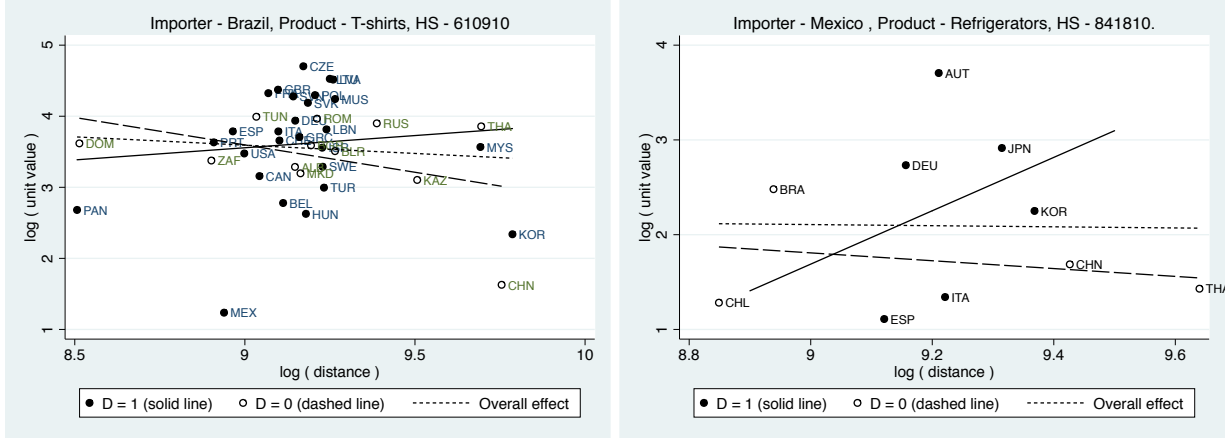


Figure 3: Unit value of imports and distance.

Notes. D reflects importer-exporter income difference; $D = 1$ corresponds to the case of relatively rich exporter, otherwise $D = 0$. The unit values are calculated in current dollars per Kg. The imports are for 2003-2005. The distances are censored at $\ln(\text{dist}) = 8.5$. The labels correspond to ISO country codes of the exporter. $D = 1$ for Luxembourg, Norway, and Japan. The exporters include OECD and upper-middle income economies.

100 to facilitate the interpretation of the magnitudes. This is because $\hat{\lambda}_{eg}$ is the fixed effect in a regression of the logarithm of the expenditure share relative to a reference category. In other words, the magnitude of $\hat{\lambda}_{eg}$ can be interpreted as a percentage deviation in the expenditure shares from the reference category. In order to match our main specification, we concentrate on differentiated manufacturing imports from OECD and middle-upper income countries.

We estimate the following auxiliary regression using a mean-difference fixed effects estimator with panel-robust standard errors to compare deviations from the product means between logs of unit values and Khandelwal's quality parameters.

$$\ln p_{egt} - \overline{(\ln p_{egt})}_{gt} = \phi \left(\hat{\lambda}_{eg} - \overline{(\hat{\lambda}_{eg})}_{gt} \right) + \left(\nu_{egt} - \overline{(\nu_{egt})}_{gt} \right) \quad (16)$$

The estimated coefficient $\hat{\phi} = 1.02$ is not significantly different from 1, with 95% confidence level. This is reassuring because the magnitude suggests that one percentage point deviation of the unit value from the product mean is significantly associated with about one percentage point deviation of quality estimate $\hat{\lambda}_{eg}$ from the product mean.

Some crucial features of Khandelwal (2010) methodology preclude us from using his estimates as our main measure of quality. Namely, the variation in $\hat{\lambda}_{eg}$ parameters is estimated on one importer and thus contains information on both the product quality and the importer's preference for quality. Additionally, our data do not meet either the time series or the product detail data requirements for re-estimating quality for all of the Latin American importers in our sample.

Among other papers devoted to the estimation of quality, the work by Feenstra and Romalis (2012) closely relates to our work, because per unit trade costs are an important feature of their model. They suggest a methodology for parsing out the quality component from the overall variation in unit values across country pairs and time within 4-digit SITC Revision 2 product cat-

egories. While our work is related to theirs, the goal of our paper is distinct. We study whether importer-exporter income differences affect export prices, which we theoretically suggest could happen through the quality channel. To separate price from quality in the data that varies by importer-exporter product-time, their model implicitly assumes that the fixed cost of production is sufficiently low, so that the producers in each country make destination-specific quality choices in each product. The analysis in our paper complements Feenstra and Romalis (2012) in that we discuss a specific margin of quality adjustment. We concentrate on the situation where producing destination-specific quality is not always feasible. To model quality choice under such incentives, we explore the other extreme: single-quality firms. We explicitly acknowledge and model destination-specific quality choices in addition to the single-quality firms in Lugovskyy and Skiba (2013). As long as single-quality firms exist, relative income should matter. Note that our model is different from Feenstra and Romalis (2012) even in the two-country case because foreign and domestic demands jointly determine quality.

3.2.1 Linder correction dummy

The main goal of the empirical specification is to test whether the geographical variation in export prices depends on importer-exporter income differences in the way that our theory predicts. Is there evidence that the Linder effect significantly alters the Alchian-Allen effect on export prices? Specifically, we estimate how the importer-exporter income differences affect the trade-cost elasticities of export prices. The result in Proposition 1 is driven by the importer-exporter difference in the preference for quality δ . This difference in incomes alters the way that trade barriers affect quality. Proposition 2 confirms this conclusion in the presence of a third country. In order to incorporate income differences into unit-value regressions in the most direct way, we construct a binary variable that reflects the importer-exporter income differences. We refer to this binary variable as the Linder correction dummy because it is intended to capture differences in the estimated coefficients driven by the relative strength of the importer and exporter Linder effects. The Linder correction dummy is defined as follows:

$$D_{iegt} = \begin{cases} 1, & \text{if } \frac{y_{it}}{y_{et}} < A_{iegt} - 0.1 \\ 0, & \text{if } \frac{y_{it}}{y_{et}} > A_{iegt} + 0.1 \end{cases}, \quad (17)$$

where $A_{iegt} = (1 + a_{iegt}) / (1 + a_{iegt} + s_{iegt} / p_{iegt})$. Even though a and s are not directly observed, we do have information on predominantly ad valorem tariffs and predominantly specific transportation costs. Correspondingly, we proxy for A_{iegt} by $(1 + tar_{iegt}) / (1 + tar_{iegt} + f_{iegt} / p_{iegt})$, where p_{iegt} is the unit value, f_{iegt} is the per unit freight bill, and tar_{iegt} is tariff expressed in ad valorem terms. Note that we also define the Linder correction dummy with a 10% level of tolerance (-0.1 and +0.1 in the equation above). We do this to ensure that the income differences between the importer and exporter are sufficiently large to imply the differences in preferences for quality. That is why we

exclude the trade flows between countries for which $|\frac{y_{et}}{y_{it}} - A_{iegt}| < 10\%$.²²

In order to ensure that our findings are not confined to predictions stemming only from a two-country model, we also use an alternative definition of the Linder correction dummy, that is robust to a multi-country context. In particular, this definition follows the theoretical predictions of Proposition 2.

$$D_{iegt}^M = \begin{cases} 1, & \text{if } \frac{y_{it}}{y_{et}} < A_{iegt} - 0.1 \ \& \ \frac{y_{it}}{\bar{y}_{iegt}^O} < A_{iegt} - 0.1 \\ 0, & \text{if } \frac{y_{it}}{y_{et}} > A_{iegt} + 0.1 \ \& \ \frac{y_{it}}{\bar{y}_{iegt}^O} < A_{iegt} + 0.2 \end{cases}, \quad (18)$$

where \bar{y}_{iegt}^O is the export-weighted GDP per capita of all *other* than the importer i destinations for exports of good g from country e in period t .

Unitary freight charge and tariff are unique to our data and are not available for many other data sets. In order to verify the applicability of our methodology to a wider range of datasets, we experiment with the definition of the Linder correction dummy to make it independent of the product-level composition of the trade costs. In particular, in our sample, 97.5% of importer-exporter product-year ad valoremness observations are in the $(0.8, 1)$ interval²³. Thus, for the vast majority of our data, the redefined Linder correction dummy,

$$\tilde{D}_{iet}^M = \begin{cases} 1, & \text{if } \frac{y_{it}}{y_{et}} < 0.8 - 0.1 \\ 0, & \text{if } \frac{y_{it}}{y_{et}} > 1 + 0.1 \end{cases}, \quad (19)$$

satisfies the constraints imposed by equation (17). That is, by potentially sacrificing some degrees of freedom (the new band is presumably larger than the original one, causing loss of observations), we can test our hypothesis without having access to the product-level specific and ad valorem measures of the trade costs.

The multilateral version of the Linder dummy that uses the universal approximation for the degree of advaloremness is redefined similarly to equation (18) as follows.

$$\tilde{D}_{iegt}^M = \begin{cases} 1, & \text{if } \frac{y_{it}}{y_{et}} < 0.8 - 0.1 \ \& \ \frac{y_{it}}{\bar{y}_{iegt}^O} < 0.8 - 0.1 \\ 0, & \text{if } \frac{y_{it}}{y_{et}} > 1 + 0.1 \ \& \ \frac{y_{it}}{\bar{y}_{iegt}^O} > 1 + 0.1 \end{cases}. \quad (20)$$

Note that the Linder correction dummy in the above equation varies over goods, hence subscript g , even though we do not use product-level trade costs. This is because the trade-weighted exports to the rest of the world, \bar{y}_{iegt}^O , are calculated for each exporter and product.

²²We lose less than 2% of our observations as a result of the tolerance band.

²³1 is the theoretical maximum of A_{iegt} .

3.2.2 Empirical specifications and results

We test the predictions of Propositions 1 and 2 for the effects of distance and contiguity on export prices, using several specifications. The results of the estimation are presented in Tables 2, 3, 4, and 5. All specifications are estimated for the OECD and upper-middle income countries (denoted as “Middle” in the tables) according to the World Bank classification described earlier. OECD membership is used as a proxy for development and presumably indicates a comparative advantage in quality.

Table 2 presents our main set of results. In what follows, we describe the specifications used in this table.

Specification I is our main specification and our point of departure for the rest of the empirics. It is given by the following estimating equation:

$$\begin{aligned} \ln p_{iegt} = & \alpha_5 \ln(dist_{ie}) + \alpha_6 \ln(dist_{ie}) \times D_{iegt} + \alpha_7 \ln(Y_{et}) + \alpha_8 \ln(Y_{et}) \times D_{iegt} \\ & + \alpha_9(cont_{ie}) + \alpha_{10}(cont_{ie}) \times D_{iegt} + \alpha_{11}D_{iegt} + \alpha_{12} \ln(y_{et}) \\ & + \alpha_{igt} + \nu_{iegt} \end{aligned}, \quad (21)$$

where p_{iegt} is price measured as the unit value (value-to-weight ratio);

y_{et} , Y_{et} are income per capita and GDP (of the country exporter), respectively;

$dist_{ie}$ is the distance between importer and exporter;

D_{iegt} is the Linder correction dummy defined by equation (17);

$cont_{ie}$ is the contiguity dummy, equal to 1 if the importer and exporter share a common border;

α_{igt} is the term that captures unobserved importer-product-time heterogeneity in unit values;

ν_{iegt} is the error term.

The error term in this equation, as well as in all specifications below, captures measurement error in the dependent variable²⁴ and idiosyncratic reasons for quality variation that are not related to trade barriers, exporter size, and exporter income. It also captures variation in the unit values that is not related to the quality determinants.

Specification I-M differs from Specification I by the definition of the Linder correction dummy that reflects the multi-country extension of the model. The dummy D_{iegt} is defined according to equation (18), which takes into account the relative income of the destinations other than the importer. This specification verifies the robustness of our findings to the presence of multiple countries because the third country can be thought of as “the rest of the world.”

Specification II is obtained from Specification I by excluding the Linder correction dummy and its interactions terms. This specification most closely resembles the exercise performed in Baldwin and Harrigan (2011). Contrasting the coefficient on distance with Specifications I and I-M

²⁴One source of measurement error arises from the differences in the unit weights of high versus low quality goods. Higher quality goods can be heavier or lighter depending on the weight of the demand enhancing attributes embodied in the goods. This is likely to produce a measurement error because, driven by data quality and availability, we use weight to measure quantity.

reveals the polarization of the distance effect on export prices that can result in a composition bias. Even though ignoring the Linder correction dummy produces a positive effect of distance on export price, this effect is stronger for the country pairs where the importer has a lower income than the exporter.

The results presented in Table 2 provide strong support for our theoretical predictions. The interaction term of distance with the Linder correction dummy is statistically significant and positive in most cases. This is because the Alchian-Allen effect of distance is reinforced by the Linder effect that works in the same direction when the exporter is relatively rich $D_{iegt} = 1$. Curiously, for the OECD exporters in Specification I, a 10% increase in distance reduces the export price by 1.7% if the ratio of importer-exporter incomes is greater than the advaloremness of trade costs, but the same increase in distance increases the export price by almost equivalent to 1.6% when the ratio of importer-exporter incomes is less than the advaloremness. In fact, for the OECD exporters, the customary positive association between bilateral distance and unit values holds only when the exporter has a higher income than the importer. A comparison of Specifications I and II shows how the overall effects of distance and contiguity on export prices conceal the important polarization of those effects. Additionally, the magnitudes of the distance and contiguity effects on export prices, for each value of D_{iegt} are much larger in Specification I than the combined effect in Specification II. This conclusion survives various robustness checks presented in subsequent tables.

Even though our results appear particularly strong due to the reversal of the distance and contiguity coefficients, such a reversal is not required to test our theory. The test for our theory is not based on the reversal of the distance coefficient but on the positive coefficient of the interaction. This is because the Linder and Alchian-Allen effects work in opposite directions when the importer is relatively rich, $D_{iegt} = 0$. Therefore, for the upper-middle income exporters the direct effect of distance is positive in all specifications.

The polarization of the common border effect also occurs in a way that is consistent with the theory. Sharing a border with a relatively rich destination ($D_{iegt} = 0$) has a positive effect on export prices. The magnitudes of the effect are in the range of 0.21 – 0.42, which corresponds to a 23 – 52% increase in export prices if the neighboring destination country is relatively rich. On the other hand, sharing a border with a relatively poor destination has a pronounced negative effect on export prices. For both sets of exporters in Table 2, the interaction of the contiguity dummy with the Linder correction dummy is significantly negative and the magnitudes are larger than the magnitudes of the direct effect. It is also illustrative to point out that even though the effect of importer-exporter income difference on the contiguity coefficient is negative for both the OECD and upper-middle income countries, the net effect can go either way. As Specification II in Table 2 illustrates, when ignoring the Linder dummy, the effect of contiguity is positive for the OECD exporters and negative for the upper-middle income exporters.

Redefining the Linder correction dummy in a way that is consistent with the multi-country model in Specification I-M does not affect the results for the OECD countries, but it does reduce the support for our theory on the sample of upper-middle income exporters. The interaction with distance becomes indistinguishable from zero, while the interaction with contiguity continues to

be significantly negative. Perhaps, as the number of observations decreases, the correlation with contiguity becomes a bigger issue.

Controlling for product-level measures of trade costs

One issue that arises when we take theoretical predictions to the data is that we do not know the exact breakdown of the transportation cost into ad valorem and specific components. Fortunately, our data contain direct product-level measures of trade costs, that is, the freight charge, that can be used to trace the relative importance of the specific component of the trade costs. Using this information, we extend Specification I with unitary freight charge as a proxy for the specific component of distance and tariff as a shifter to the ad valorem component. The estimation results are presented in Table 3. **Specification III** is defined by the following estimating equation:

$$\begin{aligned} \ln p_{iegt} = & \alpha_1^E \ln(f_{iegt}) + \alpha_2^E \ln(f_{iegt}) \times D_{iet} & + \alpha_3^E \ln(tar_{iegt}) + \alpha_4^E \ln(tar_{iegt}) \times D_{iet} \\ & + \alpha_5^E \ln(dist_{ie}) + \alpha_6^E \ln(dist_{ie}) \times D_{iet} & + \alpha_7^E \ln(Y_{et}) + \alpha_8^E \ln(Y_{et}) \times D_{iet} \\ & + \alpha_9^E (cont_{ie}) + \alpha_{10}^E (cont_{ie}) \times D_{iet} & + \alpha_{11}^E D_{iet} + \alpha_{12}^E \ln(y_{et}) \\ & & + \alpha_{igt}^E + \varepsilon_{iegt} \end{aligned}, \quad (22)$$

where f_{iegt} – is the per unit freight bill ('freight bill'-to-weight ratio);

tar_{iegt} – is tariff expressed in ad valorem terms ('duty paid'-to-value ratio);

ε_{iegt} – is the error term.

Specifications IV is obtained by dropping the Linder correction dummy (and corresponding interaction terms) from Specification III. It is similar to the one used in Hummels and Skiba (2004). The important differences are that distance is included along with the unitary freight charge, and the estimation here is done within the importer-product-period, not within the exporter-product-period. Notably, the effect of distance on the export prices becomes negative in Specification IV when transportation costs are explicitly included in the model. This finding is interesting because, while this is consistent with our theory, it is harder to reconcile with other ones. Generally, theories where the size of the trade barrier, and not its nature, affects the quality of traded goods cannot immediately accommodate the negative effect of distance on export prices. A notable example is the model of Baldwin and Harrigan (2011). The estimates themselves are not at odds with the previous literature, because in Specification II in Tables 2 and 3, the effect of distance is still positive; it is just that the effect is more nuanced than previously acknowledged.

The rest of the results in Table 3 confirm our previous findings. The interaction of the Linder dummy with distance in Specification III affects the distance coefficient in a way similar to that shown in Table 2. Specifications III and I for OECD exporters do not include the interaction of contiguity with the Linder correction dummy because, after we retained only countries for which we observed product-level trade barriers, there was no variation in the interaction term.²⁵ For

²⁵Since Mexico is not in the sample, we lose information on the United States as the exporter that belongs to the OECD, is contingent to one of the importers, and has a higher income than the importer.

the upper-middle income countries both the interaction of the Linder dummy with distance and contiguity remain consistent with our theory.

The magnitude and the sign of the coefficients on freight and tariffs are generally in line with the previous findings. As expected, freight has a positive effect on quality and tariff, a negative effect on quality.

Table 3 also replicates Specifications I and II for the data set, where product-level controls are available, matching the sample used in Specifications III and IV in order to ascertain that the results of Specifications III and IV are not driven by sample restriction.

There is a potential endogeneity between price and freight charge in equation (22), because the unit cost of shipping more expensive goods is generally higher due to special shipping requirements or successful price discrimination by the shippers. In order to trace out the cross-country variation in shipping costs that is exogenous to the cost of shipping a particular product, we rely on the variables that reflect the transportation infrastructure. Infrastructure can be a valid instrument because it facilitates transportation at the aggregate level and is exogenous to the shipment of any particular product. We use the World Development Indicators variables, “Passengers carried by air” and “Carrier departures worldwide.” Each of the above variables is in logarithms. The instrument is then constructed by multiplying the importer and exporter variables.²⁶ The multiplication of the importer and exporter variables reflects the idea that the infrastructure on both ends of the transportation route affects the transportation costs. Note that even though the passenger counts and carrier departures are not scaled by any measure of the country size, the exclusion restriction on instruments is still satisfied because the main specification includes controls for the size of both the importer and exporter.

To motivate the choice of instruments note that some of the potential instruments were not suitable for our purposes. Notably, distance is a natural candidate for instrumental variable, as it was used in previous studies. However, our research question disqualifies distance from the set of potential instruments because distance can create trade barriers other than transportation costs. Measures of transportation scale produce similar qualitative results, but require assumption on the exogeneity of the supply and demand shocks. This could be problematic, given our focus on the importance of the aggregate market size in determining the demand for quality.

Additional fixed effects and an alternative Linder correction dummy

Table 4 provides a more stringent test of our theoretical predictions than Table 3, because all specifications include exporter-period fixed effects in addition to the importer-product-period fixed effects. This is an extremely stringent specification because the geographic proximity of the Latin American importers and the similarity of their incomes make the across-exporter variation important for the identification of distance and the Linder correction dummy. Not surprisingly, the significance levels are affected adversely. However, the main qualitative finding of polarization

²⁶In specifications that include the interaction terms, we instrument both freight rate and freight rate interacted with the Linder correction dummy by adding the interaction terms between all regular instruments and the Linder correction dummy to the list of the regular instruments described above.

persists, offering even stronger support for the theoretical channel suggested in our model.

Table 5 presents estimation results, where the Linder correction dummy is re-defined without using product-level measures of ad valorem trade costs share. The Linder correction dummy in **Specifications I' and I-M'** is defined according to equations (19) and (20) respectively, which allows us to test our predictions even when the data on the ad valorem share of trade costs are not readily available. The OECD results persist, while the results for the upper-middle income countries become somewhat weaker with regard to distance. Note that the re-definition of the Linder correction in Specification I-M' resulted in significant loss of observation. The results presented in Table 5 are encouraging. The results are robust to the re-definition of the Linder correction dummy. Thus, the main implications of our model are usable for a wide range of datasets that do not have an explicit measure of ad valorem and specific components of trade costs.

3.3 Implications for gravity estimation

In this section we consider the possible effect of our findings on the estimation of the widely used gravity model. Theoretically, our results have implications for gravity estimation, because distance and contiguity can have a differential effect on price and quantity in the gravity regressions. To evaluate the empirical relevance of our findings for gravity, we first re-estimate the unit value regressions on the HS6 bilateral trade flows taken from WITS.

The results are presented in the first two columns of Table 6. The two columns correspond to Specification I-M'.²⁷ Column (2) reports the estimation results with a full set of exporter-period fixed effects in addition to the importer-product-period effects.²⁸ Notice that the effect of the exporter income can still be estimated, because we use three-year averages when a particular product was traded between a given country pair. Our theory is broadly supported by the results in columns (1) and (2). The interactions of distance and contiguity with the Linder correction dummy have the expected signs and are statistically significant. The number of observations is substantially larger because, now, the sample includes all importers worldwide.

Next, we use the same regressors to explain the variation in quantity and value at the product level. Our theory does not offer clear predictions about the effect of the Linder correction dummy on the effect of distance and contiguity in the quantity regressions. Therefore, the quantity regression is necessary to understand the effect on value, which is a combination of the export-price and quantity effects. In other words, the coefficients in column (4) can be obtained as the sum of coefficients in columns (2) and (3). This is an implication of the linear property of the ordinary least squares estimator. The interaction of the Linder correction dummy and distance reduces the absolute value of the distance coefficient in the product-level gravity by about one-fifth. Most of this change comes through the price. The coefficient on $\ln(dist_{ie}) \times D_{iegt}$ in the price regression

²⁷The sample used to estimate columns (1) – (5) of Table 6 is restricted in the same way as the sample used in Table 5. The data are averaged for two three-year periods: 2000–2002 and 2003–2005. Only trade in differentiated manufacturing goods between the OECD and middle-income countries is included in the data.

²⁸Recent papers on gravity equation provide compelling reasons for the inclusion of both importer and exporter fixed effects. See, for example, Anderson and Wincoop (2003), and Anderson and Yotov (2010).

is 0.039 while the coefficient in the quantity regression is 0.016. The effect of contiguity does not seem to be affected by the importer-exporter income difference because the negative effect on price is offset by the positive effect on quantity.

It should be noted that the reliability of the product-level unit-value data in the WITS data is perhaps an important concern. We compared the WITS unit values to the better measured US and Latin American data. The comparison suggested that while the total value of trade is reasonably close between the two data sets, the similarity does not extend to the unit values. The unit values in the WITS data are much more dispersed with extreme outliers. Once the outliers are omitted, the WITS data offer a closer match to the Latin American data. Unfortunately, we have no way of assuring the general quality of the unit values data, and because the outliers can be fairly extreme, we chose not to use the unit values from the WITS data as our main specification.

The last two columns present the results of the aggregate gravity estimation. The sample used to estimate column (5) is obtained from the sample used to estimate column (4) by aggregating product-level trade to the importer-exporter-period. The magnitude of the distance coefficient is lower for exports from relatively rich exporters. The interaction of the contiguity with the Linder dummy is positive, indicating that the quantity effect found in column (3) probably dominates. In the last column of Table 6, we estimate gravity for all countries and all goods. The effect of income differences does not persist. This is not surprising because the model of trade in vertically differentiated products is not well suited for those cases.

4 Conclusions

In this paper we argue that the Alchian-Allen effect on export prices ought to be considered in combination with the Linder effect. Our simple two-country model combines these two effects in order to study the interaction between specific trade costs and preferences for quality. The introduction of the Linder effect produces one of the key findings of this paper: the effect of trade costs on export prices crucially depends on the importer-exporter income differences. The novel crux of our theory is that a specific trade barrier simultaneously lowers the relative price of high quality goods and decreases foreign demand for exports. As a result, if the foreign demand for quality is higher than the domestic demand, then even a specific trade barrier can reduce the quality of exports, contradicting the Alchian-Allen effect. When the Linder effect is ignored in the empirics, the trade costs elasticities of export prices are affected by the composition of the sample with respect to the importer-exporter income differences. If the sample contains mostly exports from high income countries the effect of distance would be consistent with the Alchian-Allen effect.

Our model has implications beyond the ones described in this paper. For example, the size of the domestic market affects specialization in a way that is distinct from the traditional home market effect. Other things held constant, a larger domestic market increases the incentive to produce the quality that is most demanded by the domestic producers.

The effect of trade barriers on the export prices can be generalized to a multi-country setting.

In a companion paper, Lugovskyy and Skiba (2013), we develop a fuller model that allows for multiple importers and exporters, and we do not restrict firms to producing a single quality. The multilateral setting is used to study the effect of geographic position on specialization. In this paper, we assume that quality cannot be adjusted for every destination, to focus on the effect of the demand composition on quality. If the firms can adjust quality costlessly for each destination, then the Linder effect would be completely captured by the importer-product-period fixed effect.

The effect of trade barriers on export prices has been studied extensively in the literature on pricing-to-market and more recently in the models that feature selection into export markets by firms with heterogeneous productivity. While these alternative theories could explain some of the effects of trade costs on unit values, they generally could not explain the empirical variation in the signs of these effects and variation of these effects with respect to the importer-exporter price differences as readily as our theory does. Selection models predict a pattern similar to the Alchian-Allen effect but would need to be modified to simultaneously accommodate the negative effect of ad valorem trade barriers and positive effect of specific trade barriers on export price. Furthermore, in order for the selection effect on export price to be stronger for the imports from high income countries, the trade barrier from those countries should be higher. Pricing-to-market is consistent with the negative effect of ad valorem trade costs on export price²⁹, but we are not aware of research that predicts the pattern and variation in the pass-through of trade barriers related to importer-export income differences.

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²⁹It would require very special convexity of the demand curve to accommodate the positive effect of the specific trade barriers.

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Appendix. Proofs of SOCs (quality) and Propositions 1.

Recall that our main focus is on the equilibrium quality and prices of Exporter's goods shipped to Importer and thus, for brevity, we omit exporter and sector subscripts.

Proof of the Second-Order Conditions with respect to quality.

The second derivative of the profit with respect to quality is given by

$$\begin{aligned} \frac{d\pi_\gamma^2}{d^2\lambda_\gamma} &= \sum_i \left[\frac{d(X_{\gamma i} b w \tau_{\gamma i})}{d\lambda_{\gamma i}} \left(\frac{\delta_i}{\lambda_\gamma} - \frac{A_{\gamma i}}{\beta} \right) + X_{\gamma i} b w \tau_{\gamma i} \left(-\frac{\delta_i}{\lambda_\gamma^2} - \frac{A_{\gamma i}}{\beta \tau_{\gamma i}} \frac{d\tau_{\gamma i}}{d\lambda_\gamma} \right) \right] \\ &= \sum_i X_{\gamma i} b w \tau_{\gamma i} \left[(\sigma - 1) \left(\frac{\delta_i}{\lambda_\gamma} - \frac{A_{\gamma i}}{\beta} \right)^2 + \left(-\frac{\delta_i}{\lambda_\gamma^2} - \frac{A_{\gamma i}}{\beta \tau_{\gamma i}} \frac{s_i}{\beta p_\gamma} \right) \right]. \end{aligned}$$

where $A_{\gamma i} = \frac{1+a_i}{1+a_i+s_i/p_\gamma}$ is the ad valoremness of trade costs. After adding and subtracting $(\sigma - 1) \frac{\delta_i^2}{\lambda_\gamma^2}$, the expression can be transformed into:

$$\begin{aligned} \left. \frac{d\pi_\gamma^2}{d^2\lambda_\gamma} \right|_{\lambda=\lambda^*} &= - \sum_i \frac{X_{\gamma i} P_{\gamma i}}{\sigma} \left[\frac{A_{\gamma i}}{\beta} \left(\frac{\delta_i}{\lambda_\gamma} - \frac{A_{\gamma i}}{\beta} + \frac{\delta_i}{\lambda_\gamma} \right) + \frac{\delta_i}{\lambda_\gamma^2} \left(\frac{1}{\sigma - 1} - \delta \right) + \frac{A_{\gamma i}}{\beta \tau_{\gamma i}} \frac{s_i}{\beta p} \right] \\ &= \underbrace{\sum_i \frac{X_{\gamma i} P_{\gamma i}}{\beta \sigma} \left(\frac{A_{\gamma i}}{\beta} - \frac{\delta_i}{\lambda_\gamma} \right)}_{=0 \text{ at } \lambda=\lambda^*} - \sum_i \frac{X_{\gamma i} P_{\gamma i}}{\beta \sigma} \left[\underbrace{\frac{\delta_i}{\lambda_\gamma \tau_{\gamma i}} \left(1 + a_i - \frac{s_i}{p} \right)}_{>0 \forall s_i < p} + \underbrace{\frac{\beta \delta_i}{\lambda_\gamma^2} \left(\frac{1}{\sigma - 1} - \delta \right)}_{>0 \forall \delta(\sigma-1) < 1} + 2 \frac{A_{\gamma i}}{\beta \tau_{\gamma i}} \frac{s_i}{p} \right] < 0. \end{aligned}$$

As follows from the expression above, the second-order conditions are satisfied when $s_i < p_\gamma$ and $\delta(\sigma - 1) < 1$ which we have already assumed. \square

Proof of Proposition 1

Our task of evaluating the effect of the magnitude of trade cost on quality net of the ad valoremness relies on utilizing the functional form of the trade costs (see equation (5)). In particular, we derive the net of ad valoremness effect of trade costs on quality by deriving the effect of the scaling parameter η_I on quality. To this goal, we apply the Implicit Function Theorem to equation (10):

$$\frac{d\lambda_\gamma^*}{d\eta_{\gamma I}} = - \frac{\frac{\partial^2 \pi_\gamma}{\partial \lambda_\gamma^2}}{\frac{\partial^2 \pi_\gamma}{\partial \lambda_\gamma \partial \eta_I}} \bigg|_{\lambda=\lambda^*} = - \frac{\frac{\partial^2 \pi_\gamma}{\partial \lambda_\gamma^2}}{-(\varepsilon - 1) \frac{1}{\eta_I} X_{\gamma I} b w \tau_{\gamma I} \left(\frac{\delta_I}{\lambda_\gamma^*} - \frac{A_{\gamma I}}{\beta} \right)} \bigg|_{\lambda=\lambda^*}.$$

From the Second Order Conditions, the numerator is negative, and thus the sign of the entire expression coincides with the sign of the denominator. By using the equilibrium value of quality λ_γ^* (equations (13)), the denominator can be expressed as:

$$(\varepsilon - 1) \frac{1}{\eta_I} X_{\gamma I} b w \tau_{\gamma I} \left(1 + \frac{L_I}{L_E} \lambda_\gamma^{(\delta_i - \delta_e)(\varepsilon - 1)} \frac{\delta_E}{\delta_I} \tau_{\gamma I}^{1 - \varepsilon} \right)^{-1} \left(A_{\gamma I} - \frac{\delta_I}{\delta_E} \right),$$

from which it is straightforward that the net of ad valoremness effect of trade costs on quality is positive if $\frac{\delta_I}{\delta_E} < A_{\gamma I}$ and is negative if $\frac{\delta_I}{\delta_E} > A_{\gamma I}$, as stated in Proposition 1. \square

Proof of Proposition 2

As in the proof of Proposition 1, we derive the net of ad valoremness effect of trade costs on quality by deriving the effect of the scaling parameter η_I on quality. To this goal, we apply the Implicit Function Theorem to equation (14):

$$\frac{d\lambda_\gamma^*}{d\eta_{\gamma I}} = - \frac{\frac{\partial^2 \pi_\gamma}{\partial \lambda_\gamma^2}}{\frac{\partial^2 \pi_\gamma}{\partial \lambda_\gamma \partial \eta_I}} \Big|_{\lambda=\lambda^*} = - \frac{\frac{\partial^2 \pi_\gamma}{\partial \lambda_\gamma^2}}{-(\varepsilon - 1) \frac{1}{\eta_I} X_{\gamma I} b w \tau_{\gamma I} \left(\frac{\delta_I}{\lambda_\gamma^*} - \frac{A_{\gamma I}}{\beta} \right)} \Big|_{\lambda=\lambda^*} .$$

From the Second Order Conditions, the numerator is negative, and thus the sign of the entire expression coincides with the sign of the denominator. By using the equilibrium value of quality λ_γ^* (equations (15)), the denominator can be expressed as:

$$\frac{(\varepsilon - 1) \frac{1}{\eta_I} X_{\gamma I} b w \tau_{\gamma I}}{1 + K_I \frac{\delta_I}{\delta_E} \tau_{\gamma I}^{1-\varepsilon} + K_O \frac{\delta_O}{\delta_E} \tau_{\gamma O}^{1-\varepsilon}} \left[\left(\frac{A_{\gamma I}}{A_{\gamma E}} - \frac{\delta_I}{\delta_E} \right) + K_O A_O \frac{\delta_O}{\delta_E} \tau_{\gamma O}^{1-\varepsilon} \left(\frac{A_I}{A_O} - \frac{\delta_I}{\delta_O} \right) \right],^{30}$$

from which it is straightforward that the net of ad valoremness effect of trade costs on quality

is positive if $\frac{\delta_I}{\delta_E} < \frac{A_{\gamma I}}{A_{\gamma E}}$ and $\frac{\delta_I}{\delta_O} < \frac{A_{\gamma I}}{A_{\gamma O}}$;

is negative if $\frac{\delta_I}{\delta_E} > \frac{A_{\gamma I}}{A_{\gamma E}}$ and $\frac{\delta_I}{\delta_O} > \frac{A_{\gamma I}}{A_{\gamma O}}$;

as stated in Proposition 2. \square

³⁰Recall that the ad valoremness for internal sales is assumed to be 1, that is $A_{\gamma E} = 1$.

Table 2: Linder correction and determinants of unit values

Specification	I	I-M	II	I	I-M	II
Inc.Group	OECD	OECD	OECD	Middle	Middle	Middle
	(1)	(2)	(3)	(4)	(5)	(6)
Income _{Exp} , $\ln(y_{et})$	0.60 (0.01)**	0.60 (0.01)**	0.54 (0.01)**	0.30 (0.01)**	0.17 (0.01)**	0.42 (0.01)**
Linder correction, D_{iegt}	-2.90 (0.25)**	-2.61 (0.41)**		-4.37 (0.17)**	-2.93 (0.22)**	
Distance, $\ln(dist_{ie})$	-0.17 (0.02)**	-0.15 (0.02)**	0.08 (0.01)**	0.02 (0.01)*	0.07 (0.02)**	0.06 (0.01)**
$\ln(dist_{ie}) \times D_{iegt}$	0.33 (0.02)**	0.32 (0.02)**		0.09 (0.01)**	0.00 (0.02)	
GDP _{Exp} , $\ln(Y_{et})$	-0.15 (0.00)**	-0.16 (0.00)**	-0.19 (0.00)**	-0.16 (0.00)**	-0.14 (0.00)**	-0.13 (0.00)**
$\ln(Y_{et}) \times D_{iegt}$	-0.03 (0.00)**	-0.02 (0.00)**		0.15 (0.01)**	0.13 (0.01)**	
Contiguity, $cont_{ie}$	0.26 (0.03)**	0.30 (0.04)**	-0.66 (0.02)**	0.21 (0.02)**	0.42 (0.03)**	0.11 (0.01)**
$cont_{ie} \times D_{iegt}$	-1.89 (0.04)**	-1.93 (0.04)**		-0.24 (0.02)**	-0.51 (0.03)**	
N Imp-Prd-Yr grs.	32,546	32,525	32,548	26,371	19,675	26,371
N Obs.	269,611	259,636	279,122	119,919	67,822	125,468
R2 Adjusted	0.10	0.10	0.07	0.11	0.04	0.09
Proportion of $D_{iegt}=1$	0.75	0.77		0.26	0.43	
Proportion of $cont_{ie}=1$	0.03	0.03	0.03	0.22	0.23	0.23
Proport. of $cont_{ie} \times D_{iegt}=1$	0.02	0.02		0.10	0.17	
F-st: $dist_{ie}+dist_{ie} \times D_{iegt}=0$	282**	308**		134**	37**	

Notes. + $p < 0.05$; * $p < 0.01$; ** $p < 0.001$. Estimated with importer-product-year fixed effects. Robust standard errors. For OECD Exports: N Importers = 10, N Exporters = 31. For non-OECD Exports: N Importers = 10, N Exporters = 49. All specifications include importer-product-year fixed effects. Linder correction dummy D_{iegt} used in columns (1), (3), (4), and (6) is defined in equation (17); in columns (2) and (5) it is defined according to equation (18).

Table 3: Linder correction dummy and determinants of unit values (product-level controls)

Specification	III	IV	I	II	III	IV	I	II
Inc.Group	OECD	OECD	OECD	OECD	Middle	Middle	Middle	Middle
Freight, $\ln(f_{iegt})$	0.74 (0.04)**	0.86 (0.04)**			0.44 (0.05)**	0.63 (0.07)**		
$\ln(f_{iegt}) \times D_{iegt}$	-0.06 (0.04)				-0.01 (0.07)			
Tariff, $\ln(tar_{iegt})$	-1.22 (0.10)**	-2.64 (0.08)**			-0.78 (0.08)**	-1.33 (0.13)**		
$\ln(tar_{iegt}) \times D_{iegt}$	-1.91 (0.12)**				-0.93 (0.14)**			
Income _{Exp} , $\ln(y_{et})$	0.26 (0.01)**	0.22 (0.02)**	0.53 (0.01)**	0.53 (0.01)**	0.14 (0.01)**	0.16 (0.03)**	0.25 (0.01)**	0.37 (0.01)**
Linder correction, D_{iegt}	0.05 (0.25)		-2.98 (0.26)**		-2.02 (0.33)**		-4.15 (0.19)**	
Distance, $\ln(dist_{ie})$	-0.18 (0.02)**	-0.12 (0.01)**	-0.18 (0.02)**	0.05 (0.01)**	-0.06 (0.01)**	-0.09 (0.02)**	-0.01 (0.01)	0.02 (0.01)*
$\ln(dist_{ie}) \times D_{iegt}$	0.10 (0.02)**		0.29 (0.02)**		0.05 (0.02)*		0.09 (0.01)**	
GDP _{Exp} , $\ln(Y_{et})$	-0.05 (0.01)**	-0.06 (0.00)**	-0.14 (0.00)**	-0.14 (0.00)**	-0.11 (0.00)**	-0.08 (0.00)**	-0.14 (0.00)**	-0.12 (0.00)**
$\ln(Y_{et}) \times D_{iegt}$	-0.04 (0.00)**		0.00 (0.00)		0.07 (0.01)**		0.14 (0.01)**	
Contiguity, $cont_{ie}$	-0.02 (0.03)	0.04 (0.03)	0.27 (0.03)**	0.59 (0.02)**	0.14 (0.02)**	0.11 (0.01)**	0.12 (0.02)**	0.02 (0.01)
$cont_{ie} \times D_{iegt}$					-0.11 (0.03)**		-0.19 (0.03)**	
Weak Ident Test	112.11	161.24	.	.	77.48	46.23	.	.
UnderIdent P-val	0.00	0.00	.	.	0.00	0.00	.	.
N Imp-Prd-Yr grs.	23,396	23,416	23,414	23,416	18,728	19,408	19,408	19,408
N Obs.	193,820	202,791	193,838	202,791	87,527	92,007	88,207	92,007
R2 Adjusted			0.06	0.06			0.11	0.10
Proportion of $D_{iegt}=1$	0.66		0.66		0.28		0.28	
Proportion of $cont_{ie}=1$	0.02	0.02	0.02	0.02	0.24	0.24	0.24	0.24
Proport. of $cont_{ie} \times D_{iegt}=1$	0.00		0.00		0.13		0.13	
Chi ² : $dist_{ie} + dist_{ie} \times D_{iegt}=0$	45**		100**		1		52**	

Notes. + $p < 0.05$; * $p < 0.01$; ** $p < 0.001$. Estimated with importer-product-year fixed effects. Robust standard errors. For OECD Exports: N Importers = 8, N Exporters = 31. For non-OECD Exports: N Importers = 8, N Exporters = 43. All specifications include importer-product-year fixed effects. Linder correction dummy D_{iegt} used in this table is defined in equation (17). The number of observations is smaller than in Table 2 table due to availability of instruments. In specifications I and II, per unit freight is instrumented with the importer-exporter product of World Development Indicators variables “Passengers carried by air” and “Carrier departures worldwide”, both variables are in logarithms. Both instruments are also interacted with D in specification I.

Table 4: Linder correction dummy and determinants of unit values (product-level controls and additional exporter-year fixed effects)

Specification	III	IV	I	II	III	IV	I	II
Inc.Group	OECD	OECD	OECD	OECD	Middle	Middle	Middle	Middle
Freight, $\ln(f_{iet})$	0.37 (0.12)*	-0.01 (0.09)			0.31 (0.05)**	0.30 (0.09)**		
$\ln(f_{iegt}) \times D_{iegt}$	0.08 (0.08)				0.06 (0.07)			
Tariff, $\ln(tar_{iegt})$	-0.58 (0.17)**	-1.33 (0.16)**			-0.68 (0.10)**	-0.84 (0.16)**		
$\ln(tar_{iegt}) \times D_{iegt}$	-2.20 (0.13)**				-0.85 (0.13)**			
Linder correction, D_{iegt}	0.88 (0.62)		-0.90 (0.36)+		-0.50 (0.38)		-1.17 (0.22)**	
Distance, $\ln(dist_{ie})$	0.06 (0.03)	0.30 (0.06)**	0.22 (0.04)**	0.32 (0.02)**	-0.05 (0.02)*	-0.04 (0.02)+	0.02 (0.02)	0.01 (0.01)
$\ln(dist_{ie}) \times D_{iegt}$	0.01 (0.05)		0.16 (0.03)**		0.04 (0.02)		0.05 (0.02)*	
$\ln(Y_{et}) \times D_{iegt}$	-0.03 (0.01)**		-0.02 (0.01)**		0.02 (0.01)		0.04 (0.01)**	
Contiguity, $cont_{ie}$	0.46 (0.05)**	0.86 (0.09)**	0.68 (0.05)**	0.85 (0.03)**	0.05 (0.02)+	0.02 (0.02)	0.02 (0.02)	-0.05 (0.01)**
$cont_{ie} \times D_{iegt}$					-0.02 (0.04)		-0.10 (0.03)**	
Weak Ident Test	23.74	53.12	.	.	92.58	40.56	.	.
UnderIdent P-val	0.00	0.00	.	.	0.00	0.00	.	.
N Imp-Prd-Yr grs.	23,396	23,416	23,414	23,416	18,728	19,408	19,408	19,408
N Obs.	193,820	202,791	193,838	202,791	87,527	92,007	88,207	92,007
R2 Adjusted			0.09	0.09			0.14	0.14
Proportion of $D_{iegt}=1$	0.66		0.66		0.28		0.28	
Proportion of $cont_{ie}=1$	0.02	0.02	0.02	0.02	0.24	0.24	0.24	0.24
Proport. of $cont_{ie} \times D_{iegt}=1$	0.00		0.00		0.13		0.13	
Chi ² : $dist_{ie} + dist_{ie} \times D_{iegt}=0$	2		241**		0		25**	

Notes. + $p < 0.05$; * $p < 0.01$; ** $p < 0.001$. Estimated with importer-product-year fixed effects. Robust standard errors. For OECD Exports: N Importers = 8, N Exporters = 31. For non-OECD Exports: N Importers = 8, N Exporters = 43. All specifications include importer-product-year and exporter-year fixed effects. Linder correction dummy D_{iegt} used in this table is defined in equation (17). . The number of observations is smaller than in Table 2 table due to availability of instruments. In specifications I and II, per unit freight is instrumented with the importer-exporter product of World Development Indicators variables “Passengers carried by air” and “Carrier departures worldwide”, both variables are in logarithms. Both instruments are also interacted with D in specification I. The effect of exporter specific variables can potentially be estimated due to three-year averaging; the averaging includes only the years when the product was traded.

Table 5: Redefined Linder correction and determinants of unit values

Specification	I'	I-M'	II	I'	I-M'	II
Inc.Group	OECD	OECD	OECD	Middle	Middle	Middle
	(1)	(2)	(3)	(4)	(5)	(6)
Income _{Exp} , ln(<i>y_{et}</i>)	0.62 (0.01)**	0.62 (0.01)**	0.54 (0.01)**	0.30 (0.01)**	0.17 (0.01)**	0.42 (0.01)**
Linder correction, <i>D_{iegt}</i>	-3.38 (0.26)**	-3.24 (0.38)**		-4.80 (0.18)**	-3.23 (0.24)**	
Distance, ln(<i>dist_{ie}</i>)	-0.18 (0.02)**	-0.17 (0.02)**	0.08 (0.01)**	0.02 (0.01)+	0.06 (0.02)**	0.06 (0.01)**
ln(<i>dist_{ie}</i>) × <i>D_{iegt}</i>	0.35 (0.02)**	0.35 (0.02)**		0.03 (0.01)+	-0.02 (0.02)	
GDP _{Exp} , ln(<i>Y_{et}</i>)	-0.15 (0.00)**	-0.16 (0.00)**	-0.19 (0.00)**	-0.16 (0.00)**	-0.14 (0.00)**	-0.13 (0.00)**
ln(<i>Y_{et}</i>) × <i>D_{iegt}</i>	-0.02 (0.00)**	-0.01 (0.00)**		0.18 (0.01)**	0.15 (0.01)**	
Contiguity, <i>cont_{ie}</i>	0.23 (0.03)**	0.26 (0.04)**	-0.66 (0.02)**	0.21 (0.02)**	0.40 (0.03)**	0.11 (0.01)**
<i>cont_{ie}</i> × <i>D_{iegt}</i>	-1.86 (0.04)**	-1.90 (0.04)**		-0.28 (0.02)**	-0.50 (0.03)**	
N Imp-Prd-Yr grs.	32,546	32,505	32,548	26,345	17,462	26,371
N Obs.	267,404	258,301	279,122	113,023	62,740	125,468
R2 Adjusted	0.10	0.11	0.07	0.11	0.05	0.09
Proportion of <i>D_{iegt}</i> =1	0.75	0.76		0.22	0.37	
Proportion of <i>cont_{ie}</i> =1	0.03	0.03	0.03	0.21	0.22	0.22
Proport. of <i>cont_{ie}</i> × <i>D_{iegt}</i> =1	0.02	0.02		0.09	0.15	
F-st: <i>dist_{ie}</i> + <i>dist_{ie}</i> × <i>D_{iegt}</i> =0	309**	343**		27**	13**	

Notes. + $p < 0.05$; * $p < 0.01$; ** $p < 0.001$. Estimated with importer-product-year fixed effects. Robust standard errors. For OECD Exports: N Importers = 10, N Exporters = 31. For non-OECD Exports: N Importers = 10, N Exporters = 49. All specifications include importer-product-year fixed effects. Linder correction dummy *D_{iegt}* used in columns (1), (3), (4), and (6) is defined in equation (19); in columns (2) and (5) it is defined according to equation (20).

Table 6: Implications for gravity estimation

Dep.var.	$\ln(p)$	$\ln(p)$	$\ln(q)$	$\ln(pq)$	$\ln(pq)$	$\ln(pq)$
Aggregation	iegt	iegt	iegt	iegt	iet	iet
FE	igt	igt, et	igt, et	igt, et	it, et	it, et
	(1)	(2)	(3)	(4)	(5)	(6)
Income _{Exp} , $\ln(y_{et})$	0.267 (291.67)**	0.240 (2.05)*	3.310 (12.74)**	3.551 (15.20)**		
Linder correction, D_{iet}	-0.489 (22.34)**	0.914 (31.34)**	0.265 (3.59)**	1.179 (17.52)**	-2.334 (5.33)**	0.543 (2.44)*
Distance, $\ln(dist_{ie})$	0.106 (96.98)**	0.121 (89.95)**	-0.814 (235.86)**	-0.693 (222.97)**	-1.606 (57.69)**	-1.556 (94.77)**
$\ln(dist_{ie}) \times D_{iet}$	0.026 (15.86)**	0.039 (22.19)**	0.016 (3.79)**	0.055 (14.56)**	0.082 (2.30)*	-0.059 (2.75)**
GDP _{Exp} , $\ln(Y_{et})$	-0.054 (91.93)**	0.445 (3.73)**	-4.214 (16.24)**	-3.769 (16.22)**		
$\ln(Y_{et}) \times D_{iet}$	0.013 (15.24)**	-0.044 (40.07)**	-0.009 (3.04)**	-0.052 (19.66)**	0.069 (4.50)**	0.001 (0.08)
Contiguity, $cont_{ie}$	-0.029 (10.75)**	-0.049 (17.89)**	0.543 (74.74)**	0.494 (74.16)**	0.458 (3.49)**	0.611 (7.15)**
$cont_{ie} \times D_{iet}$	-0.054 (12.58)**	-0.044 (10.07)**	0.029 (2.81)**	-0.015 (1.63)	0.426 (2.17)*	0.386 (2.99)**
R^2	0.10	0.12	0.25	0.26	0.86	0.76
N	2,667,691	2,667,691	2,667,691	2,667,691	9,425	47,351

Notes. * $p < 0.05$; ** $p < 0.01$. T-stats are shown in brackets. Linder correction dummy D_{iegt} used in this table is defined according to equation (20). In specifications (1) through (5), the sample matches the empirical exercise and contains only trade between OECD and upper-middle income countries in manufacturing differentiated products; in specification (6) the sample is not restricted the same way. In product-level specifications (1)-(4) the sample is screened to exclude observations with volume of trade that is smaller than \$5,000; we also keep only observations with at least 5 observations per product-period, per exporter-product-period, and importer-product-period group; we also drop observations where price exceeds the 90th percentile for a given product in a given period. Product g in this table corresponds to a unique combination of HS6 and quantity unit because the same HS6 category in the WITS is measured in different quantity units.