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Who Exports Better Quality Products to Smaller or More Distant Markets?

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Abstract

This paper examines the role of across-firm differences in product quality and firms' competitiveness in determining the spatial patterns of within-product export unit values across destinations. Using product-level export data, I show that the average export unit value of a product shipped from the U.S. or Korea increases with distance and decreases with destination market's size. However, within-product average unit values for products exported from China and India decrease with distance and increase with market size. To interpret these different spatial patterns of unit values across exporting countries, I develop a model of quality heterogeneity in which firms differ in their workers' skill level and higher-skilled workers show greater productivity in performing tasks that improve product quality. The model predicts that in relatively skill-abundant countries, exporting firms specialize in high-quality products using relatively cheap skilled labor, whereas, in relatively skill-scarce countries, firms that produce lower-quality products are more competitive.

Keywords: average f.o.b. export unit values; quality differentiation; monopolistic competition

JEL Classification: F10, F12

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1. Introduction

Average export unit values vary across destinations even within narrowly defined product categories. For instance, U.S. exports of men's blazers to New Zealand are 30 times more expensive than the same product exported to Korea. One explanation for these differences in average export unit values across markets is firms' self-selection behavior. As is well known in the literature, firms' self-selection into exports is often derived from the sorting of firms with heterogeneous productivity across markets. In these standard models, a product's average export unit value varies across destinations because of the differing composition of exporting firms across markets.¹ To be more specific, Melitz (2003) considers a model of firm heterogeneity with respect to productivity, where labor is assumed to be homogeneous and product quality is identical across firms. In this model, a more productive firm, with a lower marginal cost, charges a lower price and becomes more profitable. In this context, more productive firms can penetrate difficult markets relatively easily, and as a result within-product average unit values would decrease with the increasing difficulty in market penetration (e.g., smaller and/or more distant markets).

Recent empirical evidence, however, shows that larger exporting firms are more skill intensive, and they pay higher wages simply due to their employing a higher proportion of skilled labor (e.g., a higher ratio of skilled to unskilled workers).² Further, the spatial patterns of export unit values - the variation of average free-on-board (f.o.b.) unit values with respect to importer characteristics, such as distance and market size - seem inconsistent with standard theories of heterogeneous firms in that exporters charge higher prices than non-exporters do (see, e.g., Baldwin and Harrigan 2011). In this paper, I examine product-level export data from four different countries (the U.S., South Korea, China, and India) to document the spatial patterns of export unit values by using a reduced-form gravity equation.³ The variations in the average export unit values across foreign markets are systematically related to the distance between countries and the destination market's size. The effects of market size and distance on average export unit values have opposite signs regardless of exporting country, whereas these spatial patterns vary across exporting countries. The average export unit values of products shipped from the U.S. or Korea are positively (negatively) associated

with distance (market size). In contrast, these effects are the opposite for China and India.

In line with recent studies (e.g., Baldwin and Harrigan 2011; Johnson 2012) that emphasize the importance of product quality in determining firms' competitiveness, I incorporate across-firm differences in product quality in the spirit of firm heterogeneity with heterogeneous workers, where firms endogenously determine their own product quality in response to their employees' skill level. In this theoretical framework, quality differentiation and firms competition in a model with firm heterogeneity play an important role in explaining the observed spatial patterns of export unit values found in the empirical evidence. Two main features of the model are outlined as follows: First, firms in a country are heterogeneous with respect to the skill level of their workers. Higher-skilled workers are more expensive to employ, and they have no productive advantage in producing a basic unit of physical output (e.g., assembly work such as screwing nuts onto bolts). However, higher-skilled workers have a productive advantage in improving product quality compared to lower-skilled workers.⁴ Second, firms in different countries face different wage schedules as a function of skill level. To be more precise, the skill elasticity of the wage rate is assumed to be lower in relatively skill-abundant countries than in relatively skill-scarce countries.

This paper aims to contribute to the literature as follows: First, existing studies (e.g., Kneller and Yu 2008; Baldwin and Harrigan 2011; Johnson 2012) focus on the spatial patterns of unit values using export data from a single country. Consequently, they are unable to capture the differences in the spatial patterns of unit values across exporting countries.⁵ Second, this paper introduces quality heterogeneity in the standard model of trade, where product quality is endogenously chosen by individual firms, whereas Kneller and Yu (2008), Baldwin and Harrigan (2011), and Johnson (2012) incorporate product quality into a model of heterogeneous firms by assuming that quality is determined exogenously as a function of a firm's idiosyncratic marginal cost. Finally, the model can present some stylized facts that are not clearly explained in the existing theoretical models, such as within-product specialization across countries.⁶ Firms producing lower-quality products in developed/skill-abundant countries are less efficient, so they are more likely to exit a market. As a result, only the firms with high enough product quality tend to be exporters. In contrast, in developing/skill-scarce countries, firms producing low-quality varieties using relatively

cheap, unskilled labor are more competitive and tend to export.

The remainder of this paper is organized as follows: Section 2 contains a brief review of the relevant theories and empirical evidence on the relationship between unit values and the characteristics of exporters and importers. Section 3 describes the data, the empirical methods, the results, and robustness checks. Section 4 lays out a model of endogenous quality differentiation that potentially explains the different spatial patterns of the average f.o.b. export unit values of products across the exporting countries that are found in Section 3. The last section provides a conclusion.

2. Literature Review

In standard models of heterogeneous firms without quality differentiation, pioneered by Melitz (2003), a product's average f.o.b. export price should decrease with distance and increase with market size due to the self-selection of more efficient firms with lower prices into tougher markets. On the other hand, an increasing number of authors emphasize the role of product quality in accounting for a link between the patterns of the average export price and the importer's characteristics such as trade cost and market size (see, e.g., Schott 2004; Baldwin and Harrigan 2011; Johnson 2012). For instance, Johnson (2012) investigates a relationship between the observed export price and the export threshold across importing countries, which informs on the correlation between the quality-adjusted and the observed price. He finds that the average export price is negatively correlated to the quality-adjusted price in the majority of U.S. manufacturing sectors. These findings are consistent with models of quality heterogeneity in which firms that supply higher-quality products at higher prices become more competitive.

Another recent paper by Baldwin and Harrigan (2011) exploits US export data and uses a simple reduced-form gravity equation to show that within-product unit value is positively associated with distance as a proxy for trade costs, while it decreases with the market size of a destination. The authors point out that leading theoretical models of firm heterogeneity fail to account for these findings and suggest a quality-augmented model, where quality rises faster than (idiosyncratic) marginal cost. Under this assumption of quality differences across firms, firms with the highest marginal cost are most profitable because they compete on a quality-adjusted price. Since Baldwin

and Harrigan assume that the firm's product quality is exogenously determined by its marginal cost, they have some difficulty accounting for the exogenously given quality function. Further, Baldwin and Harrigan's model cannot support the spatial patterns of export unit values for products sourced from China. Indeed, Kneller and Yu (2008) find that the average unit values are positively associated with both distance and market size in the majority of Chinese export sectors, which is inconsistent with the model suggested by Baldwin and Harrigan (2011) as well as the standard Melitz model. To account for these findings, Kneller and Yu consider a price discrimination model with a linear demand and show that average export prices are jointly determined by the sorting of heterogeneous firms and by within-firm price discrimination.

Bastos and Silva (2010) also show that the positive effects of both distance and market size on unit values can be explained by within-firm price discrimination as well as by firms' self-selection using Portuguese firm-level data. These findings by Bastos and Silva are, however, inconsistent with the heterogeneous quality model with a linear demand proposed by Kneller and Yu (2008) in that firms differentiate their products and charge higher prices in smaller and/or distant markets.⁷ On the other hand, Harrigan et al. (2011) use U.S. firm-level data and confirm that there is no empirical evidence to support within-firm price discrimination based on geographical distance.

This paper builds on recent empirical evidence on the relationship between the level of exporter development and product quality (e.g., Schott 2004; Hallak and Schott 2011) and the link between firm-specific product quality and firm's skilled-labor intensity (marginal cost) (e.g., Verhoogen 2008; Kyoji and Keiko 2010; Johnson 2012; Kugler and Verhoogen 2012) to analyze the role of within-product quality differences in a model with heterogeneous firms and to explain the different spatial patterns of the average export unit values across exporting countries.

3. Empirical Analysis

Data Description

The main data set is drawn from the UN Commodity Trade Statistics Database (COMTRADE) database for the year 2007. I mainly use export data from the U.S., South Korea, China, and India.

For each country's exports, the United Nations Statistical Division reports data for all trading partners classified by the 6-digit Harmonized System (HS). These data contain total export value and quantity for each HS-6 product broken down by trading partner. The analysis also includes country information: the level of real income (GDP per worker) and market size (PPP GDP).⁸ In addition, I use several proxies for bilateral trade costs from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) gravity dataset. The geographic distances are measured between the most populated city in both exporting and importing countries.⁹ The common legal system variable takes the value one if the exporting and importing countries share the same legal system, and the common language dummy is one if the same language is spoken by at least 9% of the population in both countries. Also, if the destination country is landlocked, the landlocked variable is one. I also use trade policy measures for 2006 such as World Trade Organization (WTO) membership, regional trade agreements (RTA), and common currency region.

The variable of interest is the average unit value of exports for each HS-6 product category, which is computed by dividing total value by quantity. The unit value captures the average f.o.b. export price of all firms that export a given product to a given destination. For instance, the average unit value of product p from country i to destination country j , UV_{pij} , is the ratio EX_{pij}/Q_{pij} , where EX_{pij} is the total export value and Q_{pij} is the quantity.

Varieties within the HS-6 category are assumed to be vertically differentiated, but horizontally equivalent in order to highlight the fact that a higher unit value is associated with a higher product quality. However, this assumption may be problematic in that there are horizontally different multiple varieties within the 6-digit-level HS category. Vodka, for instance, can be referred to as a single product within the HS-6 category (HS6: 220860) because it has no sub-category in the 10-digit commodity code (i.e., HS10: 2208600000); however, an electrothermic coffee or tea maker (HS6: 851671) defined as a single HS-6 code has two 10-digit categories: Electrothermic Coffee Maker (HS10: 8516711000) and Electrothermic Tea Maker (HS10: 8516712000).

Table 1 below describes summary statistics for product comparisons between HS-6 and HS-10 categories for U.S. exports in 2011. The U.S. exports approximately 8,900 different HS-10-category products, while it exports in more than 5,000 different HS-6-category products. Nearly

Table 1. Summary Statistics for U.S. Exports

	HS 6		HS 10	
	All Sectors	Manufacturing	All Sectors	Manufacturing
Total Number of Products	5059	4189	8904	7346

Notes: The U.S. Census Bureau reports HS 10-digit product categories sourced from the United States that allows one to identify which products within the HS-6 category have multiple sub-varieties defined by HS 10-digit level.

70% (i.e., approximately 3,500 different products) of total products listed under HS-6 are the same under both HS-6 and HS-10 categories. Because most HS-6-category products coincide with those under HS-10, the assumptions about vertical differentiation and horizontal equivalence are not a concern. For a more detailed comparison, I estimate the effects of importer characteristics on average export unit value for products that are common in both HS-6 and HS-10 categories and compare these with the estimation results obtained using all products under the HS 6-digit category. In fact, the estimated results for these two different sample groups are almost exactly the same. They are reported later in Table 3.

Estimation and Results

For each exporting country i , the average f.o.b. unit value is regressed on the importing country's characteristics, which include distance, market size, real income per worker, and several proxies for trade costs. The regression equation is of the form:

$$\ln(UV)_{pij} = \alpha_p + \beta_{i1}\ln(Y)_j + \beta_{i2}\ln(Y/L)_j + \beta_{i3}\ln(Dist)_{ij} + \beta_{i4}LandL_j + \beta_{i5}Comleg_{ij} + \beta_{i6}Comlang_{ij} + \beta_{i7}RTA_{ij} + \beta_{i8}WTO_j + \beta_{i9}Comcur_{ij} + \varepsilon_{pj}, \quad (1)$$

where $\ln(UV)_{pij}$ is the log of the average f.o.b. export unit value of a product p shipped from country i to destination j . Y and Y/L represent PPP GDP (e.g., market size) and PPP GDP per worker, respectively.¹⁰ $Dist_{ij}$ is a measure of distance between i and j . $LandL_j$ is the dummy variables, which equals one if country j is landlocked. The dummy variable $Comleg_{ij}$ takes the value one if both countries share a common legal system. The $Comlang_{ij}$ variable indicates whether the same language is spoken by at least 9% of the population in both countries. Trade policy measures are WTO membership, a regional trade agreement (RTA), and a common currency ($Comcur$).¹¹

The product fixed effect, α_p , controls for the difference in average unit value (e.g., gold versus copper). It also captures the difference in unit measurement (e.g., items versus kilograms). The most common measurements of quantities are items and kilograms, which account for 97% of total observations in U.S. export data. In the regression, I drop all other units including bushels, barrels, and squares. In what follows, I restrict the sample to trade flows by manufacturing sectors only. In addition, I remove possible outliers by discarding export flows below 20 units. Product-level average unit values are noisy indicators, especially for small enough trade volume. By dropping export flows of fewer than 20 units, the estimation results are less affected by noisy or economically unimportant observations. The remaining observations cover more than 93% of total U.S. exports.

First, I estimate equation (1) using ordinary least squares (OLS) regression with product fixed effects.¹² Table 2 reports the estimation results, where robust standard errors clustered by importing country are used for dealing with an arbitrary correlation of the error terms within each observation. In each exporting country, the effects of market size and distance on average export unit values have opposite signs. The intuition behind this result may lie in the fact that more efficient firms self-select themselves into smaller, more distant markets. Another distinct pattern is that the signs of the coefficients with respect to market size and distance for the U.S. and South Korea are the exact opposite of those for China and India. For both the U.S. and South Korea, distance has a positive effect on export unit values, while market size has a negative effect. The effects of distance and market size on average f.o.b. export unit values, however, are negative and positive, respectively for China and India. These spatial patterns of unit values for products exported from the U.S. and Korea are consistent with findings by Baldwin and Harrigan (2011). As mentioned in the previous section, however, their model cannot account for the spatial patterns of China and India's average export prices.

Another interesting finding is that the effect of distance on average unit values for Chinese exports is exactly opposite to that for Korea. Note that China is the closest country to Korea. If there exists within-firm selection of product quality across markets with variable geographical distances exists, the effect of distance on unit values determined by within-firm selection should be the same for both countries. For example, each firm produces vertically differentiated varieties,

Table 2. Main Estimation Results from Four Different Countries' Exports Data

Variables	Exporting Countries			
	USA	CHN	KOR	IND
Log real GDP	-0.021*** (-3.37)	0.020*** (3.20)	-0.015** (-2.09)	0.026*** (4.91)
Log real GDP per worker	0.057*** (5.69)	0.064*** (6.14)	0.061*** (5.34)	0.047*** (4.93)
Log distance	0.136*** (7.86)	-0.046** (-2.58)	0.025** (2.02)	-0.020* (-1.67)
Landlocked	0.116*** (4.96)	0.243*** (5.77)	0.089*** (3.21)	0.082*** (2.80)
Common Legal	-0.012 (-0.51)	0.067** (2.36)	0.081** (2.16)	-0.072*** (-2.77)
Common Language	-0.070*** (-3.42)	-0.120*** (-3.50)	-0.020 (-0.94)	0.013 (0.52)
RTA	-0.079*** (-3.27)	-	-0.084*** (-3.47)	-0.046 (-1.42)
WTO	-0.048 (-1.62)	0.037 (1.22)	0.036** (2.48)	0.059** (2.32)
Common Currency	-0.088 (-3.69)	-	-	-
Number of observation	140141	203057	56252	104515
Number of product	3665	3835	3111	3696

Notes: The estimator is the OLS with HS-6 product fixed effects. The dependent variable is the average f.o.b. export unit value of a product. For each exporting country, the sample is restricted to the largest 100 partners and trade flows for manufactured goods only. The sample includes only items and kilogram as a quantity measurement. Robust t-statistics clustered by importing country are in parentheses. ***, **, and * refer to statistical significance at the 1%, 5%, and 10% level respectively.

and exports better-quality products to more distant markets. This type of within-firm selection implies that distance has a positive effect on unit values. Thus, the opposite effects of distance on average export unit values (negative for China and positive for Korea) are mainly driven by the sorting of exporting firms across markets, but not caused by within-firm selection.¹³ In fact, recent work by Harrigan et al. (2011), using firm-level data from the U.S., shows that there is no empirical evidence that links within-firm price variation across markets and distance.

In addition to the effects of market size and distance, I find that average export unit values of a product are positively associated with the importers' real income per worker, which is statistically significant regardless of exporting country. This suggests that the demand-side effect seems to play an important role in shaping the variation in unit values across markets. The positive association between the importers' GDP per worker and the average unit values can be explained by both

within-firm selection of product quality across markets and firms' self-selection into exporting.¹⁴ In fact, Bastos and Silva (2010) exploit Portuguese firm-level data to show that the positive effect of income per worker on unit values is mainly due to within-firm selection of export prices across markets, while the sorting mechanism has a relatively small effect on the variation of unit values.

Table 3 presents two estimation results obtained by using full and restricted samples that demonstrate issues regarding the existence of multiple sub-varieties within the 6-digit-level HS category. To do so, I first estimate equation (1) using the full sample classified by the 6-digit Harmonized System for U.S. export data. I then use a restricted sample of HS-6 products that are common across both HS-6 and HS-10 categories. As shown in Table 3, estimates for these two samples are very similar. This finding supports the assumption that the HS 6-digit level of product disaggregation is high enough to identify at least the effects of market size and distance on the average export unit value.

Table 3. HS-6 versus Restricted Sample in HS-6 for U.S. Exports in 2007

	<i>Full Sample in HS 6</i>	<i>Restricted Sample in HS 6</i>
Log real GDP	-0.0239*** (0.0052)	-0.0232*** (0.0056)
Log real GDP per worker	0.0516*** (0.0103)	0.0573*** (0.0111)
Log distance	0.1461*** (0.0170)	0.1460*** (0.0163)
Number of observation	208704	118224
Number of product	4641	3124

Notes: The estimator is the OLS with HS-6 product fixed effects for U.S. export data in 2007. The dependent variable is the average f.o.b. export unit value of a product. Full sample includes all product categories in HS 6 and all importing countries (150 countries). For the sake of brevity, only the coefficients on real GDP, GDP per worker, and distance are presented. Robust standard error clustered by importing country are in parentheses. ***, **, and * refer to statistical significance at the 1%, 5%, and 10% level, respectively.

Next, I examine the role of exporting country's level of development (e.g., real GDP per worker) in shaping a relationship between unit values, market size, and distance. To do that, I regress the average unit values on distance, market size, income per worker, and the interactions between those regressors and exporters' GDP per worker. Since the spatial patterns of unit values may depend on a country's level of economic development, this estimation with interaction terms would provide useful information on a link between the spatial patterns of unit values and the

exporters' levels of development. The regression equation is

$$\begin{aligned} \ln(UV)_{pij} = & \alpha_{pi} + \beta_1 \ln(Y)_j + \beta_1' \ln(Y/L)_i * \ln(Y)_j + \beta_2 \ln(Y/L)_j + \beta_2' \ln(Y/L)_i * \ln(Y/L)_j \\ & + \beta_3 \ln(Dist)_{ij} + \beta_3' \ln(Y/L)_i * \ln(Dist)_{ij} + \beta_4 LandL_j + \beta_5 Comleg_{ij} \\ & + \beta_6 Comlang_{ij} + \beta_7 RTA_{ij} + \beta_8 WTO_j + \beta_9 Comcur_{ij} + \varepsilon_{pij}, \end{aligned} \quad (2)$$

where the country-product fixed effects, α_{pi} , controls for heterogeneity across exporting countries and products.

Table 4. Estimation Results with Interaction Terms

Variables	(1) Log(Unit Value)	(2) Log(Unit Value)
Log(Y_j)	0.290*** (6.66)	0.175*** (5.55)
Log(Y_j)*Log(Exporter GDP per worker)	-0.026*** (-5.96)	-0.017*** (-5.43)
Log(Y/L) _j	-0.009 (-0.16)	0.083* (1.80)
Log(Y/L) _j *Log(Exporter GDP per worker)	0.007 (1.20)	-0.002 (-0.62)
Log($Dist$)	-1.258*** (-8.58)	-0.496*** (-5.82)
Log($Dist$)*Log(Exporter GDP per worker)	0.123*** (8.82)	0.052*** (6.16)
Product fixed effects	Yes	
Country-product fixed effects		Yes
Number of observation	502027	502027
Number of product	4037	4037

Notes: The estimator (1) is the OLS with HS-6 product fixed effects. The estimator (2) is the OLS with country-product fixed effects. For the sake of brevity, this table only reports the coefficients of PPP GDP, GDP per worker, distance, and the interaction terms obtained from the regression equation (2). Robust t-statistics clustered by importing country are in parentheses. ***, **, and * refer to statistical significance at the 1%, 5%, and 10% level, respectively.

Table 4 presents the results of a country-product fixed effect estimation as well as a product fixed effect estimation. The estimates in column (1) with product fixed effects reveal that the positive effect of market size on within-product average unit values decreases with the exporting country's level of GDP per worker. As a result, countries like the U.S. and Korea, where real incomes per worker are relatively high, have a negative association between the average export unit value and market size. In contrast, column (1) indicates that the effect of distance on within-

product unit values varies across exporting countries' income levels. Indeed, the effect of distance on average unit values is negative for low-income countries such as China and India, while it is positive for relatively high-income countries like the U.S. and Korea.

Column (2) in Table 4 reports the results obtained under the OLS estimation with country-product fixed effects. The effects of market size and distance on within-country-product unit values vary across exporters' GDP per worker, and the role of exporters' income levels in shaping the spatial patterns is the same as shown in column (1) using a product-fixed effect estimation. The findings from these pooled regressions are qualitatively the same as in the previous results derived by using equation (1). The pooled regression with interaction terms, however, clearly shows the important link between the unit values' spatial patterns and the exporting countries' levels of development.¹⁵

On the other hand, the estimates in columns (1) and (2) provide no statistical evidence of a relationship between exporting countries' levels of development and the effect of importer's GDP per worker on unit values. In column (2), the weakly positive effect of importer's GDP per worker on within-country-product unit values does not depend on the exporters' levels of development.

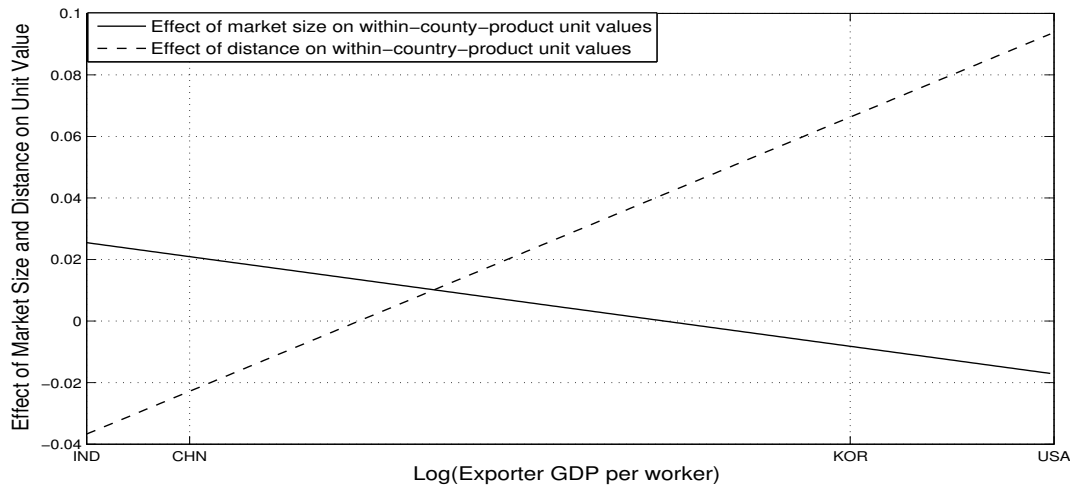


Figure 1. Relationships between Spatial Patterns of Unit Value and Exporter's GDP per worker

Figure 1 graphically illustrates the estimation results with country-product fixed effects. The dashed line captures the negative effect of distance on within-country-product unit values for relatively low-income countries like China and India. The effect of distance on the average unit value increases with the income levels of the exporting countries so that it becomes positive for high-

income countries, such as the U.S. and Korea. The solid line captures the effect of market size on within-country-product unit values. The positive effect of market size on unit values decreases with exporters' income levels and it becomes negative for relatively rich countries. Therefore, the average unit values of products sourced from poor countries increases with a destination market's size; whereas, the market size has a negative effect on unit values of products that are exported from relatively rich countries. That is, the larger the destination market size, the larger (smaller) is the average export unit value of products sent from relatively poor (rich) countries.

Robustness

To see if the main results are robust to the restricted sample, I first re-estimate equation (1) above within each HS 2-digit product category using only Chinese and U.S. export data. Table 5 presents the estimation results. For each sector of U.S. exports, the relationships between export unit values, market size, and distance are essentially the same as those in the previous results. For U.S. exports, distance has a positive effect on unit value, while the average export unit value decreases with market size. In the majority of Chinese export sectors, within-product average unit values decrease and increase with distance and market size respectively. Hence, the different spatial patterns of the average unit values between the U.S. and China are also found at the sector level.

Table 5. Estimation Results within HS 2-digit Sector Level

<i>HS 2-digit</i>	<i>US</i>			<i>CHN</i>		
	<i>GDP</i>	<i>Distance</i>	<i>Prod.</i>	<i>GDP</i>	<i>Distance</i>	<i>Prod.</i>
Chemical/Allied Industries	-0.031**	0.113***	714	0.014	0.035**	708
Plastic/Rubbers	-0.045***	0.076**	205	0.021**	-0.036*	210
Skin/Leather/Furs	-0.033**	0.061***	55	0.037**	-0.086*	58
Wood/Wood Products	-0.033***	0.066***	182	0.028***	0.016	206
Textiles	-0.017	0.113***	775	0.030***	-0.040**	729
Footwear/Headgear	-0.003	0.109**	24	0.076	-0.094**	27
Stone/Class	-0.028***	0.055***	122	0.046***	0.029	158
Metals	-0.032***	0.085***	551	0.033***	-0.004	552
Machinery/Electrical	0.001	0.054***	663	-0.005	-0.129***	742
Transportation	0.020**	0.034*	104	0.021**	-0.056*	110
Miscellaneous	-0.011**	0.071***	270	0.009	-0.144***	335

Notes: The estimator is the OLS with HS-6 product fixed effects clustering by importing country for both U.S. and Chinese export data. For the sake of brevity, this table only reports the coefficients of PPP GDP and distance obtained from the regression using equation (1). ***, **, and * refer to significance at the 1%, 5%, and 10% level, respectively.

Since a product's unit value reflects its quality, the variation in unit values across markets may depend on firms' incentives for quality upgrading, which varies across different product groups. For instance, firms may have a greater incentive to upgrade their product quality for durable consumption goods because consumers care more about the product quality of durable goods than that of non-durables. Such product groups, however, cannot be captured at the HS 2-digit level. Thus, I use Broad Economic Categories such as capital, intermediate, and consumption goods, to classify products into end-use categories and to examine the spatial patterns of unit values within product categories.

Table 6. Estimation Results within Different Product Groups Classified by End-Use Categories

	USA			CHN		
	<i>GDP</i>	<i>Dist.</i>	<i>Prod.</i>	<i>GDP</i>	<i>Dist.</i>	<i>Prod.</i>
(1) Capital goods	-.023***	.053***	552	-.030*	-.173***	559
(2) Consumption goods	-.035***	.052**	991	.031***	-.043*	987
Consumption excluding food/beverages	-.038***	.068**	580	.030***	-.061***	619
Durable consumption goods	-.058***	.112***	100	-.047	-.106**	112
(3) Intermediate goods	-.046***	.105***	2725	.004	.001	2794
Food/Beverage/Fuel	-.018	.067***	152	-.004	.084	139
Intermediate/Industrial supplies	-.047***	.107***	2573	.004	-.000	2655

Notes: The estimator is the OLS with HS 6 product fixed effects clustering by import country for both U.S. and Chinese export data. This table only displays the coefficients of real GDP and distance obtained from the regression using equation (1). ***, **, and * refer to statistical significance at the 1%, 5%, and 10% level, respectively.

Table 6 displays the results of these estimations within different end-use product groups. The first two columns for U.S. exports indicate that the average f.o.b. export unit value of a product decreases with market size, while it is positively associated with distance in most product categories except for Food/Beverage/Fuel. It should be noted that the effects of both distance and market size on unit values are higher for durable consumption goods rather than non-durable products.

For Chinese exports, on the other hand, the negative association between unit values and distance found in the previous main regression is also shown in both capital and consumption goods, but this effect is absent in intermediate goods. The negative effect of distance on the average unit value is much larger for durable consumption goods than for non-durable goods. For intermediate goods, neither distance nor market size show significant effects on unit values. Since product quality differences are more likely to occur in capital and consumption goods rather than in inter-

Table 7. Estimation Results for only Differentiated Products Classified by Rauch

Variables	Exporting Countries			
	USA	CHN	KOR	IND
Log real GDP	-0.032*** (-4.37)	0.023*** (3.32)	-0.014 (-1.62)	0.032*** (5.18)
Log real GDP per worker	0.025** (2.24)	0.061*** (5.60)	0.065*** (5.08)	0.042*** (4.38)
Log Distance	0.077*** (4.66)	-0.070*** (-3.60)	0.029** (2.11)	-0.043*** (-3.17)
Landlocked	0.090*** (4.89)	0.218*** (4.91)	0.086*** (3.31)	0.064** (2.36)
Common Legal System	0.021 (0.83)	0.076** (2.28)	0.065* (1.67)	-0.047* (-1.79)
Common Language	-0.111*** (-4.92)	-0.109*** (-2.69)	-0.019 (-0.84)	-0.005 (-0.19)
RTA	-0.099*** (-3.69)	-	-0.092*** (-4.15)	-0.075** (-2.32)
WTO	-0.076** (-2.33)	0.044 (1.23)	0.041** (2.74)	0.066** (2.36)
Common Currency	-0.165*** (-6.54)	-	-	-
Number of observation	97239	131242	35157	65670
Number of product	2673	2120	1602	2030

Notes: Dependent variable is the average f.o.b. export unit value of products. Each exporter's sample is restricted to the largest 100 partners and trade flows for manufacturing products only. Robust t-statistics clustered by importing country are in parentheses. ***, **, and * refer to statistical significance at the 1%, 5%, and 10 % level respectively.

mediate goods, it seems plausible that there is no significant evidence for a relationship between market size, distance, and unit values for intermediate goods. However, the opposite spatial patterns of unit values between the U.S. and China are remarkable for capital and consumption goods.

Finally, I re-estimate equation (1) using only the list of differentiated products classified by Rauch, which explains 77% of total observations and 55% of total products for U.S. exports. Since the spatial pattern of export unit values is mainly driven by firms' self-selection mechanism, homogeneous products are inappropriate in a model of quality heterogeneity.¹⁶ Therefore, an estimation using only differentiated products would be informative on the spatial patterns of unit values, especially for products that can be vertically differentiated in respect to quality attributes.

Table 7 reports the estimation results from the OLS regression with product fixed effects for which only differentiated products are included in the sample. For all exporting countries, the signs of coefficients of real GDP and distance are exactly the same as those shown in Table 2. However,

the magnitude of coefficients in absolute value with respect to GDP and distance increases slightly for all exporting countries except for the U.S. In contrast, in the estimation that uses only products that are classified as homogeneous (not reported here), the effects of both market size and distance on the average unit values are not statistically significant except for the U.S. The negative and positive associations between unit values, market size, and distance for U.S. exports holds in both homogeneous and differentiated goods.

4. Model of Quality Heterogeneity

The empirical evidence presented in the previous section is inconsistent with a standard model of heterogeneous firms (e.g., Melitz 2003) in the sense that the model fails to account for the spatial patterns of export unit values for U.S. and Korean export data. In this section, I develop a simple trade model where quality differentiation across firms plays a key role in accounting for why the spatial patterns of the average export unit values vary with exporting countries. Based on a Melitz-style model, I incorporate product quality into a model of firm heterogeneity with constant elasticity of substitution preference and country-specific fixed entry costs. In this framework, consumers prefer higher-quality products and firms produce goods that vary with respect to quality. In the following discussion, I focus on a one-sector version of the model.

Consumption

From the demand side, a representative consumer in each country i cares about product quality as well as price. The consumer's utility function takes the Dixit-Stiglitz CES preference over the consumption of differentiated varieties,

$$U_i = \left(\int_{\omega \in \Omega_i} [q_i(\omega)x_i(\omega)]^{\sigma-1/\sigma} d\omega \right)^{\sigma/\sigma-1}, \quad (3)$$

where ω denotes an individual variety in the potential set Ω_i of varieties that are available in country i . $\sigma > 1$ is the elasticity of substitution between varieties. $q(\omega)$ and $x(\omega)$ denote quality and quantity of variety ω , respectively. Preferences are assumed to be identical across countries.

The corresponding demand function for variety ω in country i is

$$\begin{aligned} x_i(p_i(\omega), q_i(\omega)) &= q_i(\omega)^{\sigma-1} p_i(\omega)^{-\sigma} \tilde{P}_i^{\sigma-1} E_i, \\ \tilde{x}_i(\tilde{p}_i(\omega)) &= [\tilde{p}_i(\omega)]^{-\sigma} \tilde{P}_i^{\sigma-1} E_i, \end{aligned} \tag{4}$$

where $\tilde{x}_i(\omega) = q_i(\omega)x_i(\omega)$ and $\tilde{p}_i(\omega) = p_i(\omega)/q_i(\omega)$ is the quality-adjusted price of variety ω . $\tilde{P}_i = (\int [\tilde{p}_i(\omega)]^{1-\sigma} d\omega)^{\frac{1}{1-\sigma}}$ is the aggregate price index and E_i is the total expenditure in country i .

Production

Each variety of the differentiated good is produced by a monopolistically competitive firm. Labor is the only factor of production related to variable costs, with each worker supplying one unit of labor.¹⁷ I do not close the labor market, so the model here will be a partial equilibrium model. This allows me to specify a simple cost function where workers are differentiated by skill level and higher-skilled labor commands a higher wage. Unlike the standard model of firm heterogeneity in Melitz (2003), I assume that firms do not differ in their productivity.¹⁸ Instead of the Hicks-neutral productivity differences, after paying a fixed entry cost, each firm draws a “*technology suitability or management ability*” that makes use of workers’ specific skill level.

The amount of labor that firms must hire to produce one unit of output depends on product quality as well as workers’ skill level. The units of labor required to produce a unit of output consist of two components: the amount of labor associated with simple tasks that are not involved in product quality (e.g., assembly work such as screwing nuts onto bolts) and additional units of labor related to product quality (e.g., quality-related work such as technology-combined design). I assume that productivity related to assembly work does not vary across workers’ skill levels, so all firms have the same productivity for these simple tasks. In other words, more highly skilled workers have no productive advantage in assembling the physical output. Since more highly skilled workers are assumed to be more expensive to hire, marginal cost associated with these simple tasks increases with workers’ skill level.

In addition, I assume that producing better-quality goods requires additional units of labor, and higher-skilled workers are more productive in performing tasks that improve on product quality.

This is a reasonable assumption in the sense that manufacturing higher-quality products often requires more complex technology and such a technology can be more easily handled by higher-skilled workers. As a result, firms that draw a “*technology suitability*” for a higher-skilled labor force incur a higher marginal cost of simple assembly work but a lower marginal cost of tasks associated with product quality.

A firm must bear an overhead cost to produce output. For the sake of tractability, I assume that the fixed cost takes the form of capital assets with the rental rate on capital being implicitly treated as one. For simplicity, I make the following parametric assumption regarding the form of the cost function: the total cost of firms that draw a skill level $\theta \in [\underline{\theta}, \bar{\theta}]$ in country i is

$$TC_i(\theta, q) = f_i + w_i(\theta) \left[1 + \frac{q^\phi}{\theta} \right] x_i(\theta, q), \quad (5)$$

where f_i denotes the fixed overhead cost of production in country i measured in units of capital.¹⁹ $x_i(\theta, q)$ is the quantity produced by firms with skill level θ and quality level q . $w(\theta)$ is the wage rate of workers with skill level θ . ϕ denotes the elasticity of marginal cost with respect to quality, which is common across firms as well as countries.

A firm’s marginal cost function that is positively associated with product quality, $w_i(\theta) \left[1 + \frac{q^\phi}{\theta} \right]$, can be justified as follows.²⁰ If there is no quality dimension in the model (i.e., $q = 0$), then the model is of the standard form, where it is reasonable to assume that high-skilled workers have no productivity advantage in assembling output without adding product quality (e.g., screwing nuts onto bolts). As long as a more highly skilled labor force gets paid a higher wage (i.e., $w(\theta)$ increases with θ), this translates into a higher marginal cost so that firms using more highly skilled workers are less efficient. More highly skilled workers, on the other hand, have a comparative advantage in making quality goods (i.e., $q > 0$); that is, highly skilled workers are relatively more productive in performing tasks that are related to product quality.²¹

Another key assumption is that countries differ by wage schedule as a function of skill level; that is, $w_i(\theta)$ depends on county i . I assume that i) the wage function is exogenously given based on a country’s skilled-labor abundance, ii) the wage rate increases with workers’ skill level, and iii) the rate of growth in the wage rate is higher in relatively skill-scarce countries than in skill-

abundant countries.²²

Firms' profit maximization is a two-stage process: All firms first choose their product quality q simultaneously after drawing on their workers' skill level, θ . Second, firms simultaneously choose their prices and output levels given the quality of their products. With monopolistic competition and a continuum of varieties, no one firm can influence the aggregate price and quality level so that firms take the aggregate quality-adjusted price index, \tilde{P} , as given.²³ The optimal price and quality chosen by firms with θ can be solved by working backwards from the second stage. In the second stage, a firm chooses the price and quantity given its quality q by solving

$$\begin{aligned} \max_{\{p, x\}} \quad & p_i(\theta, q)x_i(\theta, q) - f_i - w_i(\theta) \left[1 + \frac{q^\phi}{\theta}\right] x_i(\theta, q) \\ \text{s.t.} \quad & x_i(\theta, q) = q^{\sigma-1} [p_i(\theta, q)]^{-\sigma} \tilde{P}_i^{\sigma-1} E_i, \end{aligned} \quad (6)$$

taking \tilde{P}_i and E_i as given. The optimal price charged by firms with θ and q is a constant mark-up over their marginal cost: $p_i(\theta, q) = \left(\frac{\sigma}{\sigma-1}\right) w_i(\theta) \left[1 + \frac{q^\phi}{\theta}\right]$.

Knowing this price rule corresponding to given product quality q , firms in the first stage choose their optimal qualities in response to their own workers' skill level θ . The firm with skill level θ in country i chooses the optimal product quality to solve

$$\begin{aligned} \max_{\{q\}} \quad & p_i(\theta, q)x_i(\theta, q) - f_i - w_i(\theta) \left[1 + \frac{q^\phi}{\theta}\right] x_i(\theta, q) \\ \text{s.t.} \quad & x_i(\theta, q) = q^{\sigma-1} [p_i(\theta, q)]^{-\sigma} \tilde{P}_i^{\sigma-1} E_i \\ \text{and} \quad & p_i(\theta, q) = \left(\frac{\sigma}{\sigma-1}\right) w_i(\theta) \left[1 + \frac{q^\phi}{\theta}\right]. \end{aligned} \quad (7)$$

Taking \tilde{P}_i and E_i as given, solving the maximization problem above gives the optimal choice of quality for firms with their workers' skill level θ ,

$$q^*(\theta) = \left(\frac{1}{\phi-1}\right)^{\frac{1}{\phi}} \theta^{\frac{1}{\phi}}. \quad (8)$$

where $\phi > 1$, which is the sufficient second-order condition for the solution to be a maximum. It is not obvious whether the marginal cost of quality is convex in some abstract measure of quality.

However, the fact that the quality elasticity of marginal cost is greater than one, $\phi > 1$, seems plausible in that higher-skilled labor involves relatively high-quality products.²⁴ In fact, Kyoji and Keiko (2010) use Japanese factory-level data to show that a product's unit value (product quality) is positively associated with a firm's skilled-labor intensity.

Substituting the optimal quality into the marginal cost function yields: $MC(\theta) = \left(\frac{\phi}{\phi-1}\right) w_i(\theta)$. Since $\frac{\phi}{\phi-1} > 1$, all firms in country i pay more than $w_i(\theta)$ to produce one unit of output. That is, all firms have an incentive to improve their products' quality: $q^*(\theta) > 0$ for all $\theta \in [\underline{\theta}, \bar{\theta}]$.

Firms Selection into Exporting

To enter the export market, firms must bear a fixed cost as well as an iceberg-type variable cost. Each firm chooses which foreign markets to enter and its export price. Firms in a country i selling to destination d pay a fixed entry cost f_{id} and must ship $\tau_{id} > 1$ units of the variety for one unit to arrive in destination d . Using the optimal quality schedule in equation (8), a firm with θ in a country i sets its f.o.b. export price for destination d , which is given by

$$\frac{p_{id}(\theta, q^*)}{\tau_{id}} = \frac{\sigma}{\sigma-1} MC(\theta, q^*) = \frac{\sigma\phi}{(\sigma-1)(\phi-1)} w_i(\theta). \quad (9)$$

Since $\frac{\sigma\phi}{(\sigma-1)(\phi-1)} > 0$, firms with a higher θ export a higher-quality product at a higher price. It should be noted that the within-firm f.o.b. export price of a product does not vary across markets due to the absence of an iceberg trade cost term τ_{id} on the right-hand side of equation (9). Since each firm charges the exact same f.o.b. export price across destinations, there is no price discrimination across markets in this theoretical framework. In this context, the variation of average f.o.b. export unit values across destinations can be driven by the sorting of heterogeneous firms across export markets. In other words, the number of firms that are efficient enough to sell their products to foreign markets varies across destinations. For example, only a few large profitable firms tend to export their varieties to relatively difficult markets (e.g., smaller and/or more distant markets).

Based on the optimal price, quantity, and quality schedule constructed in the previous section,

the revenue of firms with θ in country i exporting to country d is

$$R_{id}(\theta) = p_{id}x_{id} = \left(\frac{p_{id}(\theta)}{q^*(\theta)}\right)^{1-\sigma} \tilde{P}_d^{\sigma-1} E_d = \lambda E_d \left(\frac{\tilde{P}_d}{\tau_{id}}\right)^{\sigma-1} [w_i(\theta)]^{(1-\sigma)} \theta^{\frac{(\sigma-1)}{\phi}}, \quad (10)$$

where λ is a positive constant. Notice that firm revenue is a function of product quality as well as price because firms compete on quality-adjusted price, p/q . Whether firms' revenue increases with their workers' skill level θ depends on a country-specific wage schedule, $w_i(\theta)$. Since $\sigma > 1$ and $\phi > 1$, the firm-specific value θ has two opposite effects on firms' revenue: (i) a higher θ leads to a higher revenue via the last term $\theta^{\frac{(\sigma-1)}{\phi}}$ in equation (10). (ii) the increase in θ reduces revenue because firms with higher θ face a higher wage rate, which is captured by $[w_i(\theta)]^{(1-\sigma)}$, where we have a negative exponent. It follows from equation (10) that

$$\frac{dR_i(\theta)}{d\theta} \begin{cases} > 0 & \text{when } w'_i(\theta) \frac{\theta}{w_i(\theta)} < \frac{1}{\phi} \\ < 0 & \text{when } w'_i(\theta) \frac{\theta}{w_i(\theta)} > \frac{1}{\phi}, \end{cases} \quad (11)$$

where $w'_i(\theta)$ denotes the derivative of wage with respect to θ . Note that the term $w'_i(\theta) \frac{\theta}{w_i(\theta)}$ refers to the skill elasticity of the wage rate for country i . When the wage increases relatively slowly as skill level rises, this is $w'_i(\theta) \frac{\theta}{w_i(\theta)} < \frac{1}{\phi}$, firms with the highest θ are the most efficient. In contrast, in countries with $w'_i(\theta) \frac{\theta}{w_i(\theta)} > \frac{1}{\phi}$, an increase in θ reduces revenue. Since the wage rate increases relatively quickly with skill level, the benefits of producing higher-quality goods using more highly skilled workers are offset by the relatively higher wages for skilled labor. In other words, firms in these countries benefit from manufacturing lower-quality products using relatively cheap, less-skilled labor.

A firm from country i selling to country d must incur a country-specific fixed cost f_{id} . Firms opt to export if they earn positive profits, that is, $\frac{1}{\sigma}R_{id} \geq f_{id}$. The zero-profit condition and the revenue equation (10) yield a cut-off level of θ , at which a firm is indifferent between exporting and not exporting:

$$[w_i(\theta_{id}^*)]^{-\phi} \theta_{id}^* = \gamma \left(\frac{\tau_{id}}{\tilde{P}_d}\right)^\phi \left(\frac{f_{id}}{E_d}\right)^{\frac{\phi}{\sigma-1}}, \quad (12)$$

where $\gamma > 0$ is constant. Note that the effects of the variable trade cost τ_{id} (e.g., distance between

trading partners) and E_d (e.g., a destination market's size) on the threshold skill level θ_{id}^* depend on a country-specific wage schedule $w_i(\theta)$.

When $w'_i(\theta)\frac{\theta}{w_i(\theta)} < \frac{1}{\phi}$ holds, the quality-adjusted export price decreases with θ , so that only the firms with $\theta \in [\theta_{id}^*, \bar{\theta}]$ are able to export.²⁵ In this case, the skill level cut-off, θ_{id}^* , increases with variable trade cost (τ_{id}) and decreases with market size (E_d). As a consequence, the average f.o.b. export unit value of products shipped from these countries with $w'_i(\theta)\frac{\theta}{w_i(\theta)} < \frac{1}{\phi}$ is positively associated with distance, while it decreases with a destination market's size.

On the other hand, for exporting country i with $w'_i(\theta)\frac{\theta}{w_i(\theta)} > \frac{1}{\phi}$, only the firms with $\theta \in [\underline{\theta}, \theta_{id}^*]$ are profitable enough to export their varieties to country d and the skill level cut-off decreases with distance and increases with market size. Since firms with higher θ charge higher prices, the average f.o.b. export unit values decrease with increasing distance to a destination market, while it is positively related to market size.

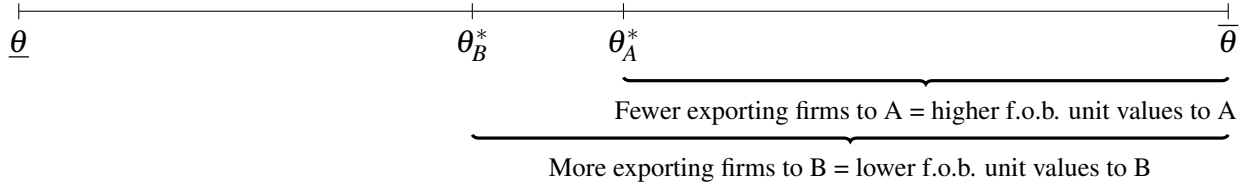


Figure 2. $w'_i(\theta)\frac{\theta}{w_i(\theta)} < \frac{1}{\phi} \iff \theta_A^* > \theta_B^*$

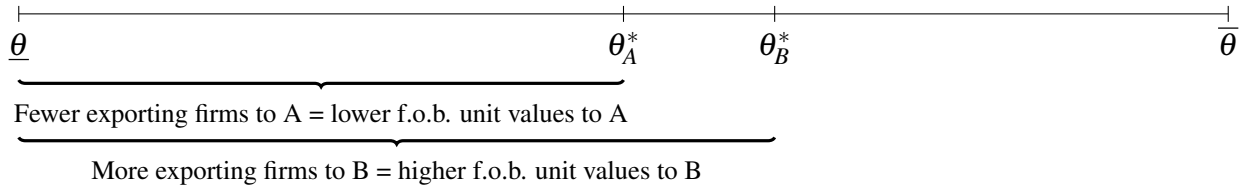


Figure 3. $w'_i(\theta)\frac{\theta}{w_i(\theta)} > \frac{1}{\phi} \iff \theta_A^* < \theta_B^*$

Suppose that firms in country i export their varieties to countries A and B , and country A is more distant and/or smaller than country B . Thus, for firms in country i , exporting to country A is more difficult than exporting to country B . Figure 2 and 3 graphically illustrate the spatial patterns of unit values across exporting countries: the market difficulty has a positive effect on the average f.o.b. export unit values in the case that $w'_i(\theta)\frac{\theta}{w_i(\theta)} < \frac{1}{\phi}$; whereas within-product unit

values decrease with distance and increase with market size when $w'_i(\theta)\frac{\theta}{w_i(\theta)} > \frac{1}{\phi}$. In Figure 2, the average unit values of products sold in country *A* are higher than that in market *B* because firms' export prices monotonically increase with θ and fewer firms with relatively high θ export to more difficult market *A*. In contrast, the negative association between market difficulty and average export prices is illustrated in Figure 3. These different spatial patterns of the average export unit values across exporting countries are driven by firms' self-selection into exports under the assumption of a country-specific wage schedule.

Table 8 below summaries the theoretical analysis in which the spatial patterns of unit values depend on a country-specific wage schedule as a function of skill level $w_i(\theta)$. Assuming $w'_i(\theta)\frac{\theta}{w_i(\theta)} < \frac{1}{\phi}$, the model predicts that firms employing higher-skilled labor are more profitable and, as a result, they can provide their varieties to relatively difficult markets. This prediction seems to be consistent with the empirical findings from U.S. and Korean exports. In contrast, when $w'_i(\theta)\frac{\theta}{w_i(\theta)} > \frac{1}{\phi}$, the model suggests that firms with lower-skilled labor are more competitive and can more easily penetrate difficult markets. This prediction seems to fit the empirical findings using export data from China and India. Skilled workers in China or India are relatively less efficient at producing high-quality varieties compared to those in relatively skilled-labor abundant countries. As a result, in relatively skill-scarce countries, firms that produce lower-quality products using relatively cheap unskilled labor tend to be more competitive.

Table 8. Summary of Different Spatial Patterns of the Average f.o.b. Export Unit Value

$w'_i(\theta)\frac{\theta}{w_i(\theta)} < \frac{1}{\phi}$	$w'_i(\theta)\frac{\theta}{w_i(\theta)} > \frac{1}{\phi}$
Quality-adjusted price decreases with skill level	Quality-adjusted price increases with skill level
Average unit value increases with distance	Average unit value decreases with distance
Average unit value decreases with market size	Average unit value increases with market size
Specialize relatively high-quality products	Specialize relatively low-quality product
Relatively skill-abundant countries (US and Korea)	Relatively skill-scarce countries (China and India)

In sum, the different spatial patterns of the average f.o.b. export unit values across exporting countries are captured by the wage schedule for skilled labor, which differs across countries. The difference in wage schedules for skilled labor is a key factor in the theoretical model used to explain the empirical results obtained from the data. The results of the data analysis seem to be supported

by the theory that assumes that the slope of the wage schedules in skill-scarce countries such as China and India is steeper than one in both the U.S. and Korea, which are relatively skill-abundant countries. This assumption can be partially supported by some statistical data, which shows that the wage ratio of skilled- to unskilled-labor is much lower in developed than developing countries.²⁶ It should be noted, however, that potential differences in the wage schedules between those two groups of countries cannot be inferred from the empirical findings obtained from the data analysis.

5. Conclusions

The main purpose of this study is to emphasize the role of product quality differences in the model of firm heterogeneity to explain the variation of export unit values across destination markets. I estimated the effects of distance and destination market size on the average f.o.b. export unit values using HS-6 product level data for different exporting countries and found that the average f.o.b. export unit values of a product shipped from the U.S. or Korea increase with distance and decrease with market size. Within-product average unit values for products sourced from China and India decrease with distance and increase with market size. A model is developed to reconcile these two different spatial patterns, where a country-specific wage schedule over skill level has an important role in determining the spatial patterns of unit values across exporting countries. The model predicts that in relatively skill-abundant countries, firms using higher-skilled labor are more competitive and are able to export their varieties at higher prices to more difficult markets. In contrast, firms in relatively skill-scarce countries prefer being lower cost in order to produce lower-quality products using lower-skilled workers, and the average f.o.b. export unit values decrease with the increasing difficulty in market penetration.

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Notes

1. Another possible explanation involves within-firm price discrimination or within-firm selection of product quality across markets. See Harrigan et al. (2011) and Bastos and Silva (2010), which explain within-firm price variations across destinations using firm-level data. Without firm-level data at hand, one cannot directly distinguish the within-firm selection effect from the firms’ self-selection effect. However, the estimation results conducted in a later section with product-level data allow one to indirectly capture the relative importance of the firms’ self-selection effect rather than the within-firm channel.

2. See Schank et al. (2007) and Irarrazabal et al. (2009) for evidence of skill-intensity differences across firms and the exporter wage premium.
3. I choose China and India because the size of their economies is similar to that of the U.S., but these countries are different from the U.S. in regard to income level and skilled-labor abundance. Comparing Chinese exports to Korean exports also gives useful information about within-firm selection of export prices across markets in that Korea is the closest country to China.
4. For evidence of a positive association between firms' product quality and the skill level of their workers, see Kyoji and Keiko (2010) and Kugler and Verhoogen (2012).
5. The spatial patterns of within-product export unit values may depend on the exporting country's characteristics, such as its level of development or skill abundance.
6. For empirical evidence of within-product specialization across exporting countries, see Schott (2004).
7. In the model of Melitz and Ottaviano (2008) with a linear demand, firms can more easily export their products to relatively large and more distant foreign markets. In contrast, in the Melitz model with CES preference, more difficult markets are represented by longer distance and smaller market size.
8. The country indicator variables are taken from the World Development Indicators (WDI).
9. For instance, distances for U.S. exports are measured in kilometers from Chicago to the most populated city in importing countries.
10. I include GDP per worker in the regression as an independent variable that controls for demand-related effects.
11. WTO_j takes the value of one if the importing country j is a WTO member. RTA and $Comcur$ variables indicate one if both exporting and importing countries are in a regional trade agreement and common monetary area, respectively.
12. The regression includes both GDP and GDP per worker as regressors, so the coefficient on GDP is hard to interpret if these two variables are highly correlated. Thus, I also test it including GDP alone in the regression, and the result is significant and similar as in Table 2. Even if the coefficient of GDP increases slightly for all exporting countries, its sign remains the same as shown in Table 2. In fact, the correlation between GDP and GDP per worker is negligibly low (smaller than 0.16).
13. Bastos and Silva (2010) use Portuguese firm-level data to show that the positive correlation between distance and the average export unit values is driven by not only within-firm selection, but also by the differing composition of firms across exporting markets. Based on this within-firm variation of export prices

across markets, the absolute value of the coefficient on distance estimated from Chinese exports is smaller than the true effect, while the positive effect of distance obtained from Korean exports is overestimated.

14. See Bernard et al. (2006) where the authors point out the importance of the within-firm channel in determining the effect of real income per worker on trade flows.

15. As a robustness check, I extend the empirical analysis by adding six more exporting countries (Brazil, France, Germany, Japan, Mexico, and the UK) and compare it with the previous results shown in Table 4. The basic results of this estimation, including the ten largest exporting countries (not reported here), are consistent with the estimation results presented in Table 4.

16. Examples of homogeneous products at the HS 6-digit level are unwrought gold powder and refined copper.

17. Production involves both fixed and variable costs. The fixed costs take the form of capital assets with the rental rate on capital being normalized to one, while the variable costs require only the labor.

18. See Irarrazabal et al. (2009) where the authors confirm that over 67% of the exporter productivity premium reflects differences in skill-intensiveness rather than intrinsic firm efficiency using Norwegian firm-level data that matches employer and employee. That is, firm heterogeneity is mainly sourced by workers' skill level across firms.

19. Note that the cost function is homogeneous of degree one in input prices.

20. See Xiang (2005), Verhoogen (2008), and Kugler and Verhoogen (2008) for evidence of a positive association between product quality and input costs (and hence marginal costs).

21. Taking the derivative of the second term of marginal costs, $w(\theta)\frac{q^\theta}{\theta}$, with respect to the skill level θ gives that marginal costs decrease with θ under the assumption of $w'_i(\theta)\frac{\theta}{w_i(\theta)} < 1$. Hereafter, I assume that $w'_i(\theta)\frac{\theta}{w_i(\theta)} < 1$ holds, that is, higher-skilled workers are relatively more productive when doing the quality-related tasks compared to lower-skilled workers.

22. That is, the skill elasticity of the wage rate differs across countries and it is steeper in skill-scarce countries than in relatively skill-abundant countries.

23. Note that $\tilde{P} = (\int_\omega [\tilde{p}(\omega)]^{1-\sigma} d\omega)^{1/1-\sigma}$, where \tilde{p} is the quality-adjusted price defined by p/q . Although \tilde{P}_i is endogenous to the industry, firms take it as an exogenous variable since firm's size is negligible relative to the industry as a whole under the assumption of monopolistic competition.

24. See Cremer and Thisse (1994), Khandelwal (2010), and Schmitt (2002), where the authors assume the quadratic form of marginal cost (MC) with respect to quality: $MC(w, q) = w + q^2$, where w and q are a

firm-specific and a quality-specific component, respectively.

25. The f.o.b. based quality-adjusted price can be expressed by $\frac{p_{id}^*(\theta)}{\tau_{id}q^*(\theta)} = \eta w(\theta)\theta^{-1/\phi}$, where η is a positive constant. Thus, firms' quality-adjusted price decreases with θ when the following condition holds:

$$w'_i(\theta) \frac{\theta}{w_i(\theta)} < \frac{1}{\phi}.$$

26. Based on the Global Trade Analysis Project (GTAP) data set in 1995, the average ratio of skilled- to unskilled-labor wage is 1.8 for developed countries, while it is about 3.5 for developing countries (see, e.g., Markusen 2002).