Product Quality, Duration, and Trade Growth

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Abstract

We investigate the effects of product quality on the probability of survival in export market and the trade growth condition on exports. We present a tractable model of heterogeneous firms and endogenous quality choices. The model shows that product quality is positively related to the probability of survival and trade growth. The empirical results using 5-digit SITC level bilateral trade data and IMF 4-digit SITC quality data support the theoretical predictions: products with higher quality are less likely to cease and have larger trade growth.

Keywords: Product quality, duration, trade growth

JEL Classification: F12; F14

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1 Introduction

Product quality plays an important role in international trade and much evidence indicates that the quality of products in international markets significantly varies across countries. On one hand, higher quality brings good reputation for producers. On the other hand, higher quality requires higher costs. Producers face a trade-off between quality and costs. Although a substantial amount of trade models point to the importance of product quality, there are very few empirical studies addressing how product quality affects trade over time because of lack of quality data. More recent literature has empirically studied the effects of quality on international trade using various approximations of quality data. Hallak (2006) uses unit value as a proxy of product quality and examines how product quality determines the direction of trade. He finds that rich countries import relatively more high-quality goods. Schott (2004) shows that product quality is a key factor of how countries specialize in production. Hummels and Klenow (2005) find that richer countries produce higher quality goods and export more units. Hallak (2009) develops a model predicting and verifying empirically that exporters sell products of higher quality at higher prices conditional on size. Baldwin and Harrigan (2011) propose a model incorporating quality into Melitz's (2003) model to explain the "zero exports" which trade models failed to explain.

Another strand of product quality literature is to estimate the quality of exported products. Khandelwal (2010) estimates the quality of products exported to the U.S. using the standard industrial organization method. Hallak and Schott (2011) estimate the differences in product quality across countries and find that unit value could be a poor approximation for quality. Unlike the above two papers focusing on the demand side, Feenstra and Romalis (2014) model both demand and supply sides and estimate the quality and quality-adjusted prices for most countries over 1984-2011. However, we use the IMF quality data in our paper because it has the longest time period and richest country sample. We will discuss this data set in detail at section 3.

Our paper contributes to the literature by examining how product quality affects trade growth conditional on survival. As Besedeš et al (2014) examine how credit constraints affect trade growth, we develop a similar model investigating how product quality affects trade growth. In our model, consumers have preferences for both quantity and quality. They treat products exported from different countries differently. Therefore, firms from origin countries have to decide the price and quality of their products. We derive the relationship between quality and trade growth, which predicts that the effect of quality on growth depends on the value of parameter of quality affecting marginal cost. In addition, our model implies that the relationship between product quality and total imports also depends on that parameter.

This paper contributes to the trade duration literature too. Besedeš and Prusa (2006) show that product differentiation affects the duration of trade relationships. Araujo et al (2016) find that if an importer has higher institution quality, then the trade relationship would be longer. In our paper, we contribute to the duration literature by studying how product quality influences the duration of trade relationships. In our model, we assume product quality varies each period, which means producers could adjust their quality to compete with rivals according to consumers' preferences. Therefore, if exporters' quality continues to be worse than others, consumers would purchase goods from their rivals, with such firms being more likely to exit the market. Thus, we argue that product quality may influence the probability of firms' survival. On the other hand, quality affects costs dramatically. If costs increase too fast as quality increases, producers would not make any profits. Therefore, producers need to lower costs as well as maintain quality at some level. In our paper, we assume that quality affects marginal costs positively, but the magnitude of quality on marginal costs depends on the value of parameter. Following Baldwin and Harrigan (2011) model which is based on Melitz's (2003) heterogeneous firms model, we predict that quality is positively related to the probability of success in trade partnerships.

We examine the above predictions using data on disaggregated bilateral trade flows and data on product quality. Our trade data are annual 5-digit SITC revision 1 imports from 1962 to 2005 for all countries in the UN Comtrade database. Data on product quality come from the IMF export diversification and quality database. This database provides 1- to 4- digit SITC product quality from 1962 to 2010. Using these data, we are able to empirically confirm the three theoretical predictions: products with higher quality are more likely to survive, higher product quality is positively related to trade growth, and is positively related to total trade value.

2 Conceptual framework

In this section, we theoretically analyze the effect of product quality on the probability of firms' survival in export markets and trade growth. We assume that consumers could perceive the quality of products from various original countries. In addition, the marginal cost of the producer depends on product quality. Formally, we assume that the international market consists of $e = 1, 2, ..., E$ countries. Each country has monopolistically competitive firms which produce differentiated varieties and may export to all other countries. We arbitrarily pick one Export(e) country and one Import(i) country, and examine trade flow from an Exporter to an Importer.

2.1 Quality and hazard

2.1.1 Consumer preferences

Following Besedeš et al (2014), we define the utility function as CES with a numeraire but incorporating the product quality into consumer preferences:

$$u_t = z_t + \lambda_t \sum_{e \geq 1} \sum_{d \geq 0} (\sum_{v \in v_{ed}} (\theta_{vt} x_{vt})^{\frac{\sigma-1}{\sigma}}) \tag{1}$$

where x_{vt} and θ_{vt} are the individual consumption and quality of differentiated variety v in period t, v_{ed} is the set of total varieties and e represents exporters, σ is the elasticity of substitution. λ_t is a period-specific demand shifter and the subscript "ed" defines a cohort of firms producing differentiated varieties in country e and existing in export markets for d years. Price of the numeraire,z_t, is normalized to one.

The budget constraint is given by

$$z_t + \sum_e \sum_d (\sum_{v \in v_{ed}} p_{vt} x_{vt}) = I_t$$

where I_t is the total income. Individual demand for variety v in period t is derived as

$$x_{vt} = \theta_{vt}^{\sigma-1} (\frac{\sigma - 1}{\sigma} \frac{\lambda_t}{p_{vt}})^{\sigma} \tag{2}$$

2.1.2 Firm's optimal choice of price and quality

Assuming labor is the only input of production and all costs are measured as units of labor. Firms have two types of fixed costs and marginal costs. The first fixed cost F_I is the standard production fixed costs incurring one time. The second fixed cost, F, reflect the fixed exporting cost which incurs every period. We also assume that marginal cost, c, is related to quality. Note that quality varies across varieties and over time. Similar to Baldwin and Harrigan (2011), we assume quality affecting marginal cost in the following:

$$c_{vt} = \theta_{vt}^{k} \quad k > 0$$

As is Melitz (2003), potential firms pay F_I to take a draw from the random distribution of marginal cost (or productivity). The distribution of marginal cost, c, satisfies the Pareto distribution. After that, firms need to decide price and quality level to maximize profit. In addition, we assume that there exist iceberg transportation costs, so only a portion of shipped goods arrive in the destination country and a firm needs to produce some extra goods to meet the demand of the destination country. Then the total output of a firm is $\tau_e x_{vt}$ and its profit is:

$$\pi_{vt} = p_{vt}(d)x_{vt}(d) - w_e(c_{vt}\tau_e x_{vt} + F + F_I) \tag{3}$$

where w_e and τ_e are the labor wage and iceberg transportation cost, respectively. Solving the F.O.C with respect to p_{vt} results in:

$$p_{vt} = w_e c_{vt} \tau_e \tfrac{\sigma}{\sigma-1}$$

Then we calculate the operating profit as following:

$$(p_{vt} - w_e\tau_e c_{vt})x_{vt} = (w_e\tau_e)^{1-\sigma}(\frac{\sigma-1}{\sigma})^{2\sigma}\lambda_t^{\sigma}\theta_{vt}^{(\sigma-1)(1-k)}/(\sigma-1) \tag{4}$$

The value of parameter k plays a crucial role for our analysis. If $k > 1$, the marginal cost increases quickly with quality. In this case, a firm's revenue and operating profit fall with quality. If $0 < k < 1$, by contrast, marginal cost increases slowly with quality. If this is true, the operating profit increases as quality increases. This is the more interesting case. Therefore, we assume $0 < k < 1$ in following analysis.

2.1.3 Export decision

A firm from country e with marginal cost c and quality θ will export if and only if:

$$(p_{vt} - w_e \tau_e c_{vt}) x_{vt} \geq w_e F \tag{5}$$

From equation (4) and (5), we can derive the cutoff condition of marginal cost for export:

$$c_{vt}^{*\frac{(\sigma-1)(1-k)}{k}} \geq (w_e F(\sigma - 1))(w_e \tau_e)^{\sigma-1}(\frac{\sigma}{\sigma - 1})^{2\sigma} \lambda_t^{-\sigma} \tag{6}$$

We can write the cutoff condition in terms of quality:

$$\theta_{vt}^{*(\sigma-1)(1-k)} \geq (w_e F(\sigma - 1))(w_e \tau_e)^{\sigma-1}(\frac{\sigma}{\sigma - 1})^{2\sigma} \lambda_t^{-\sigma} \tag{7}$$

Since $0 < k < 1$ is the more interesting case, we can find that firms with higher product quality are more likely to export controlling for the per-period shock.[1] Notice that the marginal cost (quality) is the minimum cost (quality) threshold rather than the maximum as in the standard Melitz (2003) model.

Proposition 1. From equation (7), firms with higher product quality are more likely to satisfy the cutoff condition. Therefore, controlling for time shock, product quality is positively related to the probability of success in exports i.e., the higher the quality is, firms are more likely to survive.

2.2 Trade growth

Now we investigate the trade growth conditional on exporting within a spell, which is defined by a consecutive years during which a bilateral trade relationship for a specific product is active. Duration of a trade spell is denoted by $d = 0, 1, 2, ..., D$. Here firms

[1] We can derive the probability of exporting using the Pareto distribution, but the cutoff condition is enough to illustrate the relationship between quality and probability of exporting.

have already decided to export at time t, but there is an exogenous probability that producers may not export or the trade relationship break down at $t+n$ as Araujo et al (2016). Therefore,we assume the number of new entrants in each period is given by n_e, out of which only $\phi_e(0)$ will succeed in exports similar to the Besedeš et al (2014) framework. Define $\phi_e(d)$ as the probability of success of partnership between the exporter and importer with duration d. The total length of duration of a partnership is D. Then, the expected profit of a firm with duration d is:

$$E[\pi_{vt}(d)] = \phi_e(d)p_{vt}(d)x_{vt}(d) - w_e(c_{vt}\tau_e x_{vt} + F + F_I) \tag{8}$$

where the quantity, x_{vt}, is given by equation (2).
Solve the F.O.C with respect to p_{vt}:

$$p_{vt} = \frac{w_e c_{vt}\tau_e}{\phi_e(d)}\frac{\sigma}{\sigma-1} \tag{9}$$

Our model differs from Besedes et al (2014) in the sense that the price, given by equation (9), varies over time in each origin e and duration d cohort. To simplify our analysis, we assume that firms within an exporting country have the same quality for period t. But quality of the same variety varies across countries and over time. The quantity of variety v exported from e is equal to the consumption of destination country:

$$Q_{evt}(d) = Q_{vt}(d) \equiv L_i x_{vt}(d) \tag{10}$$

where L_i is the total number of consumers in an import country.

Then the aggregate value of exports of a new variety v exported by country e are given by:

$$V_{evt}(0) \equiv n_e\phi_e(0)p_{evt}(0)Q_{evt}(0) = n_e\phi_e(0)L_i(\frac{\sigma-1}{\sigma})^{2\sigma-1}\lambda_t^{\sigma}(\frac{w_e\tau_e}{\phi_e(0)})^{1-\sigma}\theta_{vt}^{(\sigma-1)(1-k)} \tag{11}$$

The number of firms with duration d is given by:

$$N_e(d) = n_e\phi_e(0)(\widetilde{\phi})^d \tag{12}$$

where $\widetilde{\phi} = \phi_e(d \geq 1) > \phi_e(0)$ is the probability of success of trade relationship for $d \geq 1$.

We can express the value of exports by all firms with duration d as a function of exports by new exporters, $V_{evt}(0)$:

$$V_{evt}(d) \equiv N_e(d)p_{evt}(d)Q_{evt}(d) = V_{evt}(0)(\frac{\phi_e(0)}{\phi_e(d)})^{1-\sigma}(\widetilde{\phi})^d \tag{13}$$

This result allows us to derive the value of exports by all firms from country e with "exporting age" $D \geq 1$ as a function of exports by new exporters, $V_{evt}(0)$:

$$\sum_{d=0}^{D} V_{evt}(d) = V_{evt}(0)[1 + \sum_{d=1}^{D}(\frac{\phi_e(0)}{\widetilde{\phi}})^{1-\sigma}(\widetilde{\phi})^d] \tag{14}$$

From equation (14), we can derive the export growth of variety v from country e with $D \geq 1$:

$$G_{evt}(d) = \sum_{d=0}^{D} V_{evt}(d) - \sum_{d=0}^{D-1} V_{ev(t-1)}(d) = V_{evt}(0)(\frac{\phi_e(0)}{\widetilde{\phi}})^{1-\sigma}\widetilde{\phi}^D \tag{15}$$

Substitute $V_{evt}(0)$ into equation (15), the export growth can be expressed as:

$$G_{evt}(d) = n_e\phi_e(0)L_i(\frac{\sigma-1}{\sigma})^{2\sigma-1}\lambda_t^{\sigma}(\frac{w_e\tau_e}{\widetilde{\phi}})^{1-\sigma}\widetilde{\phi}^D\theta_{vt}^{(\sigma-1)(1-k)} \tag{16}$$

Taking log value of equation (16), we obtain the log value of export growth as

$$\begin{aligned} lnG_{evt}(d) = (2\sigma-1)ln(\frac{\sigma-1}{\sigma}) + ln(n_eLi) + (1-\sigma)ln(w_e\tau_e) \\ +\sigma ln\lambda_t + ln\phi_e(0) + (\sigma - 1 + D)ln\widetilde{\phi} + (\sigma-1)(1-k)ln\theta_{vt} \end{aligned} \tag{17}$$

From equation (17), we can see that the effect of product quality on trade growth depends on the value of k (since $\sigma > 1$) controlling for everything else. Since we assume $0 < k < 1$, then we have the following proposition:

Proposition 2. Trade growth is positively related to product quality, ceteris paribus.

Similarly, from equation (13) we can show that the level of imports of within a spell are positively related to product quality of the same period t if $0 < k < 1$. Then we have the following proposition:

Proposition 3. Level of imports of each year within a spell are positively associated with the product quality at the same period.

3 Data and empirical methods

3.1 Bilateral trade and product quality data

To verify our theoretical predictions, we need trade flow data and the associated quality of products. One could examine them using firm-level data or country-product or country-industry-level data. The last type of data are more readily available and are used in our paper.

We combine two main data sets in our study. The bilateral trade flow data come from the UN Comtrade Database, which provides annual industry-level imports and exports data. We use the 5-digit SITC revision 1 classification years ranging from 1962 to 2005. In addition, we use the data reported by importers because they are more accurate than exporter' reported data. Since the data set includes all countries, our analysis can be interpreted as an analysis of imports or of exports. Thus, we use trade and imports interchangeably.

Data on product quality come from the IMF Export Diversification and Quality Databases. To construct the quality data, the researchers first simply assume that the trade price (unit value) is a linear function of unobservable product quality, exporter income per capita, distance between the importer and exporter, and other unobservable factors. Next, they substitute quality into the common bilateral gravity equation as an interaction term with the importer's income per capita. After rearranging the quality as a function of price, all variables on the right-hand side of the gravity equation are observable. The following step is to estimate the gravity equation for each of the 851 SITC 4-digit categories using the two-stage least squares method. Finally, the researchers normalize all quality estimates by their 90th percentile in product-year combination and aggregate estimates across importers using trade values as weights.[2] The data provide the 4-, 3-, 2-, 1-digit SITC quality, and overall country-level average quality for each exporter in sample periods. We use 4-digit quality values ranging between 0 and 1.2 and year from 1963 to 2010. The mean and median of quality are 0.9162 and 0.9546 respectively.

Figure 1 presents the distribution of product quality. From Figure 1, we can find that product quality is skewed and concentrates around 1. Figure 2 gives an example of quality of one sector changing over time for four countries: United States, Germany, Japan, and China. For this particular sector of Heating and Cooling equipment (SITC=7191), China has the lowest quality but experiencing a large increase since 1990. The other three countries have a similar pattern of quality evolution which is relatively stable over the sample period, while the quality of the U.S. is slightly higher than Germany and Japan.

[2] `https://www.imf.org/external/datamapper/Technical%20Appendix%20for%20Export%20Quality%20database.pdf`

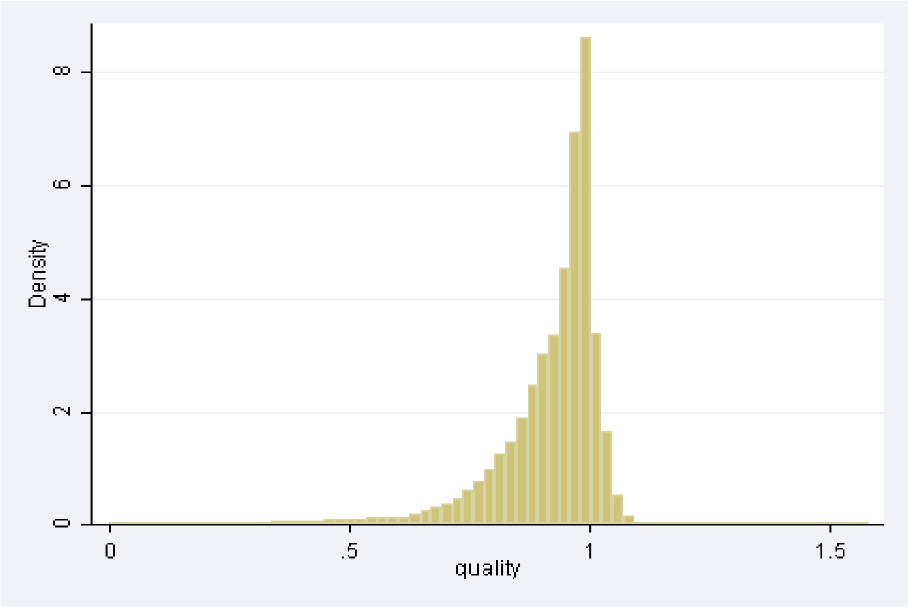

Figure 1: Quality Distribution

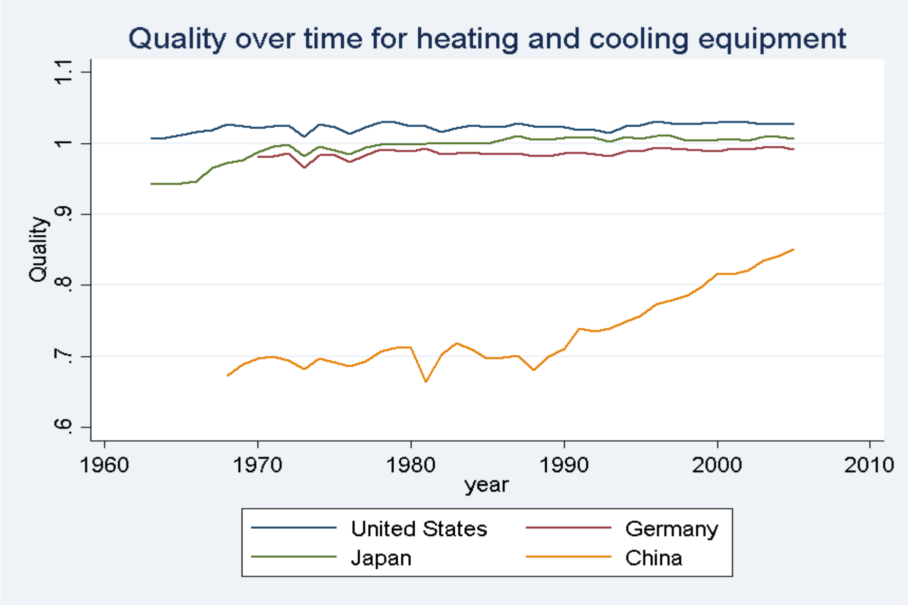

Figure 2: Quality Changes for Heating and Cooling Equipment (SITC=7191)

We use standard gravity variables in our analysis which followed our theoretical analysis. The data on these variables come from the CEPII database which provides both the exporter's and importer's GDP, the distance between them, and whether they share a common border and a common language.

Our sample observations are the intersection of two sources available from 1963 to 2005. After we merge the above two data sets, we have a total of 14,574,526 observations and 257 distinct 4-SITC sectors. Our data structure consists of spell-episodes with positive exports. Put another way, it consists of exporter-importer-product spells with positive imports over consecutive years. There are a total 5,784,321 exporting spells with a total of 8,790,205 years of growth since some relationships only exist in one year.

Table 1 shows that the majority of observed spells of trade have a very short duration, with approximately half of all spells lasting one year and about 90% being observed for 10 or fewer years. The average export growth within a spell is about 0.1445 million US dollars, and the standard deviation of it is about 1.4557. Our hazard estimation sample is smaller by 2,375,717 observations due to three factors. The majority of these observations, 1,349,738 to be precise, are caused by missing values of product quality. The second factor is left censored observations which is caused by the nature of survival data. To be specific, there are 1,080,184 missing observations due to left censor. The reason for left censoring is that for all spells which are active in the first year in which an importing country reports data, we cannot observe the actual starting year of that relationship. For example, if the U.S. reports imports in 1962 which is the first year of our trade data set, then all spells involving the U.S. imports in 1962 are left censored, and we omit such spells from

Table 1: Distribution of Spell Length

Spell length	Number of spells	Fraction
1	2,874,453	49.7%
2	893,135	15.4%
3	439,474	7.6%
4	265,918	4.6%
5	197,373	3.4%
6	167,865	2.9%
7	112,739	1.9%
8	96,629	1.7%
9	79,194	1.4%
10	84,033	1.5%
11-20	336,530	5.8%
21-30	90,723	1.6%
31-44	146,255	2.5%
Total	5,784,321	100.0%

our analysis. The remaining omitted observations are caused by the missing values of gravity data.

We examine the effect of product quality on trade relationships based on a unit of observation with a continuous trade spell involving an exporter, an importer, and a specific product. More specifically, we focus on consecutive years, beginning with a clearly observed starting point, during which a trade relationship is active and we call this a trade spell. A trade spell slightly differs a trade relationship. The latter denotes an exporter-importer-product triplet, while the former defines the consecutive years during which a relationship is active.

3.2 Empirical methods

3.2.1 Hazard estimation

The hazard is the probability of exports of variety v from country e to importing country i in spell s ceasing at time $t+n$ conditional on it having survived until time t, $P(T^v_{sei} \leq t+n | T^v_{sei} \geq t)$, where T^v_{sei} is a random variable measuring the survived duration of spell sei. Many papers studying the duration of trade relationships have followed Besedeš and Prusa (2006) and estimate various versions of continuous-time Cox proportional hazards models. However, Hess and Persson (2011) show that discrete-time models are more suitable to estimate hazards in large trade data sets because of three major reasons. The first one is that the continuous-time models cannot deal well with tied duration times which leads to biased estimates. Trade data have many tied ceasing times by nature since the number of spells usually dwarfs the number of time dimension of the data. Secondly, it is difficult to control for unobserved heterogeneity in the Cox model as the estimation requires evaluation of a multidimensional integral. If one were to model unobserved heterogeneity at the level of trade relationships, the dimensionality of this integral would equal the number of trade relationships in our data, which is more than 2 million. Finally, the Cox model imposes a restrictive assumption of proportional hazards which is questionable empirically. By contrast, the discrete-time models can handle all three drawbacks without difficulties.

We define the hazard of a spell trade ceasing, h^v_{seit} and estimate the hazard of exports ceasing at time t by random-effects probit model as

$$\begin{aligned} h^v_{seit} &= P(T^v_{sei} \leq t+n | T^v_{sei} \geq t) \\ &= \Phi(\theta^v_{et} + lns(t)_{seit} + lnV^v_{seit} + lnGDP_e + lnGDP_i + X_{ei} + \epsilon^v_{sei}) \end{aligned} \tag{18}$$

where θ^v_{et} represents the quality of variety v of exporter e at year t, $lns(t)_{seit}$ is the log of age of spell s in year t, lnV_{seit} is the log of bilateral trade volume of spell s in year t between e and i, $lnGDP_{e(i)}$ represents the GDP of exporter (importer), X_{ei} is a vector of bilateral time-invariant gravity variables (distance, common border, common language). ϵ^v_{sei} captures the relationship-specific random effect.

3.2.2 Growth and level of imports estimation

To investigate the effect of quality on trade growth, we estimate equation (17) by OLS as following:

$$lnG^v_{seit}(d) = \alpha + \delta_e + \gamma_i + \lambda_t + D_s + \mu_s + V + \beta ln\theta^v_{et} + X + \epsilon^v_{seit} \tag{19}$$

where $lnG^v_{seit}(d)$ is the log of the growth of trade from year $t-1$ to t of variety v within the spell s between e and i, α is a constant, δ_e and γ_i represents the exporter and importer fixed effects respectively, λ_t is the calendar year fixed effects, D_s is the spell length fixed effects, μ_s is the spell fixed effects, V is the 4-digit SITC industry fixed effects, X is a vector including the spell age, GDP of both countries, gravity variables, and first year trade value of the spell. ϵ^v_{seit} is the error term.

We apply a similar specification to investigate the effect of quality on the level of imports at the same period but excluding the initial trade value as an independent variable.

4 Results

4.1 Duration

Proposition 1 states that the probability of a trade relationship ceasing (surviving) is negatively (positively) related to product quality. To test the relationship empirically,

Table 2: Hazard Regression

	Hazard (RE probit)
Quality (ln)	-0.0664***
	(0.00286)
Duration (ln)	-0.552***
	(0.000701)
Trade size (ln)	-0.107***
	(0.000240)
Importer GDP (ln)	-0.00848***
	(0.000227)
Exporter GDP (ln)	-0.0471***
	(0.000296)
Distance (ln)	0.0822***
	(0.000591)
Contiguity	-0.0929***
	(0.00239)
Common language	-0.0135***
	(0.00129)
_Constant	1.000***
	(0.00691)
Observations	12,198,809
Relationships	2,609,873

Robust standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

we estimate the specification given by equation (18).

Results presented in Table 2 are consistent with the prediction of our model. The higher quality is negatively related to the hazard rate, which confirms our prediction. However, interpreting the magnitude of probit model depends on other variables' value and the starting value of quality. Figure 3 plots the predicted hazard at the mean values of all explanatory variables against the spell age. As the relationship survives

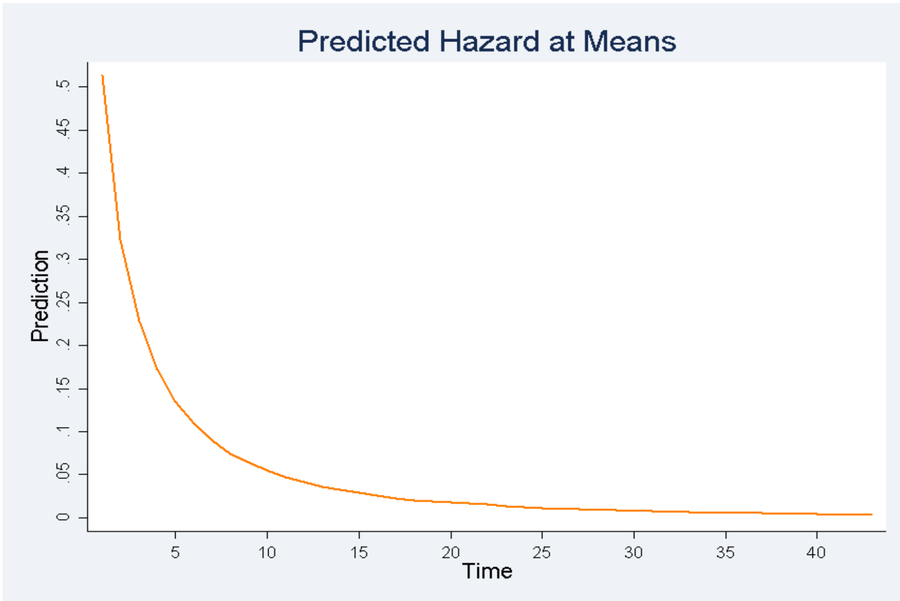

Figure 3: Predicted Hazard

longer, the probability of ceasing decreases. All other variables have expected effects on hazard and are consistent with literature. For example, longer lived spells (longer duration) are less likely to cease. Also larger spells are more likely to survive. The larger are the GDP of both exporter and importer the less likely is trade to cease too. All independent variables are significant at the 1% level.

We can conclude that product quality has a positive effect on the probability of survival in international markets. Intuitively, consumers would prefer the goods with higher quality over those with lower quality conditional on prices. The implication is that exporters should not only pursue lower price or costs and neglect quality. The higher quality may help exporters stay longer in the market despite the likely higher costs associated with it.

4.2 Trade growth

Proposition 2 states that higher product quality is positively associated with trade growth given $0 < k < 1$. In particular, we examine the growth of trade conditional on spell survival. Empirically, we can examine the coefficient of quality, β, by estimating equation (19). If $\hat{\beta}$ turns out to be positive, then it implies that $0 < k < 1$ which makes our assumption sensible. To estimate equation (19), we use the OLS method adding the exporter and importer, year, spell number and spell length, 4-digit SITC industry fixed effects besides the variables we used in the hazard regression. Note that we use the initial trade value instead of current value of a spell in the growth regression because the dependent variable, trade growth, is calculated by subtracting the trade value of previous period from current value.

Table 3 presents the results of growth regression. The result shows that the coefficient of quality is 0.0321 (indicating $0 < k < 1$), which implies that trade would increase 0.0321% as an exporter's product quality increases 1% controlling for other variables. This confirms our prediction in the model. Similar to the results of Besedeš et al (2014), we find that the growth of trade within a spell decreases as the relationship lasts longer. The coefficient of duration indicates that the trade growth would decrease 0.297% as the relationship survives 1% longer. The initial trade value has a negative effect on growth too. Specifically, the growth would be lower by 0.109% if the initial value increases 1%. The GDP of exporter and importer have opposite effects on growth. The higher the GDP of an importer, the larger the growth of trade. By contrast, the higher the GDP of an exporter, the lower the growth of bilateral trade. One possible explanation is that, during this period, developing countries have experienced large growth in exports such as China. The gravity variables are consistent to

Table 3: Growth Regression

	Growth (ln)
	OLS
Quality (ln)	0.0321***
	(0.00461)
Duration (ln)	-0.297***
	(0.00123)
Initial Trade (ln)	-0.109***
	(0.000300)
Importer GDP (ln)	0.154***
	(0.00225)
Exporter GDP (ln)	-0.0133***
	(0.00231)
Distance (ln)	-0.0472***
	(0.000804)
Contiguity	0.0414***
	(0.00225)
Common language	0.0242***
	(0.00171)
_Constant	0.310***
	(0.0565)
Observations	8,127,770
R^2	0.038

Robust standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

the literature findings. The longer the distance, the lower the growth because of larger transportation costs. Sharing a common border and a common language benefit the growth. All independent variables are statistically significant at the 1% level.

Product quality has a positive effect on trade growth. We are interested in investigating the channel behind this effect. One can argue that high quality products may have small initial trade values since they are more expensive, which leads to the positive relationship between quality and growth, as smaller starting relationships grow faster. Arujo et al (2016) indeed find that lower institution quality results in larger trade growth because those institutions results in lower initial trade values. Therefore, we want to examine whether higher quality is negatively related to initial trade values. If so, then it could provide one explanation for larger growth of high quality products. The specification is following:

$$lnimports_{seit}^{v}(0) = \alpha + \delta_e + \gamma_i + \lambda_t + \mu_s + V + \beta ln\theta_{et}^{v}(0) + X + \epsilon_{seit}^{v}$$

The dependent variable is the imports of first year within a spell. The explanatory variables are the same as the growth regression but excluding the variable duration sice we only consider the trade values of first year. However, our empirical test shows that product quality has no significant impact on first year imports. This implies that higher quality positively associated with larger growth is not because higher quality is associated with lower initial imports. We present the results in the Table A.

4.3 Level of imports

Proposition 3 states that imports are positively related to product quality of the same period if $0 < k < 1$. Our empirical results confirm the assumption about $0 < k < 1$. Then we would expect that the value of imports would be positively related to product quality too. To test the prediction, we estimate a similar specification as the growth estimation except that we use imports not growth as the depend variable. We exclude the initial trade value as an independent variable.

Table 4 presents the results of the estimation. The coefficient of quality is about 0.0735 and significant at 1% level, which confirms our prediction. The interpretation of the magnitude is that the imports would increase by 0.0735% as product quality

Table 4: Level of Imports Regression

	Value of imports (ln)
	OLS
Quality (ln)	0.0735***
	(0.00519)
Duration (ln)	0.560***
	(0.00100)
Importer GDP (ln)	0.420***
	(0.00214)
Exporter GDP (ln)	0.110***
	(0.00233)
Distance (ln)	-0.167***
	(0.000876)
Contiguity	0.235***
	(0.00277)
Common language	0.0442***
	(0.00182)
_Constant	6.241***
	(0.0548)
Observations	13,093,971
R^2	0.492

Robust standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

increases 1%. This is consistent with the intuition that consumers would buy goods with higher quality conditional on prices. Since the quality data we used reflect price information, product quality being positively related to contemporaneous imports of the same period is not surprising. Also, we can find that imports are larger for longer lived spells. The larger the GDP of both the exporter and importer, the larger the trade. The gravity variables have expected effects but bigger magnitudes than those in the growth regression.

4.4 Robustness checks

For the growth and imports estimations, we use exporter, importer, year, 4-digit SITC industry, spell number, and spell length fixed effects. However, some unobserved characteristics may be captured by exporter-importer pair fixed effects. Then we estimate a specification using exporter-importer pair fixed effects instead of using exporter and importer fixed effects separately and keep all other fixed effects. The results are presented in Table 5. We can find that product quality is positively related to trade growth and imports. The magnitude of the effect of quality on growth is slightly smaller than that in the baseline specification, while the magnitude of quality for level of imports is slightly bigger than that in the baseline specification.

5 Conclusion

Product quality plays an important role in international trade. It has already been shown (Hallak 2006 and Schott 2004) that product quality could affect direction of trade and the specialization of production. In this paper, we analyze the effect of product quality on trade duration and growth. We develop a theoretical framework which characterizes firms' choices of price and quality to start a trade relationship. Our model predicts the effects of product quality on duration, growth, and level of trade of active spells. Duration increases in product quality. The growth and level of imports within a spell are increasing in product quality. All these predictions are confirmed by our empirical results. Moreover, empirical findings show that duration of a trade relationship increases in size and age of a spell, while the growth of a spell decreases in duration and its initial size.

Table 5: Exporter-Importer Pair FE

	Growth	Imports
Quality (ln)	0.0277***	0.100***
	(0.00661)	(0.0235)
Duration (ln)	-0.294***	0.576***
	(0.00237)	(0.00613)
Initial trade (ln)	-0.112***	
	(0.000987)	
Importer GDP (ln)	0.172***	0.397***
	(0.00649)	(0.0141)
Exporter GDP (ln)	-0.0219***	0.120***
	(0.0.00536)	(0.0151)
_Constant	-0.414*	3.617***
	(0.0797)	(0.182)
Observations	8,127,770	13,093,971
R^2	0.035	0.367

Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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Table A: Initial Trade Value Regression

	Initial trade value
	OLS
Quality (ln)	0.000360
	(0.00818)
Importer GDP (ln)	0.206***
	(0.00342)
Exporter GDP (ln)	0.0660***
	(0.00364)
Distance (ln)	-0.0358***
	(0.00155)
Contiguity	0.0379***
	(0.00566)
Common language	-0.0432***
	(0.00309)
_Constant	7.148***
	(0.0766)
Observations	4,067,145
R^2	0.259

Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$