

# The Desire for Quality across Products and Destinations\*

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## Abstract

Recent theories of international trade have disparate predictions concerning the correlation between a firm level prices and sales. To test these theories, I estimate the correlation between firm prices and sales within a market. I do this for all six-digit products and destination countries to which Denmark exports between 1999-2006. I find that most Danish exports are to markets in which the price is positively correlated with sales, that these correlations are significantly different across destinations for a given product, and that most of them constant across years. While some of the existing theories perform better than others at predicting these patterns, none of them can reconcile the variation across destinations. To fully explain the patterns, I introduce a model in which the desire for high quality goods over low cost substitutes differs across countries and products. When controlling for endogenous selection, I find that countries with higher populations have a higher desire for quality. Countries with higher incomes increase their desire for high quality basic manufacturing goods and decrease their desire for complex manufacturing goods.

**Keywords:** exports, firm heterogeneity, quality, productivity

**JEL Codes:** F12

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\*PRELIMINARY AND INCOMPLETE. PLEASE DO NOT CITE WITHOUT PERMISSION. I thank Jakob R. Munch for insightful discussions. All errors are my own.

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# 1 Introduction

What is the cause of the variation in firms sales within a market? More specifically, do high-quality varieties garner higher sales than low-cost substitutes of the same product in the same destination country? This study proposes that a country's desire for quality determines the sales ranking of firms with heterogeneous quality. When countries differ in their desire for quality, the correlation between prices and sales differ across countries.

Recent theoretical work has suggested that differences in firm level technologies lead to this sales variation within a market<sup>1</sup>. While these models have interpreted the technology differences as differences in production costs, we can also interpret them as differences in production quality<sup>2</sup>. These two interpretations have disparate predictions on the correlation between firm prices and sales. Suppose the price of a firm variety increases with increasing quality<sup>3</sup> and decreases with decreasing costs<sup>4</sup>. If firms are different via costs, then firms posting lower prices should garner higher sales. If instead firms are different via quality, then firms posting higher prices should garner high sales.

Baldwin and Harrigan (2009) introduces a model in which quality and costs are linked: high quality production requires high costs. Although other studies have endogenized the choice of quality<sup>5</sup>, Baldwin and Harrigan (2009) skip that step and simply assume a loglinear relationship between costs and quality. If quality increases slower than costs, then low-quality/low-cost firms will garner higher sales. If quality increases faster than costs, then high-quality/high-cost firms will garner higher sales. Baldwin and Harrigan (2009) find industry-level, cross-country evidence that quality increases faster than costs. Two other recent papers<sup>6</sup> have run direct regressions on firm prices and sales, holding destination country constant; they also find evidence that prices are positively correlated with sales within a destination, on average for the exporting country.

This study estimates the correlation between prices and sales for all product-destination-year categories supplied by Danish exporters between 1999 and 2006, instead of estimating a single correlation for all of a country's exports. Not surprisingly, we find that the correlation differs across products. A simple extension of Baldwin and Harrigan's (2009) model can reconcile this difference across products.

What is surprising is our finding that this price-sales correlation is not constant across

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<sup>1</sup>See Melitz 2003, Eaton and Kortum 2002, Bernard Eaton Jensen Kortum 2003 for seminal works.

<sup>2</sup>e.g. see Baldwin and Harrigan (2009), Kugler and Verhoogen (2009), Hallak and Sivadasan (2009), Johnson (2009)

<sup>3</sup>Crozet, Head, and Mayer (2009) find firm level evidence for this for French wines.

<sup>4</sup>This is a cornerstone of Krugman (1980) and most competitive markets in Economics, really.

<sup>5</sup>See Baldwin and Harrigan (2007) for a more detailed discussion.

<sup>6</sup>See Kugler and Verhoogen (2009) for Colombian firms, Manova and Zhang (2009) for Chinese firms

destinations even within the same product category. Over 70% of Danish exports are sold in product-destination-year markets which have price-sales correlations significantly different than other markets of the same product. This variation across markets cannot be reconciled by any known model, although Baldwin and Harrigan (2009) come close. In their model, firm-specific-quality is preferred by all destination equally. Therefore, two firms, each with publicly known prices and qualities, should garner the same relative sales in all destinations.

This study introduces a model that allows destinations to differ in whether they prefer high-quality varieties or low-cost substitutes. We call this preference as the "desire for quality." Suppose the US has a (very) high desire for quality for Danish eyeglasses while India has a (very) low desire. Then a higher quality Danish eyeglasses firm would have higher sales in the US, but lower sales in India.

Finally, this study attempts to find a correlation between a country's characteristics and its desire for quality. That is, we estimate the correlation between a country's population/income and its desire for quality within a product category. We control for endogenous selection: a country's characteristics may also increase the probability that it imports an particular product. When controlling for endogenous selection, we find that countries with higher populations have a higher desire for quality. Countries with higher incomes increase their desire for high quality basic manufacturing goods and decrease their desire for complex manufacturing goods.

The following section gives a brief overview of the data. The section after presents a general model of international trade with heterogeneous firms. We show how this general model can be simplified to that of Krugman (1979), Melitz (2003), Baldwin and Harrigan's (2009), and finally our model. Each model has a different prediction concerning the sign of price-sales correlations within product-destination-year markets. We then show evidence from Danish firm level export data to refute or collaborate these models. Finally, we show how the desire for quality correlates with destination characteristics such as population and income.

## 2 Data

The Danish External Trade Statistics provides product-level destination-specific export data for all Danish firms for the years 1999-2006. Our initial dataset consisted of over 3 million observations of annual firm sales by 32047 firms to 212 countries at the 6-digit Harmonized System (HS6) totalling over 3.25 trillion Danish kroner (DKK). In addition to firm sales, we have shipment weights in kilograms. HS6 product-firm-destination-year

specific prices are thus generated as the ratio to sales to weight. See Statistics Denmark (2003) for data details.

First, we eliminate countries to which Denmark did not ship at least 100 million DKK. This restriction eliminated destinations such as Andorra, Vatican City, Tajikistan, and many small Pacific and Caribbean islands. In addition, we eliminate Turkmenistan, Botswana, Belize, St. Kitts-Nevis, the Cayman Islands, and the Marshall Islands because these destinations did not have at least 300 observed annual exports over the eight years in our sample. To minimize possible measurement error, we drop the bottom and top one percentiles of sales. These restrictions corresponded to sales below 37 and above 1.56e7 DKK. We repeat for weights (below 1 and above 586128 kilograms) and prices (below 1.43 and above 14120 DKK/kg).

Finally, we drop the 1685 products with fewer than 50 observations. With these restrictions, our dataset comprises 30926 firms selling 3629 HS6 products to 157 countries. Sales totaled over 443 billion kroner, with a mean and median price of 1218 and 172 DKK/kg.

Table 1 summarizes price, weight, and sales in our final dataset. The "Raw" column presents summary statistics for the pooled data. For all three variables, the median values are an order of magnitude lower than the mean: our dataset is mostly comprised of small shipments of low priced goods. However, since the data is pooled over destinations, products, and years, we may be comparing difference in prices between product-destination-year markets and not within those markets.

To examine the spread of prices, weights and sales within a market, we need to control for market averages. The "Relative to Mean" column show those same statistics divided by the mean values in each product-destination-year market. The left-skewed distribution of prices, revenues, and weights remain even when we control for market averages. The mean-controlled medians are still lower than the mean-controlled medians. Most Danish exports to a destination are low priced, small volume shipments. The median export shipment has a price 18% lower of than that of the mean shipment, and is valued at 54% of the mean.

For population and per capita GDP, we obtain values from the Penn World Tables (Heston, Summers and Aten 2006). Distances are recorded as log kilometers between the national capital and Copenhagen.

### 3 Theories relating price and revenue

This section summarizes the current international trade literature's predictions on price and revenue by embedding several known models into a generalized model. In this generalized model, prices are affected by two independent sources of firm heterogeneity : quality and cost. Depending on the functional form relating quality and cost, this model collapses into that of Krugman (1980), Melitz (2003), Baldwin and Harrigan (2008), or this study's model.

We assume a small open economy such as Denmark. Denmark supplies many HS6 products indexed by  $h$  to foreign destination countries indexed by  $c$  in years  $t \in [1990, 2006]$ . We index a market by its product-country-year index. Each market is supplied by a set of firms  $\Omega_{hct}$ . Each firm  $f \in \Omega_{hct}$  produces a unique variety of HS6 product  $h$ . For a given market, demand for those varieties is represented by  $U_{hct}$  :

$$U_{hct} = \sum_{f \in \Omega_{hct}} (\lambda_{hctf} q_{hctf})^{\frac{\sigma-1}{\sigma}} \quad (1)$$

where  $q_{hctf}$  is the quantity of product  $h$  sold by firm  $f$  in country  $c$  in time  $t$ . The quality shifter  $\lambda_{hctf}$  affects the firm's sales in market  $hct$  and will be discussed in detail momentarily. The elasticity of substitution  $\sigma > 1$  denotes a love of variety utility. Given this utility function, a firm  $f$  pricing its variety at  $p_{hctf}$  garners the following sales:

$$sales_{hctf} = p_{hctf} q_{hctf} = \left( \frac{\lambda_{hctf}}{p_{hctf}} \right)^{\sigma-1} \Pi_{nct} \quad (2)$$

where  $(\Pi_{nct})^{-1} = \sum_{f \in \Omega_{hct}} \left[ \left( \frac{p_{hctf}}{Y_{hct} \lambda_{hctf}} \right)^{(1-\sigma)} \exp(\varepsilon_{hctf}) \right]$  is a market competitiveness term encompassing  $Y_{hct}$ , the total expenditure by country  $c$  on product  $h$ , and the prices of all other varieties of  $p$  in  $hct$ . Since Denmark is a small country, the mass of Danish firms exporting to  $c$  does not affect  $\Pi_{hct}$ <sup>7</sup>.

Given a constant marginal cost production function, the firm will set its profit maximizing price as a constant markup over marginal cost. Therefore, if  $p_{hctf}$  differs between firms in a market, we assume this reflects differences between idiosyncratic firm costs.

The firm specific variables  $\lambda_{hctf}$  and  $\varepsilon_{hctf}$  affect sales in market  $hct$  in different ways.  $\lambda_{hctf}$  is often referred to as a quality shifter that directly influences the price of a good (See Hummels and Klenow 2003). When choosing among varieties, consumers compare

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<sup>7</sup>In the data, Denmark does not constitute more than 20% of any country's total imports in any HS6 category.

the quality adjusted prices  $\frac{p_{hctf}}{\lambda_{hctf}}$ .

The relationship between  $p_{hctf}$  and  $\lambda_{hctf}$  ultimately determine the how firm level prices and revenues are correlated within a market. We examine the simplifications this model to match those predictions of Krugman (1980), Melitz (2003), and Baldwin and Harrigan (2009) below:

### 3.1 Krugman: All firms are the same

The seminal Krugman (1980) model does not address price/revenue variation among firms within a market. Algebraically, it assumes that  $p_{hctf} = p_{hct}$ ,  $\lambda_{hctf} = 1 \forall f \in \Omega_{hct}$ , or posted market prices are the same for all firms within a market. If we interpret Krugman (1980) seriously, Equation 2 simplifies to

$$sales_{hctf} = p_{hct}^{-(\sigma-1)} \Pi_{hct} \quad (3)$$

See that there is no  $f$  term on the right hand side: Krugman (1980) does not account for any variation in sales across firms. Since all firms post the same prices in market  $hct$ , taking Krugman (1980) seriously means we should expect no relationship correlation between the price of a firm and its sales in a market. Any variation in prices or revenues can be viewed as measurement errors.

### 3.2 Melitz: Firms differ by costs.

Melitz (2003) was one of the first trade models to incorporate firm heterogeneity into a Dixit-Stiglitz setting. Algebraically, it assumes that firms differ in prices  $p_{hctf}$  but share the same quality ( $\lambda_{hctf} = 1$ ). In a Melitz (2003) world, equation 2 simplifies to

$$sales_{hctf} = p_{hctf}^{-(\sigma-1)} \Pi_{hct} \quad (4)$$

Here we see that sales and prices are negatively correlated. High cost firms have higher prices and consequentially lower sales. Melitz suggests that, within a product-destination-year market, prices and revenues are negatively correlated.

### 3.3 Quality Melitz: Firms differ by Quality.

A footnote in Melitz (2003) suggests that the model can be easily viewed as a quality heterogeneity model instead of price heterogeneity model. To match that in our model,

we can simplify  $p_{hctf} = p_{hct}$  but maintain heterogeneous quality  $\lambda_{hctf}$ . In a Melitz (2003) quality heterogeneity world, equation 2 simplifies to

$$sales_{hctf} = p_{hct}^{-(\sigma-1)} \lambda_{hctf}^{\sigma-1} \Pi_{hct} \quad (5)$$

This model has the same predictions regarding price and revenues as that of Krugman (2003). Since all firms post the same price  $b_{hct}p$ , there should be no correlation between price and sales. In this model, we interpret variations in sales as due to quality differences among firms, instead of measurement error.

### 3.4 Baldwin & Harrigan: Quality comes at a cost

Baldwin and Harrigan (2009) suggests that quality is monotonically increasing with the firm's price. This comes out of a literature before the advent of firm-level datasets using unit values as proxies for quality. (See Hummels and Klenow, 2003; Hummels and Skiba, 2003). Other papers (e.g. Kugler and Verhooven 2008) endogenizes the choice of quality given an exogenous marginal cost draw, which leads to a one-to-one mapping between costs and quality. A major contribution of Baldwin and Harrigan (2007) is to abstract from this quality choice problem. In their words, models of quality "invariably deliver a mapping between an exogenous parameter... and the possibly endogenous supply of quality." Therefore, if a firm's quality is optimally chosen after a firm is endowed with an exogenous cost parameter, the resultant choice function could simplify to a monotonical relationship between exogenous costs and endogenous quality.

Specifically, Baldwin and Harrigan (2008) uses the quality production function  $\lambda_{hctf} = \lambda_f = p_f^{\theta+1}$ ,  $\theta > -1$ , to model the relationship between the firm price and quality. Baldwin and Harrigan term  $\theta$  as the "quality elasticity", and it denotes how expensive it is to upgrade product quality. The market price  $p_{hctf}$  then reflects both the quality of the good and its supply cost. With these relationships, equation 2 simplifies to

$$sales_{hctf} = p_{hctf}^{\theta(\sigma-1)} \Pi_{hct} \quad (6)$$

This model is more flexible than the ones discussed prior. If  $\theta < 0$ , then prices are negatively correlated with sales. If  $\theta > 0$ , then prices are positively correlated with sales. Baldwin and Harrigan (2009) use variation in  $b_{hct}$  across different markets to provide evidence that  $\theta > 0$ , on average, across all exports.

As discussed earlier, price-sales correlations supporting  $\theta > 0$  is also provided by Kugler and Verhoogen (2008) and Manova and Zhang (2009).

### 3.5 This study: Markets desire quality differently

The brilliance of Baldwin & Harrigan (2009) is in their flexible form connecting quality and price. It would be quite straightforward to place an  $h$  subscript on  $\theta$  and suggest that some products have  $\theta < 0$  and others have  $\theta > 0$ . We then can use price-sales correlations for each product that Denmark exports to measure the quality elasticity of that product.

Using Baldwin and Harrigan's setup restricts us to the same product-specific  $\theta$  across destinations, however. As we will see in the empirics section, price-sales correlations are not constant across destinations. And the magnitude and direction of the correlation depends on destination specific characteristics as well as product category. In Baldwin and Harrigan's (2003) framework, we would need to add a  $c$  subscript to  $\theta$  to account for this variation. But a quality production function  $\lambda_{hctf} = p_f^{\theta_{hc}+1}$  suggests that the firm's quality is not constant across destination. If quality is produced, the firm needs to have a different production line for each destination. Would a Danish pencil maker build a line to make high quality pencils for export to Norway and then build another line to make low-quality pencils for export to India? The literature to date assumes that a firm's production coming off a single line, with a firm-specific quality.

If all of a firm's output comes off a single production line with identical qualities irregardless of its export destination, then we need a market-specific factor to reproduce the variation of price-sales correlation across markets. We accomplish this by assuming markets desire quality differently. We interpret  $\lambda_{hctf}$  as market  $hct$ 's added utility from consuming a unit of firm  $f$ 's output. Then, we model the relationship between  $\lambda_{hctf}$  and  $p_{hctf}$  as

$$\lambda_{hctf} = \lambda_f^{d_{hc}+1}, \quad (7a)$$

$$p_{hctf} = b_{hct} p_f, \quad (7b)$$

$$\lambda_f = p_f. \quad (7c)$$

The  $d_{hc}$  term is market  $hct$ 's desire for quality. The  $\lambda_{hctf}$  term increases if the firm-specific quality  $\lambda_f$  increases, or if market  $hct$ 's desire for quality  $d_{hc}$  increases. The last equation embodies the assumption that market-differenced prices  $p_f$  increases with production quality  $\lambda_f$ . We could embed Baldwin and Harrigan's  $\theta$  into equation 7c, but  $\theta$  would not be identifiable separately from  $d_{hc}$ .

Given this setup, equation 2 simplifies to

$$sales_{hctf} = p_f^{d_{hc}(\sigma-1)} b_{hct}^{1-\sigma} \Pi_{hct} \quad (8)$$

This model is even more flexible than Baldwin and Harrigan’s (2009) in equation 6. Price-sales correlations can now vary across products and destinations. In markets where  $d_{hc} > 0$ , consumers desire high quality goods and are willing to pay for them. In those markets, higher-quality, higher-price varieties would enjoy high revenues. In markets where  $d_{hc} < 0$ , consumers desire low-price, low-quality goods over high price, high quality goods. In those markets, lower priced varieties would enjoy higher revenues.

To be clear, if  $d_{hc} = d\forall h, c$ , then this new model is isomorphic to Baldwin and Harrigan’s (2009) except for causal interpretation. The algebra is essentially identical. Baldwin and Harrigan (2009) suggests that price-sales correlation arise from the production side, which, if slightly extended, can vary across products. It is difficult to imagine this production quality elasticity to also vary across destinations. Our desire-for-quality setup allows price-revenue correlations to vary across destinations within a given product by allowing countries to differ in their desire to have high quality varieties. Like Baldwin and Harrigan (2009) this model can be closed by assuming a steady-state equilibrium with sunk costs of entry.

Although we could place a  $t$  subscript on the desire  $d$  term, we assume that the desire for quality does not change within a country over time. We test this assumption below.

## 4 Empirics

Econometricians do not observe quality<sup>8</sup> or marginal cost. However, we do observe firm level prices and revenues for each product-destination-year market. By finding those correlations, we can test the validity of each of Equations 3, 4, 5, 6, and 8 corresponding to the models discussed above. All of these equations, when in log form and adding an error term  $\varepsilon_{hctf}$ , can be characterized by:

$$\ln sales_{hctf} = A_{hct} + \beta_{hct} \ln p_{hctf} + \varepsilon_{hctf} \quad (9)$$

where  $A$  is a constant and  $\beta$  is the correlation between firm price and sales in a given market. In equations 3 5,  $\beta = 0$ . In equation 4,  $\beta = -(\sigma - 1)$ . In equation 6,  $\beta = \theta(\sigma - 1)$ . Finally, in equation 8,  $\beta = d_{hc}(\sigma - 1)$ .

To discern which of these models best describes the variation of Danish firm exports, we need to compare our estimates of  $\beta_{hct}$  with the predictions of the models. We can summarize the predictions of the models described above as such:

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<sup>8</sup>The notable exception being Crozet, Head and Mayer (2009) discussed in the introduction.

1.  $\beta_{hct} = 0 \forall h, c, t$  : Krugman (1980) or the Melitz (2003), quality.
2.  $\beta_{hct} = \beta_h < 0 \forall h, c, t$  : Melitz (2003), standard.
3.  $\beta_{hct} = \beta_h > 0 \forall c, t$  : Baldwin and Harrigan (2009)
4.  $\beta_{hct} = \beta_{hc} \forall t$  : Current model

We find the correlation between price and sales by estimating equation 9 for each of the 234441 HS6 product-country-year markets. Our dataset comprises 234441 markets across 3541 HS6 products, 157 countries, and 8 years (1999-2006) for a total of over 2 million observations. Approximately 25% (48782) of the markets have more than 10 firms supplying to them.

#### 4.1 Prices are (generally) positively correlated with sales

Most destination markets exhibit positive price sales correlations. The top-left histogram of Figure 1 shows the distribution of estimated  $\beta$  for each of the 48782 markets with greater than 10 firms. The distribution has a mean and median of 0.22: on average, markets exhibit positive price-sales correlations. The top-right histogram shows the same estimated  $\beta$ s for the 8208 markets for which we obtain a  $\beta$  significantly different from 0. Removing the insignificant  $\beta$ s splits the distribution into two: About 12% of the significant  $\beta$ s are negative, and 88% are positive. The mean/median of this new distribution is 0.70/0.80.

INSERT FIGURE 1

Most of Denmark's exports are supplied to markets that desire high quality over low cost. The histograms are on the bottom of Figure 1 show these results. These histograms use the same  $\beta$ s as the ones in top half, but weighed by export volume. For the lower-left distribution with all estimated  $\beta$ s, the mean/median is boosted to 0.31/0.33 from 0.22 in the unweighted case. For the population of significant  $\beta$ 's in the lower-right histogram, the mean stays at 0.70 but the median is reduced to 0.71, compared to the unweighted case. 93% of the total Danish export volume are to markets exhibiting positive  $\beta$ 's. Since many  $\beta$ 's are significantly different from 0, we reject the strict interpretation of Krugman, modeled by equation 3. Since most of the significant  $\beta$ 's are positive, we reject the standard interpretation of Melitz (2003), modeled by equation 4.

## 4.2 The correlations are not constant across markets

While our histograms showed that many  $\beta'$ s are significantly positive, they do not show whether the estimates are insignificantly different from each other. A strict interpretation of Baldwin and Harrigan (2009) suggests that  $\beta_{hct} = \beta < 0 \forall h, c, t$ , while a broader interpretation suggests that  $\beta_{hct} = \beta_h < 0 \forall c, t$ . We test the broader interpretation. If we can reject that, we can also reject the strict one.

Our test is a standard Wald test for the null hypothesis  $H_{0h} : \beta_{hct} = \beta_h$  against  $H_{1h} : \beta_{hct} \neq \beta_h$ . To do so, we pool together the observations for all product-destination categories for all markets with ten or greater firms and estimate the following equation:

$$\ln sales_{hctf} = A_{hct} + \beta_h \ln p_{hctf} + \boldsymbol{\eta}_{hct} \mathbf{Dummy}_{hct} \ln p_{hctf} + \varepsilon_{hctf}. \quad (10)$$

where  $\mathbf{Dummy}_{hct}$  is the vector of market specific dummies with corresponding specific slope vector  $\boldsymbol{\eta}_{hct}$ . If  $H_0$  is correct,  $\boldsymbol{\eta}_{hct} = 0$ . For each product  $h$ , we test the joint hypothesis that  $\boldsymbol{\eta}_{hct} = 0$  and capture the two-sided p-value. That is, we find the probability that  $\beta_{hct} = \beta_h$  for each HS6 product in our sample.

We reject  $\beta_{hct} = \beta_h$  for about half of exported product categories and for the vast majority of export volumes. Figure 2 and the first panel of Table 2 summarizes our results. The top-left histogram in Figure 2 shows that a huge plurality of products that have a close to zero probability of having identical price-sales correlations across countries and years. Table 2 shows that 24% of HS6 products have a p-value of less than 0.01 and 39% have a p-value of less than 0.10. We can reject  $\beta_{hct} = \beta_h$  for those products. This means that, by HS6 category, we cannot reject  $\beta_{hct} = \beta_h$  for 60% of HS6 categories. When we look only at HS6 categories in which we were able to estimate a significant  $\beta_h$ , we find that 32% of the categories have a p-value of less than 0.01 and 48% have a p-value less than 0.10. Therefore, we reject only about half of Baldwin and Harrigan's (2009) implicit assumption that  $\beta_{hct} = \beta_h$  for about half of Danish Exports based on this initial test.

INSERT FIGURE 2

We are able to reject the null hypothesis of  $\beta_{hct} = \beta_h$  for the vast majority of Danish exports when we weigh our product p-values by corresponding export volumes. The bottom-left and bottom-right histograms in Figure 2 illustrate this. When we weigh each HS6 p-value by its total export volume, we see a huge increase in the left most spike. Using both significant and insignificant estimates (bottom left), we find that the median p-value is 0.00018 and the 75% percentile is 0.06. This incongruency is exacerbated when we look only at HS6 categories with significant  $\beta_h$  (bottom right). The median p-value there is 0.00015 with a 75%tile p-value of 0.03. The second panel of Table 2 summarize

these results. In conclusion, over 3/4 of Danish total exports are to markets in which the desire for quality is constant across destinations and years. Most Danish exports do not fit even the broad interpretation of Baldwin & Harrigan (2009).

### 4.3 The correlations are constant across time

We can reject Baldwin and Harrigan’s (2009) implicit conclusion that price-sales correlations are constant across destination. We can now test the current model’s conclusion that price-sales correlations are constant across years for any particular product-destination category. That is, we test the null hypothesis  $H_{0hc} : \beta_{hct} = \beta_{hc}$  against  $H_{1hc} : \beta_{hct} \neq \beta_{hc}$ . To do so, we pool together the observations for all markets within each  $hc$  product-destination category and estimate the following equation for each  $hc$  product category:

$$\ln sales_{hctf} = A_{hct} + \beta_{hc} \ln p_{hctf} + \zeta_{hct} \mathbf{Dummy}_{hct} \ln p_{hctf} + \varepsilon_{hctf}. \quad (11)$$

This regression equation is exactly like the one before it except that we estimate  $\beta$  at the  $hc$  product-destination level, instead of the  $h$  product level. Our results are summarized in Figure 3 and the last two panels of Table 2. The results are only from product-destination estimations with greater than ten observations, to minimize small sample error. The histograms in Figure 3 show that there is a plurality of product-country categories that have very low p-values, but the density of p-values  $> 0.10$  is much greater in these histograms than in Figure 2. As Table 2 shows, we are only able to reject  $H_{1hc} : \beta_{hct} \neq \beta_{hc}$  for 12-16% of product-country categories, and 10-14% of Total Danish Exports. This is much lower than the reject rate for  $H_{1h} : \beta_{hct} \neq \beta_h$ . For approximately 85-90% of Danish exports, the desire for quality for a given product-destination market does not change from year to year. We argue that that is support for our modelling of desire for quality as  $d_{hc}$  and not  $d_{hct}$ .

INSERT FIGURE 3

Finally, we present summary statistics of  $\beta_{hc}$  by 15 broad HS sectors in Table 3 for both rich and poor countries. We define a rich country as having a per capita GDP above the median value of 54000 DKK. The average  $\beta_{hc}$  is positive in all Danish Export HS sectors for both rich and poor nations. Overwhelmingly, a vast majority of Denmark’s exports compete in markets where Danish high-quality varieties are desired more than Danish low-quality substitutes.

## 4.4 Desire for quality increases with population

We have shown that most countries do not share the same desire for quality, but most countries' desires for quality do not change over time. Given our results, we interpret our equation 11 estimates for  $\beta_{hc}$  as  $d_{hc}$  from now on. The magnitude and sign of  $\beta_{hc}/d_{hc}$  indicates country  $c$ 's desire to have high quality varieties of product  $h$  over low-cost substitutes. Our last empirical exercise measures how  $d_{hc}$  changes with country characteristics. We have data on the population and income (measured as real per capita GDP (Laspeyres) using reference year 1996, see Heston, A, R. Summers and B. Aten. 2006 for details) averaged over the eight years in our dataset. Since we have no priors on the relationship between  $d_{hc}$  and these country specific characteristics, we look at the linear projection of  $d_{hc}$  on log population and log income:

$$d_{hc} = \mathbf{x}_c \boldsymbol{\gamma} + a_h + u_{hc} \quad (12)$$

where  $\mathbf{x}_c = [\text{pop}_c, \text{pcGDP}_c]$  where  $\text{pop}_c$  is the log average population of country  $c$  and  $\text{pcGDP}_c$  is the log average income of country  $c$  between 1999-2006. In our estimations, we also interact  $\mathbf{x}_c$  with a dummy term equal to 1 if the country is poorer than the median country in our sample. The cutoff point is approximately 54,000 DKK or 10,000 USD.  $a_h$  is a product specific effect controlling for the worldwide average desire for quality for product  $h$ .

What if population and income also determine which products a country imports, as well as its desire for quality for the imported products? Then  $\mathbf{x}_c$  would be correlated with  $u_{hc}$  in our unbalanced panel estimated by equation 12. We need to control for selection of product  $h$  into country  $c$ . Following Wooldridge (p. 583), we model our system as:

$$d_{hc} = \mathbf{x}_c \boldsymbol{\gamma} + a_h + u_{hc} \quad (13a)$$

$$s_{hc} = 1 [\mathbf{x} \boldsymbol{\phi}_h + \nu_{hc} > 0] \quad (13b)$$

where  $\mathbf{x} = [\mathbf{x}_c, \mathbf{x}_{\bar{c}}, \ln \text{dist}_c, \ln \text{dist}_{\bar{c}}]$ , and  $x_{\bar{c}}$  indicates the average  $x_c$  term across all destination countries.

We add  $\ln \text{dist}_c$ , the distance from Denmark, as an explanatory variable in the selection equation 13b and not in 13a because distance should affect a country's probability of importing a product but not affect the market's desire for quality, given that the country already imports that product. Also notice the subscript on  $\boldsymbol{\phi}$ : we allow each product  $h$  to have a distinct selection equation. The marginal effects of income, et. al. on the import

selection of Danish pencils should be different from the their effect on the import selection of Danish eyeglasses. Here we allow large/rich/far away countries to favor some products and avoid others.

To consistently estimate  $\gamma$ , we require the following assumptions: (1) Error terms  $u_{hc}$  and  $\nu_{hc}$  are jointly normal, (2)  $\phi_h$  is constant across countries, and (3) The industry specific effect can be linearly projected onto the selection variables:  $E(a_h|\mathbf{x},\nu_{hc}) = \mathbf{x}\boldsymbol{\pi} + \kappa_c\nu_{hc}$ . Given those assumptions, we can follow Wooldridge and construct the following equation of interest:

$$E(d_{hc}|\mathbf{x}_c, \mathbf{x}, s_{hc} = 1) = \mathbf{x}_c\boldsymbol{\gamma} + \mathbf{x}\boldsymbol{\pi} + \xi \cdot mills(\mathbf{x}\boldsymbol{\phi}_h) \quad (14)$$

To generate the  $s_{hc}$  selection term, we define the set of possible export destinations for product  $h$  by HS2 industry. For each of the 88 HS2 industries  $H$ , we define  $C_H$  as the set of countries importing  $H$ . Then for each product  $h$ ,  $s_{hc} = 1$  if country  $c \in C_H$  and there exists  $sales_{hctf} > 0$ . Otherwise,  $s_{hc} = 0$ . We tried using HS4 as our industry definition but found that using HS4 categories did not generate much variation of  $s_{hc}$  across product-destination pairs. Using HS2 as our industry definition, we find that HS6 products were exported to an average of 26% of possible destinations.

To identify  $\boldsymbol{\gamma}$ , we first estimate a probit of  $s_{hc}$  on  $\mathbf{x}$  and then compute the inverse mills ratio  $mills(\mathbf{x}\boldsymbol{\phi}_h)$  evaluated at  $\mathbf{x}\boldsymbol{\phi}_h$ . The inverse mills ratio controls for selection endogeneity while assumptions (1) and (3) allow us to control for the product specific effect  $a_h$  with all of our available explanatory variables. Since we run a probit for each HSs industry, our results implies another assumption (4)  $\boldsymbol{\phi}_h = \boldsymbol{\phi}_H \forall h \in H$ .

We do not report the results of these 88 estimations- they are long and uninteresting. Instead, Table 4 column 1 presents results from estimating selection equation 13b for the pooled sample to show an average  $\boldsymbol{\phi}_H$  across all industries. As is expected, richer and more populous countries are more likely to import any product. Countries farther away from Denmark are less likely to import any product. .

We find evidence of selection endogeneity. Under the null hypothesis that selection endogeneity does not exist,  $mills(\mathbf{x}\boldsymbol{\phi}_H)$  should be insignificant if added to equation 13a and estimated using fixed effects for  $a_h$ (Wooldridge 2002). We find the coefficient on  $mills(\mathbf{x}\boldsymbol{\phi}_H)$  to be highly significantly positive. Table 4 column 2 shows our results.

When controlling for selection with  $mills(\mathbf{x}\boldsymbol{\phi}_H)$ , we find countries reduce their desires for quality as they get richer. However, the desire for quality does not change much over the sample range. We estimate equation 14 for product-country categories with significantly (at the 95% level) estimated  $\beta_{hc}$  estimated in equation 11 with more than

10 observations. We also exclude the top and bottom 1% of estimated  $\beta_{hc}$  to minimize outlier issues. We find a negative correlation between  $\beta_{hc}$  and per capita GDP but only a coefficient of -0.026. Since our mean  $d_{hc}$  is fairly high (0.86 for rich countries and 1.00 for poor countries) and our income range is fairly low (Min log per capita GDP of 7.8, max of 12.3), the expected desire for quality does not change drastically over the country's GDP. As Table 4 reports, there is no difference between rich and poor countries.

Population has a much bigger, and positive, effect on the desire for quality. With a coefficient of 0.103 reported in Table 4, a mean  $d_{hc}$  value of approximately 1 and a log population range of 4.1-14, we can predict that the largest country expects have twice the desire for quality as the smallest country, controlling for everything else. The differences between rich and poor countries are economically insignificant.

Our results are robust to excluding agricultural industries. Table 4 column 3 reports results including only HS2 industries  $> 25$ .

## 4.5 Results by Sector

We find a significantly negative but small change in the desire for quality in response to an increase in a country's income. We can imagine that this might differ across sectors. As the US becomes richer, they may desire both higher quality manufacturing and agricultural goods. India, on the other hand, may desire high quality agricultural goods but lower quality manufacturing goods. That is, suppose  $\gamma$  differed by sector. We break up our sample into the 15 HS broad sectors described in Table 3 and estimate equation 14 for each sector. Again, we include only product-country categories with significantly (at the 95% level) estimated  $\beta_{hc}$  estimated in equation 11 with more than 10 observations. We also exclude the top and bottom 1% of estimated  $\beta_{hc}$  to minimize outlier issues. Table 5 summarizes our results for the agricultural industries. Table 6 summarizes our results for basic manufacturing industries and Table 7 summarizes our results for more complex manufacturing industries.

The desire for quality change much faster within each sector in response to income changes than across all sectors. The estimated coefficients on per capita GDP are on an order of magnitude greater than the -0.026 reported in Table 4. Rich countries demand better quality animal products as their income increases, while poor countries demand more low-cost animal products as their incomes increases.

Unfortunately, there are few patterns seen in the sign and magnitude of the coefficients on per capita GDP. In basic industrial manufacturing industries such as Minerals, Chemicals, Glass, and Plastics it is positive for both rich and poor countries. This implies that

as countries accumulate income, they increase their desire for quality of industrial manufacturing goods. In complex manufacturing sectors like Textiles, Footwear, Machinery, and Transportation, we actually find a negative correlation for both rich and poor countries. All countries, as they accumulate income, lower their desire for quality in complex manufacturing goods.

## 5 Conclusion

In the heterogeneous firms trade literature, firm-specific costs and quality are often thought of as isomorphic. An increase in both results in an increase in revenue. However, decreasing costs results in a decrease in price, while increasing quality results in an increase in price. We take advantage of this dichotomy to test whether it is quality or costs that differentiates firms.

Baldwin and Harrigan (2008) provides a straightforward and simple relationship between costs and quality. This paper adds a model similar to Baldwin and Harrigan's in order to reconcile the variation of price-sales correlations across destinations within a product category. Using firm level Danish exports, we find that price-sales correlations vary immensely across products and destinations. Most are positive. This may be because Denmark is a highly industrialized, high wage country making and destinations view Danish products as "high quality" goods.

A comparison between our estimates and ones from an emerging economy may shed more light on whether price-sales correlations are caused by exporter characteristics. We leave that for a study with access to firm level exports from one of those countries.

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## A Tables and Figures

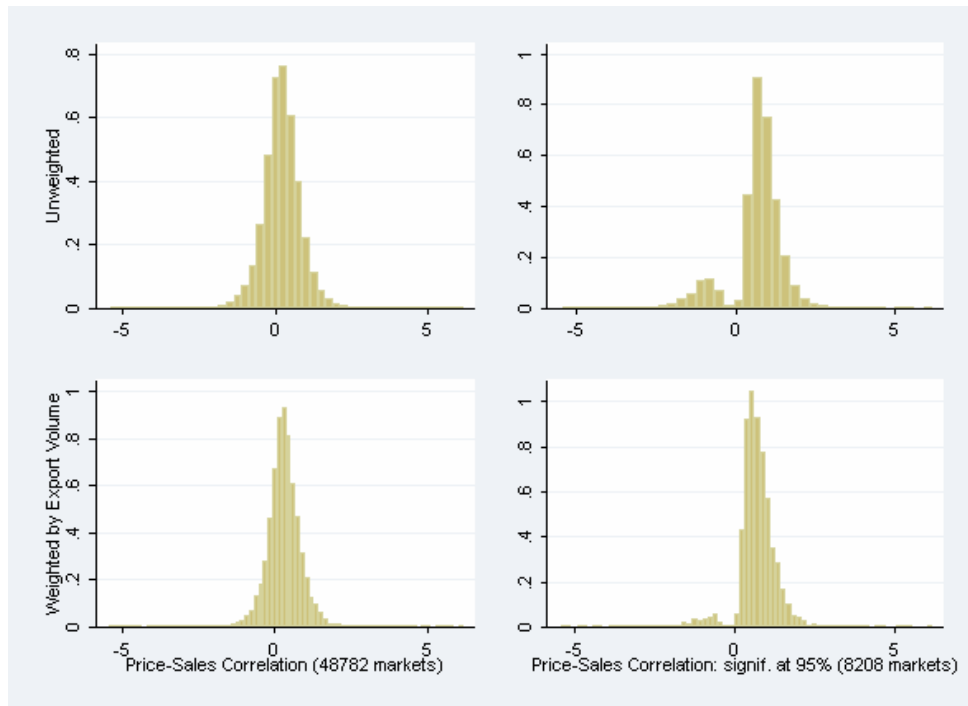


Figure 1: Distributions of  $\beta_{hct}$ , price-sales correlations

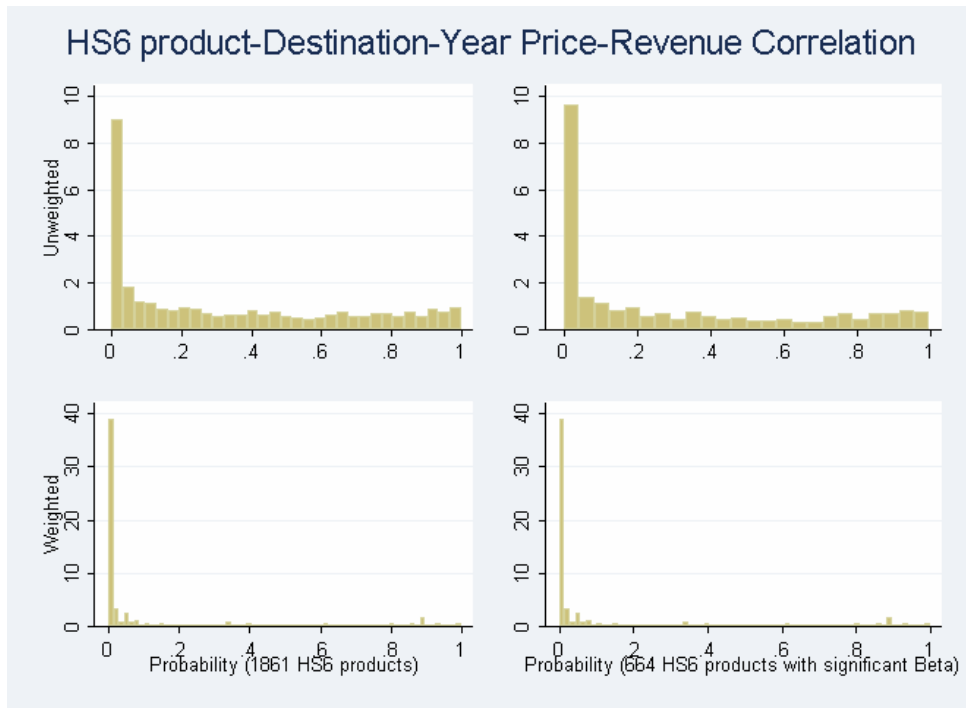


Figure 2: Probabilities that  $\beta_{hct} = \beta_h$ , by HS6 product

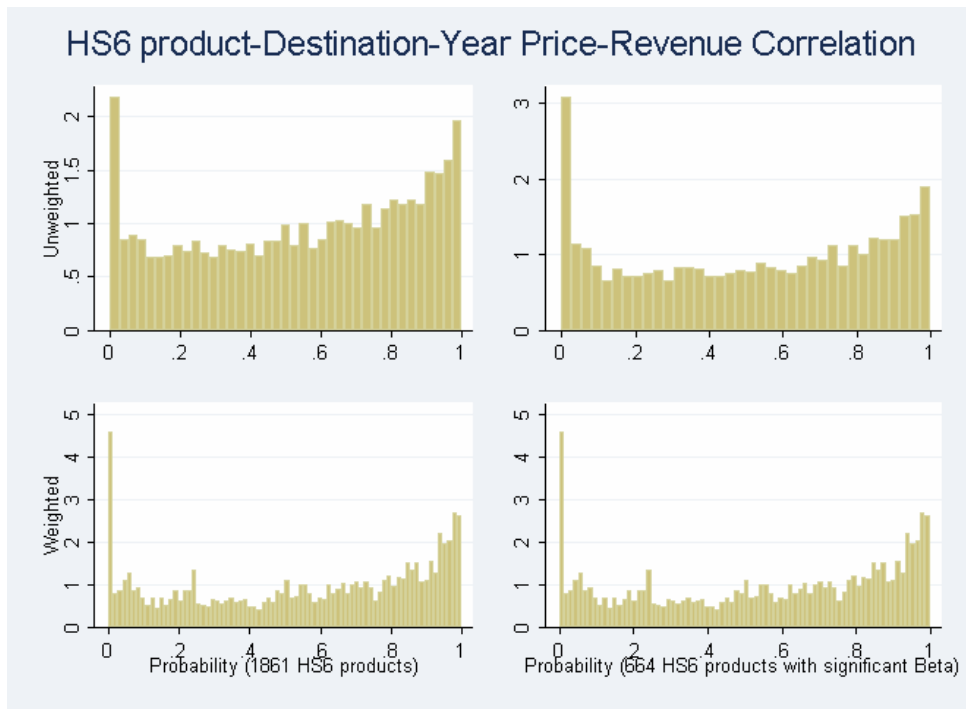


Figure 3: Probabilities that  $\beta_{hct} = \beta_{hc}$ , by HS6 product-country pair

	Raw	Relative
	(1)	(2)
Price (DKK/kg)		
Mean	1218	1
Median	172	0.82
Std. Dev.	23165	1.39
5%tile	4.1	0.06
95%tile	3489	2.67
Weight ( KG)		
Mean	1055	1
Median	104	0.49
Std. Dev.	2317	1.61
5%tile	1	0.005
95%tile	6400	3.76
Value (1000 DKK)		
Mean	166	1
Median	20	0.54
Std. Dev.	640	1.60
5%tile	0.36	0.007
95%tile	693	3.58

Table 1: Descriptive statistics on the price, revenue, and weights of Danish Exports, 1999-2003

$H_{0h} : \beta_{hct} = \beta_h$	Mean	Median	<0.01	<0.05	<0.10
By HS6 product					
$\beta_h$ ,All (1548)	0.33	0.21	24%	32%	39%
$\beta_h$ ,significant (591)	0.29	0.11	32%	41%	48%
By Total Export Volume					
$\beta_h$ ,All, weighted	0.17	0.004	53%	63%	70%
$\beta_h$ ,significant	0.18	0.001	56%	67%	71%
$H_{0hc} : \beta_{hct} = \beta_{hc}$	Mean	Median	<0.01	<0.05	<0.10
By HS6 product/country pair					
$\beta_{hc}$ ,All (9471)	0.55	0.58	3.6%	7.7%	12%
$\beta_{hc}$ ,significant (4417)	0.52	0.54	5.8%	10.9%	16%
By Total Export Volume					
$\beta_{hc}$ ,All, weighted	0.55	0.61	5.6%	9.4%	14%
$\beta_{hc}$ ,significant,weighted	0.53	0.56	6.6%	10.9%	10%

Table 2: Summary Statistics of "Probabilities of rejecting null hypotheses"

HS2 Code: Description	Rich Countries			Poor Countries		
	Mean $\beta_{hc}$	Median $\beta_{hc}$	Exports	Mean $\beta_{hc}$	Median $\beta_{hc}$	Exports
<b>Agricultural</b>						
01-05 Animal & Animal Products	0.63	1.1	35499	1.7	0.82	2003
06-15 Vegetable Products	1.4	1.3	34673	1.3	1.5	9315
41-43 Raw Hides, Skins, Leather, & Furs	0.80	0.62	32972	0.71	0.75	5651
44-49 Wood & Wood Products	0.86	1.3	41619	2.4	3.7	5292
16-24 Foodstuffs	1.6	1.4	89204	0.29	0.87	14925
<b>Basic Manufacturing</b>						
25-27 Mineral Products	0.23	0.33	720			
28-38 Chemicals & Allied Industries	1.1	1.0	429058	1.1	1.3	149395
68-71 Stone / Glass	1.1	1.1	60287	0.44	0.73	2965
72-83 Metals	0.24	0.69	88433	0.33	0.68	9662
39-40 Plastics / Rubbers	0.57	0.65	54938	1.2	0.88	9966
<b>Complex Manufacturing</b>						
50-63 Textiles	0.77	0.67	209233	0.61	0.76	18959
64-67 Footwear / Headgear	1.6	1.3	20257	3.0	2.3	4494
84-85 Machinery / Electrical	0.75	0.76	942589	0.83	0.85	162638
86-89 Transportation	0.71	0.92	74434	1.0	0.96	27908
90-97 Miscellaneous	0.89	0.88	579662	1.2	1.2	118226

Table 3: Average estimated betas by HS sector. Exports are in 1000's of DKK. Rich countries are those with greater than 54000 DKK per capita GDP

	Probit	Endogeneity	Beta Effects	Beta Effects
	(1)	Test	Beta Effects	Manu Only
	(1)	(2)	(3)	(4)
per capita GDP	.399 (.004)***	-.043 (.011)***	-.026 (.003)***	-.048 (.003)***
per capita GDP, poor difference	-.094 (.003)***	.043 (.006)***	-.0002 (.002)	.003 (.002)*
Population	.141 (.002)***	.001 (.003)	.103 (.001)***	.083 (.001)***
Population, poor difference	.083 (.003)***	-.034 (.006)***	-.005 (.002)***	-.004 (.002)***
Distance from DK	-.442 (.003)***		-.146 (.001)***	-.130 (.001)***
per capita GDP, HS2 average	.335 (.067)***		.837 (.039)***	.378 (.042)***
per capita GDP x poor, HS2 average	.308 (.069)***		.277 (.036)***	-.851 (.037)***
Population, HS2 average	-.720 (.051)***		-1.368 (.031)***	-1.787 (.031)***
Population x poor, HS2 average	-.234 (.082)***		-.304 (.043)***	.869 (.046)***
Distance from DK, HS2 average	.444 (.053)***		.148 (.037)***	-.439 (.036)***
inverse Mills ratio		-.313 (.017)***	.397 (.006)***	.297 (.007)***
Export Volume (1000DKK)	385344	1.56e+07	3255027	3069358
$R^2$		.225	.013	.01
$F$ statistic		267.716	2471.712	1992.615
Number of HS6 dummies		3610		
Average Selection	.26			

Table 4: table.heckit, all log terms, 2S Heckit, HS2 Mills Robust Std. Err's

	Animals	Veg	Wood	RawHides	Foodstuffs
	(1)	(2)	(3)	(4)	(5)
per capita GDP	.833 (.041)***	-1.112 (.043)***	-.297 (.028)***	.198 (.019)***	.121 (.034)***
per capita GDP, poor difference	-1.469 (.088)***	.458 (.017)***	.020 (.009)**	-.187 (.014)***	.013 (.014)
Population	.237 (.008)***	.043 (.011)***	.103 (.008)***	-.077 (.008)***	.539 (.007)***
Population, poor difference	1.722 (.086)***	-.688 (.020)***	-.063 (.010)***	.341 (.011)***	-.236 (.012)***
Distance from DK	-.443 (.018)***	.637 (.019)***	-.129 (.012)***	.133 (.021)***	-.409 (.025)***
per capita GDP, HS2 average	1.288 (.579)**	-6.976 (1.160)***			41.757 (.916)***
per capita GDP x poor, HS2 average	4.064 (.428)***	28.198 (1.494)***	-.057 (.240)		8.214 (.484)***
Population, HS2 average	-.145 (.331)	9.895 (1.008)***	-1.890 (.173)***	-5.556 (.143)***	-10.516 (.335)***
Population x poor, HS2 average	-4.638 (.527)***	-29.244 (1.832)***	.010 (.237)	-.157 (.017)***	5.628 (.629)***
Distance from DK, HS2 average	1.797 (.197)***	-2.817 (.419)***			-27.747 (.464)***
inverse Mills ratio	1.125 (.054)***	-1.474 (.069)***	-.227 (.052)***	-.527 (.076)***	2.175 (.088)***
Const.	-34.331 (4.101)***	21.645 (3.233)***	22.114 (1.646)***	51.611 (1.364)***	-196.831 (8.524)***
Export Volume (1000DKK)	51354	43988	38623	46911	104129
$R^2$	.088	.212	.023	.275	.271
$F$ statistic	378.306	686.719	130.036	3285.861	3972.863

Table 5: table.hs21, Country's desire for Quality, by hs2 industry restricted, Robust Std. Err's

	Minerals	Chemicals	Glass	Metals	Plastics
	(1)	(2)	(3)	(4)	(5)
per capita GDP	.701 (.238)***	.287 (.005)***	.890 (.036)***	-.521 (.032)***	.701 (.039)***
per capita GDP, poor difference		.086 (.004)***	-.127 (.017)***	.101 (.015)***	.145 (.016)***
Population	.029 (.049)	.140 (.002)***	.287 (.004)***	.361 (.008)***	-.066 (.009)***
Population, poor difference		-.068 (.004)***	.060 (.015)***	-.156 (.014)***	.028 (.016)**
Distance from DK	-.069 (.342)	-.136 (.004)***	-.449 (.008)***	-.279 (.022)***	-.079 (.025)***
per capita GDP, HS2 average		-16.380 (.300)***		4.499 (.491)***	
per capita GDP x poor, HS2 average		11.512 (.306)***	1.786 (.227)***	1.046 (.467)**	
Population, HS2 average		11.423 (.315)***		-2.103 (.522)***	1.846 (.237)***
Population x poor, HS2 average	-3.856 (.270)***	-17.967 (.454)***	-1.365 (.273)***	-.871 (.616)	
Distance from DK, HS2 average		20.808 (.633)***	-1.413 (.289)***	3.519 (.432)***	
inverse Mills ratio	2.120 (.982)**	.413 (.022)***	2.097 (.064)***	-.700 (.077)***	-.067 (.083)
Const.	5.531 (2.572)**	-72.367 (4.095)***	-1.215 (2.308)	-52.814 (4.506)***	-23.486 (2.013)***
Export Volume (1000DKK)	720	578453	63252	98095	64904
$R^2$	.5	.087	.077	.154	.035
$F$ statistic	869.465	3727.8	961.042	645.514	262.303

Table 6: table.hs22, Country's desire for Quality, by hs2 industry restricted, Robust Std. Err's

	Textiles	Footwear	Machinery	Transport	MiscManu
	(1)	(2)	(3)	(4)	(5)
per capita GDP	-0.094 (.014)***	-1.977 (.047)***	-0.782 (.008)***	-0.833 (.017)***	-0.189 (.010)***
per capita GDP, poor difference	.0009 (.014)	-.397 (.021)***	.164 (.004)***	.117 (.008)***	.025 (.003)***
Population	.164 (.003)***	-.237 (.010)***	-.169 (.003)***	-.186 (.005)***	.015 (.004)***
Population, poor difference	-.054 (.015)***	.434 (.020)***	-.170 (.003)***	-.083 (.008)***	-.025 (.003)***
Distance from DK	.127 (.007)***	1.585 (.032)***	.323 (.006)***	.245 (.009)***	-.081 (.005)***
per capita GDP, HS2 average	9.483 (.210)***	.953 (.410)**			1.479 (.138)***
per capita GDP x poor, HS2 average	-5.009 (.151)***			-1.033 (.074)***	-1.990 (.180)***
Population, HS2 average	1.738 (.087)***				.261 (.120)**
Population x poor, HS2 average	7.751 (.196)***	-3.411 (.215)***		.167 (.081)**	3.151 (.188)***
Distance from DK, HS2 average	1.250 (.094)***	26.031 (1.006)***		1.812 (.085)***	-3.517 (.113)***
inverse Mills ratio	-.173 (.022)***	-6.156 (.188)***	-1.917 (.027)***	-3.138 (.062)***	.239 (.030)***
Const.	-142.611 (2.612)***	-183.289 (6.610)***	10.359 (.096)***	2.700 (.578)***	8.348 (2.379)***
Export Volume (1000DKK)	228192	24751	1105227	122342	697888
$R^2$	.071	.369	.014	.155	.018
$F$ statistic	802.52	1561.918	2739.43	760.696	1196.898

Table 7: table.hs23, Country's desire for Quality, by hs2 industry restricted, Robust Std. Err's