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ABSTRACT

A substantial amount of theoretical work predicts that quality plays an important role as a determinant of the global patterns of bilateral trade. This paper develops an empirical framework to estimate the empirical relevance of this prediction. In particular, it identifies the effect of quality operating on the demand side through the relationship between per capita income and aggregate demand for quality. The model yields predictions for bilateral flows at the sectoral level, and is estimated using cross-sectional data for bilateral trade among 60 countries in 1995. The empirical results confirm the theoretical prediction: rich countries tend to import relatively more from countries that produce high quality goods. The paper also shows that a severe aggregation bias explains the failure of the literature so far to find consistent empirical support for the "Linder hypothesis", the conjectured corollary to the first theory relating product quality and the direction of trade.

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1 Introduction

Increasing evidence indicates that there are large differences across countries in the quality of the products that they produce and export. While traditional theories of international trade neglect the existence of product quality differences across countries, a substantial amount of theoretical work predicts that quality systematically affects the direction of international trade. In spite of the theoretical predictions, there is yet no evidence evaluating the empirical relevance of quality as a determinant of bilateral trade volumes. Understanding the influence of quality on the direction of trade might be crucial for enhancing the predictive power of benchmark empirical trade models, which will result in improved assessments of the impact of other determinants of trade, such as commercial policies or natural barriers to international exchange.

Linder (1961) first noted the role of quality as a determinant of the direction of trade. He argued that richer countries spend a larger proportion of their income on high quality goods. He also argued that closeness to demand is a source of comparative advantage, providing richer countries with a comparative advantage in the production of high quality goods—the goods that they demand. He then conjectured that the congruence of production and consumption patterns leads countries with similar income per capita to trade more with one another. This is the Linder hypothesis, the earliest theory explaining the effects of quality differences on the direction of trade. It has received considerable attention for its contrast with the standard Heckscher-Ohlin theory, which predicts trade intensity to be higher between countries of *dissimilar* income per capita—as the latter reflects differences in relative factor endowments.

More recent theoretical work has developed general equilibrium models to formalize the role of quality as a determinant of trade patterns.[1] These models share two key features with Linder's theory. First, rich countries have a comparative advantage in the production of high quality goods (comparative advantage comes here from productivity or factor endowment differences). Second, rich countries consume high quality goods in larger proportions than poorer countries. Even though the models yield theoretical results in the spirit of the Linder hypothesis, they do not obtain this conjecture as a general result.

Recent empirical work provides support for the supply-side relationship between per capita income and quality production postulated by Linder and subsequent theorists. Schott (2004) shows

[1] See Falvey and Kierzkowski (1987), Flam and Helpman (1987), Stokey (1991), Murphy and Shleifer (1997).

that export unit values increase systematically with exporter per capita income and relative factor endowments, while Hummels and Klenow (2002) use quantities exported and proxies for the number of varieties to argue that quality differences are necessary to explain (at least part of) the observed differences in unit values. In contrast to the evidence on the supply side, the demand-side relationship between per capita income and quality consumption, and the impact of this relationship on bilateral trade flows, have not been the subject of similar empirical scrutiny. In particular, there is yet no attempt at estimating the existence and magnitude of such a quality-driven demand effect on the global patterns of bilateral trade.[2]

A vast related literature has concentrated on estimating the Linder hypothesis. Since this is a conjectured corollary to a theory that places quality at center stage, tests of this hypothesis could be interpreted as evidence on the role of quality. This literature typically uses the gravity equation as benchmark[3], and adds a "Linder term", a measure of income dissimilarity between pairs of countries. The Linder hypothesis predicts a negative sign for the estimated coefficient on the Linder term. But the empirical results on the sign of this coefficient are mixed.[4] There is nevertheless an even more fundamental problem than failure to confirm the Linder hypothesis: the empirical framework used by this literature cannot properly identify the role of quality as a determinant of the direction of trade. First, the prediction that the intensity of trade is higher between countries with similar income per capita can also result from inter-sectoral non-homotheticities in demand, not related to quality. This is the case if income elasticities differ across sectors, and richer countries have a comparative advantage in sectors with high income elasticities.[5] Second, quality effects coexist with other traditional (inter-sectoral) determinants of trade, such as differences in factor proportions. But the gravity-equation framework does not nest these different forces. It is thus unable to isolate the role of quality from other inter-sectoral determinants of trade.

This paper provides a testable framework to estimate the impact of quality on the direction

[2] Brooks (2003) provides evidence of this effect in a specific context. She shows that differences in export shares among Colombian firms (in industries with exports largely oriented to the US) depend negatively on the industry-level quality gap relative to G7 countries, as measured by differences in unit value of exports to the US.

[3] The gravity equation, in its traditional form, postulates a log-linear relationship between the volume of bilateral trade, the GDP of each country, and the distance between them.

[4] See surveys in Deardorff (1984), Leamer and Levinsohn (1995), and McPherson, Redfearn, and Tieslau (2001).

[5] The role of this type of non-homotheticities has been addressed by Markusen (1986), Hunter and Markusen (1988), Bergstrand (1989), Hunter (1991), Deardorff (1998), and Matsuyama (2000).

of trade. In particular, it identifies the effect of quality operating on the demand side through the relationship between income and aggregate demand for quality. The theoretical framework, described in section 2, yields an empirical specification for estimating bilateral trade that has a strong resemblance to the gravity equation. However, it yields predictions for bilateral trade flows at the sectoral instead of at the aggregate level. By focusing on sectoral trade, the empirical specification embeds and controls for inter-sectoral determinants of comparative advantage. A parameter in the demand system captures the extent to which income per capita affects quality choice. In the empirical specification, this parameter translates into the coefficient on an interaction term between the exporter quality and the importer per capita income. If income affects quality demand—and therefore trade patterns—this coefficient is predicted to be positive.

Quality is unobservable. I follow two complementary approaches to deal with unobserved quality. First, based on recent empirical findings, in section 3 I use exporter income per capita as a proxy for quality. The relevant term in the empirical specification then becomes the interaction between exporter and importer per capita incomes, capturing respectively supply of and demand for quality. I estimate the empirical model using a cross-section of sectoral bilateral trade flows (at the 3-digit level) among 60 countries in 1995. Sectors are divided into three categories according to Rauch (1999): Differentiated, Reference-priced, and Homogeneous. The theory is primarily applicable to Differentiated sectors. In those sectors, the results support the theoretical prediction: rich countries tend to import relatively more from other rich countries—those that produce higher quality goods. I also estimate the empirical model for sectors in the other two categories to check that it is indeed quality that drives the results. In Reference-priced sectors, where the theory may still reasonably apply, the results are similar to those obtained for Differentiated sectors. In Homogeneous sectors, however, the theory is not expected to apply, as the income interaction term no longer captures supply of and demand for quality. Consistent with this prediction, the results are very different here; the interaction term shows no systematic effect on trade.

Since the interaction term is very similar to a Linder term, the results can be interpreted as a sector-level confirmation of the Linder hypothesis. Furthermore, they are not sensitive to the use of alternative Linder terms often used in the literature. But when the empirical specification is estimated on aggregate trade flows—as is typically done—the results are reversed. I show that this is the result of an aggregation bias, the direction of which depends on the extent of cross-country correlation between per capita income and sectoral pattern of specialization. The aggregation bias explains the failure of the literature so far to find consistent evidence in support of the Linder hypothesis. If quality drives its main insight—as originally conjectured by Linder—this suggests a reformulation of the hypothesis as a sector-level prediction, requiring inter-sectoral determinants of trade to be controlled for.

Keeping constant factors such as production costs, we expect higher quality goods to command higher prices. Export prices then convey useful information on product quality. In section 4, I construct export price indices at the sectoral level from unit values of exports to the US (calculated at the finest possible level of aggregation). I then use these indices as indicators of quality. The advantage of this approach, relative to the approach in the previous section, is the use of cross-sector variation in export price indices within countries to capture cross-sector variation in quality levels. The disadvantage is that measurement error is pervasive in the dataset used to construct the indices. The findings here are still consistent with the theoretical prediction: rich countries tend to import relatively more from countries that produce higher quality goods. These results further support the findings in the previous section on the role of quality as a determinant of trade. They also provide complementary evidence that it is quality—as opposed to other factors correlated with income per capita but unrelated to quality— that drives those results. Section 5 concludes.

2 Theoretical Framework

2.1 The Demand System

Demand in each country k is generated by a representative consumer with a two-tier utility function. The upper tier utility is weakly separable into subutility indices defined for each differentiated-good sector $z = 1, ..., Z$, and for each homogeneous-good sector $g = Z + 1, ..., G$,

$$U^k = U\left[u_1^k, ..., u_z^k, ..., u_Z^k, u_{Z+1}^k, ..., u_g^k, ..., u_G^k\right]. \tag{1}$$

The subutility index u_g^k is a general function of the quantity consumed of good g. The subutility index u_z^k takes the specific form:

$$u_z^k = \left[\sum_{h \in H_z} \left(\theta_h^{\gamma_z^k} q_h\right)^{\alpha_z}\right]^{\frac{1}{\alpha_z}} \qquad 0 < \alpha_z, \gamma_z^k < 1 \quad \forall z, k \tag{2}$$

where u_z^k is defined over all varieties $h \in H_z$ in sector z. In (2), q_h and θ_h are the quantity and quality of variety h, and the parameter γ_z^k is the intensity of preference for quality of country k. None of the parameters is restricted to be the same across sectors.

The subutility functions u_z^k are an augmented version of the Dixit-Stiglitz structure of preferences. Quality enters as a utility shifter, while there is still a horizontal dimension of product differentiation (consumers love variety). This specification of utility is designed to capture differences across countries in quality demand, stemming from their differences in income. For a given shape of the income distribution, we expect countries with higher average income to consume a larger proportion of high-quality goods. In the demand system that this utility generates, the parameter γ^k captures—in a reduced form—the effect of income on quality demand at the aggregate level.

The representative consumer uses two-stage budgeting. In the first stage, for a given expenditure allocation across sectors $E_1^k, ..., E_Z^k, ..., E_G^k$, expenditure on variety h in sector z is:

$$p_h^k q_h^k = \frac{\left(\frac{p_h^k}{\theta_h^{\gamma_z^k}}\right)^{1-\sigma_z}}{\sum_{r \in H_z} \left(\frac{p_r^k}{\theta_r^{\gamma_z^k}}\right)^{1-\sigma_z}} E_z^k = s^k(h) E_z^k, \tag{3}$$

where $\sigma_z = 1/(1-\alpha_z) > 1$ is the elasticity of substitution, and p_h^k is the price of h faced by consumers in country k. Equation (3) shows expenditure on h as a share $s^k(h)$ of total expenditure in sector z. This share depends on the value of γ^k, and it changes with this parameter according to:

$$\frac{\partial s^k(h)}{\partial \gamma_z^k} = \lambda_{hz}^k \left[\ln \theta_h - \sum_{r \in H_z} s(r) \ln \theta_r \right], \qquad \lambda_{hz}^k = \frac{\left(\frac{p_h^k}{\theta_h^{\gamma_z^k}}\right)^{1-\sigma_z} (\sigma_z - 1)}{\sum_{r \in H_z} \left(\frac{p_r^k}{\theta_r^{\gamma_z^k}}\right)^{1-\sigma_z}} > 0. \tag{4}$$

Equation (4) highlights the main characteristic of the demand system. For a variety h of above-average quality—the term in brackets in (4) is positive—a higher γ^k induces a larger share spent on h. For a variety h of below-average quality, a higher γ^k induces a smaller share spent on h. Countries with higher γ^k thus spend a larger share of their income on high quality goods. Allowing γ^k to vary across countries, this demand system has the convenient property of accommodating in a simple form cross-country differences in the pattern of expenditures for goods of different quality.[6] A special case arises when γ^k is the same for every country. In that case, the demand system is equivalent to the demand system generated by the Dixit-Stiglitz structure of preferences, where there are no differences across countries in quality choice.[7] Since Dixit-Stiglitz preferences are standard in international trade models and empirical frameworks with product differentiation, the proposed demand system has the additional advantage of embedding a meaningful benchmark against which to assess the impact of quality on aggregate demand and trade.

2.2 Bilateral trade flows at the sectoral level

Country i produces N_{iz} different varieties in sector z. These varieties are symmetric; they share the same quality and sell at the same price.[8] We can multiply equation (3) by the number of varieties N_{iz} to obtain country k's total imports from i in sector z:

$$imp_{iz}^k = N_{iz} \frac{\left(\frac{p_{iz}\tau_{iz}^k}{\theta_{iz}^{\gamma_z^k}} \right)^{1-\sigma_z}}{\sum_{r \in H_z} \left(\frac{p_r \tau_r^k}{\theta_r^{\gamma_z^k}} \right)^{1-\sigma_z}} E_z^k, \tag{5}$$

where we use $p_{iz}^k = p_{iz}\tau_{iz}^k$, the equality between import price and the product of export price and trade cost factor between i and k.

Countries differ in the quality of the goods they produce and in their pattern of sectoral specialization. Recent empirical work [Schott (2004), Hummels and Klenow (2002)] provides evidence characterizing supply-side determinants of quality production. This paper instead takes the distribution of quality production across countries as given and, conditional on this distribution, attempts to identify the effect of quality on the direction of trade operating on the demand side through the relationship between income and quality choice. Income as a determinant of the demand for product quality—and hence of the intensity of trade between country pairs—has been one the main ingredients of most theoretical work addressing the impact of quality on the direction of trade.

[6] I do not address here the effects of differences in higher moments of the income distribution. See Francois and Kaplan (1996) and Dalgin, Mitra, and Trindade (2004) for an empirical treatment of inequality and trade based on inter-sectoral non-homotheticities.

[7] In this case, quantity substitutes for quality at the same rate in every country. Quantities and prices can then be renormalized to "common-quality" units to obtain the typical Dixit-Stiglitz specification.

[8] This will not be a strong restriction so long as the variation of quality levels within countries is small compared to the variation of quality levels between countries.

However, there is yet no empirical evidence identifying this effect in global patterns of trade.

The proposed demand system allows quality choice to depend on a country-specific parameter. In the special case with equal γ^k across countries, the demand system is equivalent to the standard Dixit-Stiglitz structure of preferences, which does not allow the demand for quality to vary across countries. I show next that Dixit-Stiglitz preferences impose a strong restriction on the relationship between bilateral flows at the sectoral level. This restriction is independent of the distribution of quality production across countries, and thus provides a key for identifying quality effects on the direction of trade.

Using (5), consider US (country k) imports of Rubber Tires (sector z) from Germany (country i). Consider also US imports of tires from Turkey (country j) by replacing i with j in (5). The ratio between these two expressions indicates the ratio of US imports of tires from Germany relative to those originating from Turkey, and is independent of the expenditure level and the price index for tires in the US:

$$ratio_{ij}^{k}(z) = \frac{N_{iz}}{N_{jz}} \left(\frac{p_{iz}\tau_{iz}^{k}/\theta_{iz}^{\gamma_z^k}}{p_{jz}\tau_{jz}^{k}/\theta_{jz}^{\gamma_z^k}} \right)^{1-\sigma_z}. \tag{6}$$

Replacing k with l in (6), consider the same ratio for a different importer, Argentina (country l). Then, compare these two ratios by taking the ratio between the two:

$$r_{ij}^{kl}(z) = \frac{ratio_{ij}^{k}(z)}{ratio_{ij}^{l}(z)} = \left(\frac{\tau_{iz}^{k}/\tau_{jz}^{k}}{\tau_{iz}^{l}/\tau_{jz}^{l}} \right)^{1-\sigma_z} \left[\frac{(\theta_{iz}/\theta_{jz})^{\gamma_z^k}}{(\theta_{iz}/\theta_{jz})^{\gamma_z^l}} \right]^{\sigma_z - 1}. \tag{7}$$

To abstract from the impact of trade costs, assume for now that $\frac{\tau_{iz}^{k}/\tau_{jz}^{k}}{\tau_{iz}^{l}/\tau_{jz}^{l}} = 1$. Then,

$$r_{ij}^{kl}(z) = \left[\frac{(\theta_{iz}/\theta_{jz})^{\gamma_z^k}}{(\theta_{iz}/\theta_{jz})^{\gamma_z^l}} \right]^{\sigma_z - 1}. \tag{8}$$

There are three possible cases in (8). The first one is trivial. If Germany and Turkey produce the same quality of tires ($\theta_i = \theta_j$), then relative imports from Germany and Turkey are the same for both the US and Argentina ($r_{ij}^{kl} = 1$). A much more relevant case is the second one, which is our benchmark case of no income effects on quality choice. If the US and Argentina have the same intensity of preference for quality ($\gamma^k = \gamma^l$), then relative imports from Germany and Turkey will still be the same for both importers ($r_{ij}^{kl} = 1$), even if qualities are different ($\theta_i \neq \theta_j$). As argued before, standard Dixit-Stiglitz preferences can accommodate this case after an appropriate normalization to "common-quality" units. Thus interpreted, these preferences impose the restriction that any two countries' relative imports from any other two countries are identical, i.e. $r_{ij}^{kl} = 1$, regardless of the quality produced by the two exporting countries.[9] The restriction does not neglect inter-sectoral determinants of trade. Suppose that Germany has a comparative advantage in producing tires. Then, Germany will have many firms in this sector. N_{iz} will be large, and Germany will be a large exporter of tires.[10] But exports from Germany will be large to both the US and Argentina without affecting r_{ij}^{kl}. A similar exercise focusing on an importer provides the same answer. Suppose that Argentina has a comparative advantage in producing tires. We then expect a large number of firms there, leading to a low price index for tires since domestic goods do not pay trade costs. Relative prices of imported varieties will then be high, discouraging Argentina's imports from both Germany and Turkey. But again, r_{ij}^{kl} will not be affected. Finally, suppose that E_z^k is large for the US because of a combination of size and inter-sectoral non-homotheticities in demand. This will affect US imports from both countries proportionally, but it will still not affect the relative ratio r_{ij}^{kl}.

It is only in the third case, where both quality and the intensity of preference for quality are different ($\theta_i \neq \theta_j$ and $\gamma^k \neq \gamma^l$), that $r_{ij}^{kl} \neq 1$. Only then will quality affect the relative intensity of sectoral trade between different country pairs. If Germany's quality is higher ($\theta_i > \theta_j$) and US's intensity of preference for quality is higher ($\gamma^k > \gamma^l$), then the US will import relatively more from Germany while Argentina will import relatively more from Turkey. More generally, countries with higher γ^k will import relatively more from countries that produce higher quality goods.

Taking logarithms on both sides of equation (5), we obtain the following prediction for bilateral trade:

$$\ln imp_{iz}^k = \ln N_{iz} - \widetilde{\sigma}_z \ln p_{iz} - \ln \sum_{r \in H_z} \left(\frac{p_r^k}{\theta_r^{\gamma_z^k}} \right)^{-\widetilde{\sigma}_z} + \ln E_z^k - \widetilde{\sigma}_z \ln \tau_{iz}^k + \widetilde{\sigma}_z \gamma_z^k \ln \theta_{iz}, \tag{9}$$

where $\widetilde{\sigma}_z = \sigma_z - 1$. In a cross-section of bilateral trade flows, the first two terms on the RHS are specific to exporting country i. These terms take the same value when i is the exporter, independent of who importer k is. In the econometric specification, they will be captured by *exporter* fixed effects. Similarly, the next two terms are specific to importer k and take the same

[9] In the more general case, this is only true after controlling for differences in bilateral trade costs.

[10] Romalis (2004) derives the effect of comparative advantage on the number of firms in a Heckscher-Ohlin model that accounts for product differentiation and trade costs.

value independent of exporter i. These terms will be captured by *importer* fixed effects. Only the last two terms are specific to the bilateral pair. I assume that trade costs are determined by:

$$\ln \tau_{iz}^k = \eta_z \ln Dist_i^k + \widetilde{\boldsymbol{\beta}}_z \mathbf{I}_i^k - v_{iz}^k, \tag{10}$$

where $Dist_i^k$ is the bilateral distance between each country pair, v_{iz}^k is a random disturbance, and $\widetilde{\boldsymbol{\beta}}_z$ is a vector of parameters associated with dummy variables $\mathbf{I}_i^k$ indicating whether the country pair shares, respectively, a common border, a common language, a preferential trade agreement, a colonial relationship, or a common colonizer.[11] I also postulate a relationship between the intensity of demand for quality—captured by γ_z^k—and income[12]:

$$\gamma_z^k = \gamma_z + \mu_z \ln y^k. \tag{11}$$

Under the null hypothesis that income does not affect aggregate demand for quality, $\mu_z = 0$, and $\gamma_z^k = \gamma_z$. This is the benchmark Dixit-Stiglitz case. Under the alternative hypothesis that it does affect aggregate demand for quality, $\mu_z > 0$, and γ_z^k increases with income.

Combining (10) and (11) with (9), we obtain:

$$\ln imp_{iz}^k = \varphi_{iz} + \psi_z^k - \widetilde{\sigma}_z \eta_z \ln Dist_i^k + \boldsymbol{\beta}_z \mathbf{I}_i^k + \widetilde{\sigma}_z \mu_z \ln \theta_{iz} \ln y^k + \widetilde{\sigma}_z v_{iz}^k, \tag{12}$$

where φ_{iz} and ψ_z^k are fixed effects for exporter and importer country, respectively, and $\boldsymbol{\beta}_z = -\widetilde{\sigma}_z \widetilde{\boldsymbol{\beta}}_z$. I am unable to estimate (12) because I do not observe quality (θ_{iz}). The next two sections deal with unobserved quality in two different ways. First, exporter income is used as a proxy for quality. Second, export price indices (constructed from export unit values) are used as indicators of quality.

3 Exporter Income as Proxy for Quality

There is increasing evidence that suggests the existence of a positive relationship between per capita income and quality supply. Different trade theories are consistent with this evidence. For example, a Ricardian view of quality specialization would predict that richer countries will produce higher

[11] The empirical specification would not change if trade costs depended on quality, so long as they are modeled with a (negative) function of quality as an additive term in (10). This term would be subsumed into the exporter fixed effect.

[12] Throughout the paper—unless explicitly noted—income will refer to income per capita.

quality goods if they have a relatively larger productivity advantage in the production of those goods. Alternatively, a factor proportions view of quality specialization would predict that richer countries, which tend to be capital abundant, will have a comparative advantage in the production of high quality goods if these goods are capital intensive.[13] Based on the evidence of a positive relationship between quality supply and income, but without taking a stand on which underlying theory generates this relationship, I postulate the following stochastic log-linear equation:

$$\ln \theta_{iz} = \delta_z \ln y_i + \eta_{iz}. \tag{13}$$

The random disturbance η_{iz} introduces quality variation between sectors for a given country, allowing the cross-country ordering of sectoral quality levels to differ from the ordering of income.

Substituting (13) into (12), we obtain:

$$\ln imp_{iz}^k = \varphi_{iz} + \psi_z^k - \widetilde{\sigma}_z \eta_z \ln Dist_i^k + \boldsymbol{\beta}_z \mathbf{I}_i^k + \widetilde{\sigma}_z \mu_z \delta_z \ln y_i \ln y^k + \varepsilon_{iz}^k, \tag{14}$$

where $\varepsilon_{iz}^k = \widetilde{\sigma}_z \mu_z \eta_{iz} + \widetilde{\sigma}_z v_{iz}^k$.[14] The component disturbances η_{iz} and v_{iz}^k are assumed to be uncorrelated with the regressors; therefore, so is ε_{iz}^k. I will estimate (14) on a cross-section of bilateral trade flows at the sectoral level. Unfortunately, I will not be able to separately identify the magnitude of μ_z. But since $\widetilde{\sigma}_z > 0$, if based on the available evidence we maintain the assumption that $\delta_z > 0$, then a test of the joint hypothesis $\widetilde{\sigma}_z \mu_z \delta_z = 0$ will imply a test of the hypothesis $\mu_z = 0$.

Several sectors used in the estimation contain intermediate goods. If we interpret (1) and (2) as a production function of a final good based on the use of intermediate inputs, then (3) is the demand function for these inputs. In that case, it may be reasonable to assume that γ_z^k is not a function of the importer income as in (11), but of the quality of the final good θ_z^k (assuming that it is demanded in only one sector). Since the quality of the final good is in turn a function of the importer income by (13), we can still derive (14). The error term contains additional terms in this case, but it is still uncorrelated with the regressors.

Equation (14) is a prediction for bilateral trade at the sectoral level. Estimating it with aggregate data would only be appropriate if the parameters were constrained to be equal across sectors. This restriction is not plausible in general. In particular, it will be strongly violated in the case of the exporter and importer fixed effects, which must be sector-specific as they control for inter-sectoral

[13] Schott (2004) provides empirical evidence in support of this view.

[14] A constant in (13) would be absorbed in the fixed effect ψ_z^k, without affecting (14).

determinants of comparative advantage. I thus estimate (14) sector by sector. Also, to obtain a single estimate of the parameter of interest, I estimate (14) pooling the observations across sectors. In this case, I allow all the parameters to take sector-specific values except for the cross-sector restriction $\widetilde{\sigma}_z \mu_z \delta_z = \widetilde{\sigma} \mu \delta$.

Finally, I focus on differentiated-good sectors because the theory underlying (14) is only valid for those sectors. But I also use other sectors to benchmark the results.

3.1 Data and sample selection

The data consist of a cross section of bilateral trade flows and country-level variables for 60 countries in 1995. Bilateral trade data, disaggregated at the sectoral level, come from Feenstra (2000). The dataset is based on the World Trade Analyzer assembled by Statistics Canada. I define sectors at the 3-digit SITC (Rev.2) level.

I follow Rauch's (1999) classification of 4-digit SITC sectors into three categories. Homogeneous sectors include goods that are internationally traded in organized exchanges, with a well-defined price (e.g., wheat). Reference-priced sectors include goods that are not traded in organized exchanges, but have reference prices available in specialized publications (e.g., polyethylene). Differentiated sectors are those sectors that do not satisfy either of the two previous criteria. Rauch uses two standards to make his classification, one "liberal" and one "conservative". I use the liberal standard because it is more stringent in the classification of goods as Differentiated. When a 3-digit sector includes 4-digit subsectors that belong to different classifications, the 3-digit sector is broken down accordingly, each part including only the relevant 4-digit sectors.

There is a large proportion of bilateral country pairs with zero trade. The proportion is larger for smaller countries. Since I want to prevent zero-trade observations from dominating the sample, I concentrate only on relatively large countries. I include countries with a population larger than 3 million, and with more than 2 billion-dollar imports of Differentiated goods. Hungary is additionally excluded because sectoral trade data are of poor quality. Algeria, Iran, Libya, and the US are excluded because they lack data on export unit values, used in the next section of the paper. In the case of the US, export unit values are not available because they are obtained from a database on US imports. The final sample consists of 60 countries, listed in Table A1. I also drop very small sectors, keeping only sectors with a volume of trade (within the 60 selected countries) above

2 billion dollars. The final sample includes 114 Differentiated sectors, 51 Reference-priced sectors, and 38 Homogeneous sectors. They are listed in Tables A2, A3, and A4, respectively.

Distance measures great circle distance between capital cities and was prepared by Howard Shatz (1997). Dummies for border, common language, colonizer-colony relationship, and common-colonizer relationship were constructed using the CIA Factbook. Only "official" languages are considered in the construction of the common language variable. An exception is made for Malaysia-Singapore, which is recorded as having a common language. Colonial links are only considered if the colonizer-colony relationship was still in force after 1922. The indicator variable for Preferential Trade Agreement includes PTAs in force and with substantial coverage in 1995: Andean Pact, ASEAN, CACM, EFTA, EEA, EU, MERCOSUR, NAFTA, Australia-New Zealand, EC-Turkey, EFTA-Turkey, EC-Israel, EFTA-Israel. Data on PPP GDP come from the World Bank WDI.

3.2 Estimation results

I first estimate (14) separately for each Differentiated sector using OLS. Since I cannot report detailed regression results for all 114 sectors, I provide summary results for the distribution of the estimated coefficients according to sign and significance levels in Table 1. In all cases, heteroskedasticity-robust standard errors are used. The results for the coefficient of interest (the interaction term) are shown in the first row. This coefficient is positive in more than 2/3 of the sectors (78), and negative in less than 1/3 (36) of the sectors. The coefficient is positive and significant in almost 1/2 of the sectors (56), and negative and significant in 1/5 (23).

The median coefficient across sectors is 0.1218. The interpretation of this coefficient is related to the ratio of ratios in equations (7) and (8). Keeping trade costs constant, and denoting $\widehat{\mu}_z$ the estimate of $\widetilde{\sigma}_z \mu_z \delta_z$, we can use (14) to calculate the predicted ratio of ratios:

$$\ln(r_{ijz}^{kl}) = \widehat{\mu}_z \ln \frac{y_i}{y_j} \ln \frac{y^k}{y^l}. \tag{15}$$

To understand this expression, take countries at the 75th percentile (Sweden and the UK) and the 25th percentile (Dominican Republican and Lebanon) of the income distribution in our sample. Consider Dominican Republic's ratio of imports from the UK relative to those from Lebanon. How much would this ratio increase if the Dominican Republic were to have the income of Sweden? Substituting for the actual income values in (15), we obtain: $r_{ijz}^{kl} = \exp(0.1218 * 1.6115 * .1.5912) =$

1.366; Dominican Republic's imports from the UK relative to Lebanon would increase by 36.6% (in the median sector). This is the relevant exercise for interpreting the estimated magnitude of the quality effect. Other typical measures of explanatory power such as the beta coefficient are very small because size (captured by the dummy variables) and distance dominate most of the variation in bilateral trade flows.

The last column of Table 1 shows results for the pooled regression, where the coefficient on the interaction term is constrained to be the same across sectors. Here, as in every pooled regression, the estimates are reported with heteroskedasticity-robust standard errors and clustering by country pair across sectors. The pooled coefficient is substantially smaller than the median of the sectoral coefficients. But we can reject the null hypothesis that $\mu = 0$ at the 1% level of significance.

The estimated coefficients for the rest of the variables have the expected signs in most sectors. Distance hinders trade, whereas Border, Common Language, PTA, Colonial relationships, and Common Colony relationships facilitate trade, presumably through a reduction in trade costs. A similar set of results for these variables is available from the pooled regression. Since the coefficients are allowed to take sector-specific values, there is not a unique value to report, as is the case with the (constrained) coefficient on the interaction term. To save space, I do not report these results, which are very similar to those from the sectoral regressions.

Both the sectoral and the pooled regression results are consistent with the theoretical prediction: rich countries tend to import relatively more from other rich countries, which are those assumed to produce higher quality goods. However, there are two reasons for concern. First, the estimated coefficient is significantly negative in a substantial number of sectors (23 out of 114). This suggests that factors other than product quality might affect the estimates. Second, per capita income is correlated with many other characteristics of countries besides quality supply and demand, and these other characteristics instead of quality might be driving the results. To address these concerns, I repeat the estimation using Reference-priced and Homogeneous sectors.

Equation (14) is derived under the assumptions that there are cross-country differences in quality levels and that quality levels are correlated with income. Even though quality differences still exist in Reference-priced sectors and even possibly in Homogeneous sectors, the differences in those sectors are less likely to be large. They are also less likely to be strongly correlated with income, since higher product quality may stem from the higher quality of natural resources—

not obviously correlated with income—instead of the accumulation of human or physical capital. Evidence on export prices discussed in the next section suggests that, as we move from Differentiated to Homogeneous goods, both the dispersion of quality levels and the correlation between quality and income decrease. Equation (14) is also derived under the assumption that there are horizontal and vertical components of product differentiation. Absent the horizontal component, goods of similar quality would be close substitutes, and the pattern of sectoral bilateral trade would tend to have corner solutions. In that case, (14) would not be an accurate predictor of bilateral trade. However, so long as quality differences are substantial and are also correlated with income, (14) might still be able to capture the quality effect on average. Rich countries will still import relatively more from countries that produce high quality, although they will import from only a few such countries. Since the classification into the three categories of goods was originally designed to distinguish sectors according to their degree of product differentiation, we can expect the extent of this problem to increase as we move from Differentiated to Homogeneous goods. In sum, we expect the theory to work for Differentiated sectors, and we expect it not to work for Homogeneous sectors. For Reference-priced sectors, the theoretical prediction is ambiguous, as we ignore the extent to which the premises of the theory apply to them.

Table 2 compares the distribution of estimates for the interaction term in each category. To facilitate comparability, the results for Differentiated goods are repeated in this table. In the case of Reference-priced sectors, the results are similar to those for Differentiated sectors. The coefficient is positive in 2/3 of the sectors (33) and is negative in 1/3 (18). It is positive and significant in 1/3 of the sectors (17), and negative and significant in 1/8 (6). The median coefficient is considerably lower than for Differentiated goods, but the coefficient in the pooled regression is only slightly smaller (and also significant at the 1% level). For Homogeneous goods, however, the results are very different. The estimated coefficient is more often negative than positive, and more often negative and significant than positive and significant. In addition, both the median coefficient and the pooled coefficient are negative. The contrast can be visually appreciated in Graph 1, which shows the frequency distribution of the estimated coefficient for each category. These results support the idea that it is quality, and not other factors correlated with income, that drives most of the estimated effect of the income interaction term. The coefficient on this term matches the predicted sign only in those categories for which the (quality-based) theory is expected to apply.

3.3 Fixed costs of exporting

Almost half of all sectoral bilateral pairs in the sample report no trade. Since the estimating equation uses the logarithm of bilateral trade, these observations must be discarded when using OLS. Researchers working with the gravity equation have long acknowledged that dropping observations with zero values might induce selection bias. I address this concern here using fixed costs of exporting to explain the substantial fraction of zero values in bilateral trade. International trade only occurs when the profits it generates cover the fixed costs.

This is a censored data problem. However, the use of a standard censoring model for estimation is not convincing for two reasons. First, we do not know the censoring value. Second, fixed exporting costs are likely to vary across bilateral pairs. I model the (unobserved) censoring value for country-pair ik in sector z as:

$$\log c_{iz}^{k} = \delta_{0z} + \delta_{dz} \log Dist_{i}^{k} + \boldsymbol{\delta}_{z}\mathbf{I}_{i}^{k} + \delta_{xz} \log GDP_{i} + \delta_{mz} \log GDP^{k} + u_{iz}^{k}, \tag{16}$$

where $\mathbf{I}_{i}^{k}$ is the same vector of dummy variables as in (14), GDP_i and GDP^k are total income of i and k, respectively, and u_{iz}^{k} is a normally distributed random disturbance.

Given the demand structure in (3), mark-ups are constant, and profits are a constant fraction of the value of exports: $\pi_{iz}^{k} = \frac{1}{\sigma_z} imp_{iz}^{k}$.[15] Countries trade if the profits that export sales generate are sufficient to cover the fixed costs. Hence, exports occur if $\pi_{iz}^{k} = \frac{1}{\sigma_z} imp_{iz}^{k} > F_{iz}^{k}$, which implies $imp_{iz}^{k} > \sigma_z F_{iz}^{k} = c_{iz}^{k}$. Therefore, up to a constant shift, (16) is in fact the equation determining bilateral fixed costs. The empirical specification is then a censoring model with two equations, (14) and (16), where in the first equation the dependent variable is now a latent variable; (16) determines the (unobserved) censoring point c_{iz}^{k}, and (14) only takes non-zero values if $imp_{iz}^{*k} > c_{iz}^{k}$. Even though the censoring point is unobservable, the parameters of both equations can be estimated jointly by maximum likelihood. This specification is a more general version of the standard Tobit estimation, with unknown and random censoring value.[16] A shortcoming of this approach is the implicit assumption that the decision to export is made at the country-sector level, while fixed exporting costs are in fact borne at the firm level. Another shortcoming is the need to assume a

[15] With a finite number of varieties, this is only true as a limiting property.

[16] A similar approach was taken by Cogan (1981) to model labor supply with fixed costs of entry into the labor market.

particular distribution for the error disturbances. However, it is an appealing robustness exercise for assessing the potential magnitude of the selection bias.

The estimation is performed sector by sector, assuming a bivariate normal distribution for the random disturbances. Table 3 shows the results for the coefficient on the interaction term in the case of Differentiated, Reference-priced, and Homogeneous goods.[17] In this and in the next tables, I do not report results on the other controls, as they are very similar to the results in Table 1.

Despite some differences, the censoring model broadly confirms the OLS results. For the Differentiated sectors, the coefficient on the interaction term is positive in almost 2/3 of the sectors (72) and is positive and significant in almost 1/2 of them (52). The sign of the coefficient matches the sign obtained under OLS in all but 10 sectors, in 9 of which the coefficient is statistically insignificant in both specifications. The median magnitude of the coefficient is considerably lower in the maximum likelihood estimation, and it is now closer to the estimate obtained from the pooled specification. This indicates that discarding zero-valued observations does not induce important differences in sign and significance of the estimated coefficients but might overestimate the coefficient magnitude. For Reference-priced and Homogeneous sectors, the results lead to similar conclusions to those obtained using OLS. For these sectors, the magnitude of the estimated coefficient is not largely affected.

3.4 Aggregation bias and the Linder Hypothesis

The prediction that richer countries will import relatively more from countries that produce higher quality goods, i.e. other rich countries, strongly resembles the Linder hypothesis, which states that countries of similar income will trade more with one another. The Linder hypothesis is typically tested by introducing some measure of income dissimilarity between countries—the Linder term—into a standard empirical framework for estimating bilateral trade, such as the gravity equation. Examples of Linder terms used in the literature are: $\left|y_i - y^k\right|$, $\ln\left|y_i - y^k\right|$, and $\left|\ln y_i - \ln y^k\right|$. The results of estimating (14) are in fact not sensitive to the use of any of these Linder terms instead of the income interaction term $\ln y_i \ln y^k$. This is shown in Table 4, where the signs of the coefficient on the Linder terms are reversed to facilitate comparability. Both for the sector-by-sector and the pooled estimations, the results using the Linder terms are very similar to the results using the

[17] Due to computational constraints, I do not perform the maximum likelihood estimation on the pooled data.

interaction term. Thus, we can interpret the (quality-driven) predictions of this paper as Linder-type predictions, and the results as a sectoral-level confirmation of the Linder hypothesis.

As opposed to the standard Linder hypothesis, however, these predictions hold at the sectoral instead of at the aggregate level. At the sectoral level, inter-sectoral determinants of comparative advantage can be controlled for. Failure to control for these determinants introduces a severe (aggregation) bias, which obscures the effect of quality on demand and trade patterns. Furthermore, this bias explains the failure of the literature, which uses aggregate data, to find systematic support for the Linder hypothesis. I next discuss a very simple example, artificially constructed, that conveys the basic intuition of how aggregation might induce systematic bias. Then, I estimate (14) using aggregate data and show that the bias is empirically relevant.

Consider the countries of our previous example: two exporters, the UK and Lebanon, and two importers, Sweden and the Dominican Republic (DR). Table 5 shows hypothetical exports of the UK and Lebanon to Sweden and DR in two sectors, Machinery and Apparel. This artificial example abstracts from trade costs and differences in size. The UK and Sweden have similar income and a comparative advantage in Machinery. Lebanon and DR have similar income and a comparative advantage in Apparel. Therefore, the UK is a large exporter of Machinery relative to Lebanon and Sweden is a large importer of Apparel relative to DR. UK's quality is higher in both sectors.

The prediction for the quality effect holds at the sectoral level. In Machinery, Sweden imports relatively more from the UK, and DR imports relatively more from Lebanon. The ratio of ratios discussed in section 2 is higher than 1 ($r_{ij}^{kl} = 1.5$). The same is true in Apparel, where $r_{ij}^{kl} = 1.5$. However, when we aggregate trade in both sectors, the quality effect appears to be reversed. In the aggregate, Sweden imports relatively more from Lebanon and DR imports relatively more from the UK ($r_{ij}^{kl} = 0.73$) . Using the empirical framework of this paper on the aggregated data, we would probably find a misleading negative coefficient on the interaction term. The reason is the failure to control for inter-sectoral determinants of comparative advantage. In the aggregate, Sweden imports relatively more from Lebanon than from the UK, not because Sweden's demand is biased towards low-quality goods but because Sweden is a large importer of Apparel, the sector in which Lebanon is a large exporter. Similarly, DR imports relatively more from the UK than from Lebanon, not because DR's demand is biased towards high-quality goods, but because DR is a large importer of Machinery, the sector in which the UK is a large exporter.

The particular direction of the aggregation bias in this example (opposite to the prediction) hinges on the assumption that countries with similar income specialize in the same sectors. This might not always be a reasonable assumption. The first column of table 6 shows the results of estimating (14) using our data of actual trade flows aggregated across sectors in each of the three different categories of goods. In contrast to the sectoral results, the estimated coefficient is now negative for the aggregate of Differentiated sectors. Even though at the sectoral level richer countries import relatively more from other rich countries, the quality effect is overshadowed in the aggregate by a (more powerful) composition effect, the aggregation bias described in the artificial example. This example is particularly applicable to Differentiated sectors because the assumption that the determinants of comparative advantage are correlated with income level is likely to hold in those sectors. For example, richer countries are typically skilled-labor abundant, and thus they tend to be relatively large exporters of skilled-labor intensive sectors, such as Machinery. When (14) is estimated on an aggregate of only Reference-priced goods, the coefficient is also reversed, but it is not significantly different from zero. It is not surprising that the bias is weaker here, since differences in comparative advantage among Reference-priced sectors are often caused by differences in the relative abundance of natural resources, which are not systematically related to income. This is more obviously true in the case of Homogeneous sectors, where the estimated coefficient is positive, but not significantly different from zero. Finally, the last two rows of table 6 show the results when all sectors in the sample are aggregated into one, and when all trade is aggregated, including sectors both in the sample and out of the sample. In both cases, the aggregation bias is sufficiently strong to reverse the sign of the estimated coefficient. Incidentally, Linder himself explicitly argued that the quality effect on demand operated mostly within sectors instead of across sectors (Linder 1961, p. 95): "Qualitative product differences are not well brought out in empirical studies of consumer behavior along the lines first followed by Engel. The qualitative factor is submerged by taking broad groups of goods such as "food" or "clothing"."

The estimation of (14) using aggregate trade is similar to a standard test of the Linder hypothesis. In fact, it is primarily the Linder term that distinguishes it from usual empirical specifications used to test it.[18] The last three columns of table 6 show that the existence and direction of the bias are not sensitive to which Linder term is used in the estimation (the signs on the alternative

[18] Using exporter and importer GDP instead of fixed effects does not substantially affect the results.

Linder terms are again reversed to facilitate comparability). Regardless of the Linder term, there is no support for the Linder hypothesis from estimations using aggregate data.

By addressing explicitly the within-sector demand effect of quality, this paper provides a unifying framework for understanding simultaneously the long appeal of Linder's premises and the failure to find consistent empirical support for the Linder hypothesis (the hypothesized corollary). Linder's premises are correct: countries with similar income have similar production and consumption patterns—they produce and consume goods of higher quality. But the Linder hypothesis, that countries of similar income trade more with each other, only holds at the sectoral level, and relative to a benchmark where sectoral differences in comparative advantage are controlled for. At the aggregate level, it is not a valid hypothesis, since it does not follow from the premises that are supposed to imply it. Moreover, its empirical rejection using aggregate data is uninformative about the validity of the premises, as the estimates come from a misspecified empirical model.

3.5 A caveat on the notion of sectoral comparative advantage

In traditional models of international trade, both the supply and the demand side treat varieties within sectors symmetrically. For example, on the supply side of the factor-proportions model, all firms in a sector share the same production technology. On the demand side, varieties in a sector are either perfect substitutes (homogeneous goods) or closer substitutes for one another than for varieties in other sectors (differentiated goods). Sectoral comparative advantage is thus well defined, as it refers to all varieties in a sector. When quality is introduced, this is no longer true. A skill-abundant country may have a comparative advantage in skill-intensive high-quality varieties but a comparative disadvantage in unskill-intensive low-quality varieties. While a sector might still be well defined on the demand side, the production technologies for the different varieties may be very different.[19] Despite this problem, the reference to sectoral patterns of comparative advantage might still meaningfully characterize average properties of sectors. For example, exports of Apparel are systematically larger as a fraction of total exports in poor countries, and exports of Machinery are systematically larger in rich countries. Even though rich countries might have

[19]Schott (2003) argues that we should consider goods of different qualities as different sectors. This approach, although appealing from a supply-side perspective, still needs to deal with the demand-side links between goods of different qualities.

a comparative advantage in high-quality apparel, poor countries have a comparative advantage in a range of qualities that accounts for most of world demand in that sector. The opposite is true for Machinery. It is only in this average sense that we should understand any reference to sectoral comparative advantage in this context (e.g. in the artificial example of table 5). This caveat, however, does not undermine the validity of the empirical framework used here for estimation, since it does not rely on any particular interpretation of comparative advantage.

4 Export Price as Indicator of Quality

Other things equal, higher quality goods are expected to sell at higher prices. Hence, we can use prices to extract information on quality levels. This section uses export price indices, constructed from export unit values, as indicators of quality supply. The results provide complementary evidence of the existence of a quality-driven demand effect on trade patterns. They also provide further evidence, in addition to the use of different categories of goods, that it is product quality that drives the results of the previous section.

4.1 Export price indices

I construct export price indices p_{iz}, for country i and 3-digit sector z, based on cross-country differences in export unit values. Unit values measure, for a given export category, the ratio between the value and the quantity of exports. They are the average price for the category. Composition problems are pervasive in unit value comparisons. If a category includes different goods, then differences in unit values might not merely reflect differences in prices but also differences in the composition of exports within the category. To minimize the incidence of composition problems, I measure unit values at the finest possible level of aggregation for which data are available. The NBER Trade Database compiled by Feenstra, Romalis, and Schott (2002) classifies US imports by country of origin and type of good at the 10-digit level of the Harmonized Tariff Schedule (HTS), the level at which import duties are defined. For each of these categories and source countries, the database provides information on the customs value and quantity of US imports, and the units in which quantities are measured.[20] Examples of 10-digit categories are:

[20] Customs values do not include freight, and are used as the basis for duty assessment. They are intended to serve as arm's length transaction values for commodities.

HTS Code	Description
1006204060	Rice, short grain, husked (brown)
1902112000	Uncooked pasta, not stuffed or otherwise prepared, containing eggs, exclusively pasta
5208292020	Woven fabrics of cotton, containing 85% or more by weight of cotton, weighing not more than 200g/m^2, bleached, sateens
6203492010	Men's trousers and breeches of artificial fibers
8413702022	Centrifugal pumps for liquids, single-stage, single-suction, frame-mounted, with discharge outlet under 7.6 cm. in diameter
8418210010	Refrigerators of household type, compression type, having a refrigerated volume of under 184 liters

Based on cross-country differences in unit values at the 10-digit level, I construct export price indices p_{iz} at the 3-digit level using a slightly modified version of the Eltetö, Köves, and Szulc (EKS) multilateral price index, which in turn is based on bilateral Fisher indices. Appendix A describes the methodology in detail.[21]

Several shortcomings are associated with the construction of these indices. Countries often report exports to the US in only a few or even none of the 10-digit categories included in a particular 3-digit sector. When countries are active in only a few 10-digit categories, the price index is very sensitive to measurement error. When countries are not active in any 10-digit category, the price index has a missing value. To increase the availability and reliability of the indices, I merge two years of data, 1995 and 1996, instead of using only one year. I also calculate the indices at the 2-digit level and then use the 2-digit indices for the relevant 3-digit categories. This procedure has two advantages. First, the indices are more reliable, as they are based on a larger number of observations. Second, bilateral trade observations for which the exporter's 3-digit price index would be missing are kept in the sample if the corresponding 2-digit index can be calculated.

The indices are based on a source database with considerable measurement error.[22] To deal with this problem, I remove observations with extreme unit values (four times above or below the category mean) and observations with very low quantity (below the lower of 50 units or a quarter

[21] See also Diewart (1993), Ch.5, for properties of this and similar indices.

[22] The General Accounting Office (1995) conducted a detailed study of 8 specific 10-digit product categories. It found that wide dispersion among countries in unit values of US imports within the same product category is explained by two main factors: categories not including identical products and classification and data entry errors. Unfortunately, the GAO cannot assess the generality of these problems because its sample is not representative.

of the category mean quantity). Lastly, aggregation problems may still be present at the 10-digit level, but I expect these problems to be minimized at the 10-digit level of aggregation.

Table A1 provides summary measures of the export price indices. Ordering countries by income, and normalizing the indices so that Canada has a value of 1 in every sector, the table shows the geometric average of the sectoral indices for each goods category. Graphs 2a to 2c provide the same information. The correlation between export price indices and income is positive for all Differentiated sectors, and for most of Reference-priced and Homogenous sectors. The average correlation across sectors is 0.45 for Differentiated sectors, 0.36 for Reference-priced sectors, and 0.23 for Homogeneous sectors. This is consistent with the supply-side assumptions of most theoretical trade models accounting for vertical differentiation, and it confirms the findings of Hummels and Klenow (2002) and Schott (2004). The average across sectors of the cross-country dispersion of price indices is also higher for Differentiated sectors (0.43) than for Reference-priced (0.40) and Homogeneous (0.34) sectors.[23] For any given country, there is also considerable variation in export prices across sectors. The average across countries of the cross-sector dispersion of price indices is 0.49 for Differentiated goods, 0.40 for Referenced-priced goods, and 0.35 for Homogeneous goods.[24]

4.2 Empirical Specification

Quality differences are presumably one of the main sources of cross-country variation in export prices. However, this variation might also reflect differences in prices for goods of the same quality, which might stem, for example, from differences in production costs. I postulate a reduced-form specification for the determination of the export price that includes both quality level and exporter income per capita. The inclusion of the latter variable attempts to capture cross-country variation in production costs systematically related to income. Distance of country i to the US is also included to control for selection bias in the quality composition of exports to the US. Export prices are thus determined by:

$$\ln p_{iz} = \zeta_{0z} + \zeta_{1z} \ln \theta_{iz} + \zeta_{2z} \ln y_i + \zeta_{3z} \ln Dist_i^{US} + \xi_{iz}. \tag{17}$$

The partial relationship between product quality and export price is given by ζ_{1z}. Since it is

[23] Dispersion measures are calculated taking the logarithm of the indices. Thus, their magnitude does not depend on which particular country is used to normalize.

[24] The MATLAB code used to construct the indices and the detailed tables with the export price indices sector by sector are available online: http://www.econ.lsa.umich.edu/~hallak/papers.html

more costly to produce goods of higher than of lower quality, we expect this relationship to be positive. The sign of ζ_{2z} is instead ambiguous. Once we control for product quality, differences in comparative advantage are likely to drive any systematic relationship between income and production costs (and hence export prices). The relationship can take either sign. Higher income countries often have a comparative advantage in capital-intensive sectors, as they tend to be capital abundant. In those sectors, higher income implies stronger comparative advantage, and a lower export price. We thus expect $\zeta_{2z} < 0$. For other (labor-intensive) sectors, higher income is associated with comparative disadvantage. We thus expect $\zeta_{2z} > 0$. The caveat about the inappropriateness of a sectoral understanding of comparative advantage also applies here. But it now applies more forcefully since it affects the empirical specification. Once we introduce quality differences, sectors might not be either capital or labor intensive. Within a sector, high quality varieties might be capital intensive while low quality varieties are labor intensive. More generally, we expect the relationship between income and production costs to vary according to quality. The constant parameter ζ_{2z} in (17) can only capture the sectoral average of this (quality-dependent) relationship.

The distance to the US is included in (17) to capture the Alchian-Allen conjecture. In the presence of quality differences, trade costs might not be proportional to price. In particular, if transport costs depend on weight, these costs will be lower as a fraction of price for high quality goods. The quality composition of exports will then depend on the magnitude of transport costs, which in turn depends on the distance between trading partners. Hummels and Skiba (2003) provide evidence on the empirical relevance of this conjecture. In our sample of unit values of US imports, this might induce selection bias as only high quality varieties will be exported to the US by distant countries. Hence, controlling for a country's average quality of exports to *all* countries (θ_{iz}), a larger distance to the US will imply a higher quality selection of exports to that market, and thus a higher observed price index p_{iz}. We thus expect a positive sign for ζ_{3z}.[25]

The main advantage of using export price indices, compared to the use of income in the previous section, is that their cross-sector variation is able to capture variation across sectors in quality supply. However, there is considerable measurement error in the price indices, and their reliability as price measures is yet untested. The indices will be a very noisy indicator of quality if the variance

[25] The assumption of uniform quality within country-sector in fact rules out the Alchian-Allen effect. I still include distance to the US to prevent this effect from causing selection bias in the estimation.

of the error term ξ_{iz} in (17) is large. There is then a trade-off involved in the choice between the two approaches. But we can use the results of both as complementary evidence on the role of quality.

Solving for $\ln \theta_{iz}$ in (17), we obtain:

$$\ln \theta_{iz} = -\frac{\zeta_{0z}}{\zeta_{1z}} + \frac{1}{\zeta_{1z}} \ln p_{iz} - \frac{\zeta_{2z}}{\zeta_{1z}} \ln y_i - \frac{\zeta_{3z}}{\zeta_{1z}} \ln Dist_i^{US} - \frac{\xi_{iz}}{\zeta_{1z}}. \quad (18)$$

Substituting (18) into (12) yields the estimating equation:

$$\begin{aligned} \ln imp_{iz}^k &= \varphi_{iz} + \psi_z^k - \widetilde{\sigma}_z \eta_z \ln Dist_i^k + \boldsymbol{\beta}_z \mathbf{I}_i^k + \zeta'_{1z} \ln p_{iz} \ln y^k \\ &\quad + \zeta'_{2z} \ln y_i \ln y^k + \zeta'_{3z} \ln Dist_i^{US} \ln y^k + \xi'_{iz}, \end{aligned} \quad (19)$$

where $\zeta'_{1z} = \frac{\widetilde{\sigma}_z \mu_z}{\zeta_{1z}}$, $\zeta'_{2z} = -\frac{\widetilde{\sigma}_z \mu_z \zeta_{2z}}{\zeta_{1z}}$, $\zeta'_{3z} = -\frac{\widetilde{\sigma}_z \mu_z \zeta_{3z}}{\zeta_{1z}}$, and $\xi'_{iz} = -\frac{\widetilde{\sigma}_z \mu_z}{\zeta_{1z}} \xi_{iz} \ln y^k + \widetilde{\sigma}_z \nu_i^k$.

There are three interaction terms in (19): the "price interaction" ($\ln p_{iz} \ln y^k$), the "income interaction" ($\ln y_i \ln y^k$), and the "distance (to the US) interaction" ($\ln Dist_i^{US} \ln y^k$). The parameter of interest μ_z is now included in the coefficients associated with these three terms (ζ'_{1z}, ζ'_{2z}, and ζ'_{3z}). Assuming that $\zeta_{1z} > 0$, we can still test for the sign of μ_z by testing the sign of the coefficient on the price interaction (ζ'_{1z}). If $\mu_z > 0$, then $\zeta'_{1z} > 0$. We cannot do the same with the income interaction, because the sign of ζ'_{2z} also depends on the sign of ζ_{2z}. We expect $\zeta'_{2z} > 0$ in sectors where rich countries have a comparative advantage ($\zeta_{2z} < 0$) and $\zeta'_{2z} < 0$ in sectors where they have a comparative disadvantage ($\zeta_{2z} > 0$). The sign of ζ'_{3z} is expected to be negative, but a test on the sign of this parameter implies a joint test on the signs of μ_z and ζ_{3z}.

Since ξ_{iz} is a component of p_{iz}, the disturbance ξ'_{iz} and the regressor $\ln p_{iz} \ln y^k$ are correlated in (19). I calculate $p_{iz,t-1}$ for the (merged) years 1993 and 1994, and use $\ln p_{iz,t-1} \ln y^k$ as instrument for $\ln p_{iz} \ln y^k$. To the extent that ξ_{iz} captures classical measurement error in the price index, the instrument will be uncorrelated with the disturbance term. Since measurement error is substantial, I expect the use of this instrument to remove much of the correlation between regressor and error term. However, the disturbance ξ_{iz} might also capture omitted factors affecting export prices, not included in (17). For example, country i might have a technological advantage in sector z that allows it to produce at lower cost. In that case, ξ_{iz} will be persistent over time, and instrumenting with the lagged variable will not remove the correlation between regressor and error term. Since I have no alternative instrument, this is a concern to keep in mind when interpreting the results.

4.3 Estimation results

I estimate (19) using 2SLS, sector by sector and pooling across sectors. I first focus on Differentiated goods, and impose the restrictions that $\zeta_{2z} = 0$ and $\zeta_{3z} = 0$, thus keeping only the price interaction. Under these restrictions, it is only differences in quality (plus a random disturbance) that drive differences in export prices.[26] This is primarily a benchmarking exercise to compare the performance of the price interaction with the performance of the income interaction (as used in the previous section). The first row of Table 7 shows the results. Comparing them with those of Table 1, we find that the number of positive and negative estimated coefficients is very similar. However, the estimates using exporter price are on average less precisely estimated; while in Table 1 there are only 35 sectors with non-significant coefficients, there are 54 of these sectors when price is used instead of income. The last two columns of Table 7 show the results of the pooled regression, where only the coefficient on the price interaction is constrained to be the same across sectors. The first of these columns shows the unweighted 2SLS results. The second column shows estimation results with observations weighted according to the precision of the price index. Denoting by G_{iz} the number of active 10-digit categories used in the construction of p_{iz}, I assume that the precision of p_{iz} is positively related to G_{iz}, and use weights $w = \sqrt{\ln(G_{iz})}$. In both cases, results are reported with heteroskedasticity-robust standard errors and clustering by country pair. The unweighted and weighted regressions show similar results. Both coefficient estimates are positive and statistically significant at the 5% level. Maintaining the assumption that $\zeta_1 > 0$, this implies that $\mu > 0$.

The lower precision of the sector-by-sector estimates of Table 7 compared to those of Table 1 suggests that, since export prices are correlated with income, the price interaction might be merely picking up the explanatory power of the (omitted) income interaction, itself unrelated to quality. The second specification deals with this concern by including both the price and income interactions (still imposing $\zeta_{3z} = 0$). The results are shown below in Table 7. When both price and income interactions are included, the price interaction retains considerable explanatory power. In the sectoral regressions, the sign of the price interaction is still positive in the same number of sectors, even though the number of them with significantly positive coefficient decreases substantially. The change is even stronger, however, for the estimates of the income interaction. The coefficient is less often positive, and it is positive and significant in only a few more sectors than it is negative and

[26] A previous version of this paper (Hallak 2003) implicitly imposed these restrictions.

significant. Furthermore, the coefficient on the income interaction is more affected by the inclusion of the price interaction than viceversa. This is consistent with the prediction. Once export prices are controlled for, the sign of the income interaction depends on the relationship between income and production costs, and is no longer expected to be uniformly positive.

In the pooled regression, only the coefficient on the price interaction is constrained to be the same across sectors. The coefficients on all other variables are free to take sector-specific values. In particular, the coefficient on the income interaction is allowed to vary across sectors to control for the (sector-specific) average relationship between income and production costs. In the unweighted estimation, we cannot reject the null that $\mu = 0$. This in part reflects the fact that, while the coefficient on the price interaction is positive in almost 2/3 of the sectors, it is still negative in a substantial number of them (39). But it might also reflect the fact that, in sectors where the price indices are not accurately measured, the income interaction might end up misleadingly capturing, because of its correlation with the price interaction, the quality effect that the price term is unable to capture itself. This is partly supported by the results of the last column, where both the magnitude and the significance of the coefficient increase as observations are weighted according to the precision of the price measure.

The last set of results corresponds to the full specification, where distance to the US is measured by the distance from capital cities to New York. The results here are slightly more consistent with the theoretical predictions. The coefficient on the price interaction is more often positive and significant and less often negative and significant, while the median across sectors increases. The estimates for the income interaction are unaffected, except for a decrease in the median magnitude. The coefficient on the distance interaction is weekly consistent with the Alchian-Allen prediction; it is more often negative than positive, and more often negative and significant than positive and significant. The median coefficient is also negative. In most of the sectors, however, the estimates are statistically insignificant. Since the empirical specification captures the Alchian-Allen effect only indirectly—as it is not designed for that purpose—it is not surprising that it fails to identify this effect with precision.

The pooled estimates resemble those of the previous specification. The unweighted regression yields a positive but statistically insignificant coefficient (the p-value is 0.11). But the coefficient on the price interaction is significant at the 5% level when observations are weighted according to the precision of the export price index. The difference between the unweighted and weighted results for the price interaction suggests that measurement error in the export price indices might be an important reason explaining the paucity of significantly positive coefficients in the sectoral regressions. In addition, the substantial change in the estimates for the income interaction term when the price interaction is included in the regression further support the idea that quality drives the (stronger) results of section 3. It is nevertheless appropriate here to keep in mind two strong caveats already raised. First, the estimates may be biased due to the correlation between the disturbance term and the instrument (the lagged price interaction). Second, the coefficient on the interaction term fails to capture the quality-dependent nature of the relationship between production costs and income.

Table 8 shows the results of estimating (19) using OLS and alternative measures of GDP and distance to the US. The OLS estimates are in the top panel. The sector-by-sector regressions show that the coefficient on the price interaction is less often positive and less often significant, while the coefficient on the income interaction is more often positive and more often positive and significant. The median coefficient also decreases for the price interaction and increases for the income interaction. In contrast to the sectoral results, the pooled regressions show an increase in both the magnitude and significance of the estimated coefficients for the price interaction term. The middle panel shows results using per capita GDP not adjusted for purchasing power parity. The results are not very sensitive to which measure is used. The most salient change is that the coefficient on the price interaction in the weighted pooled regression is now significant at only the 10% level (the higher variance of this alternative GDP measure explains the smaller magnitude of the estimates). Finally, the bottom panel shows results when distance to the closest US coast (Los Angeles or New York) is used as an alternative measure of distance to the US. Here, the results are almost unchanged.

Even though the baseline results in Table 7 are in general consistent with the theoretical prediction, the sign of the estimated coefficient has the opposite sign in many sectors. In 14 of these sectors, the estimates are significantly different from zero. To evaluate whether sectors with similar results have common characteristics, Graph 3 groups the 114 sectors into 11 broader categories. For each of these groups, the upper bar summarizes the results for the coefficient on the price interaction and the lower bar for the coefficient on the income interaction. The part of the bar to the right (left) of the vertical center line counts the number of sectors with positive (negative) coefficients. Darker colors represent significant coefficients. The results are systematic for some of these groups. For example, the sign of the coefficient on the price interaction is positive, as predicted, in all 17 sectors in the group "Textiles, Apparel, and Footwear". It is positive and significant in 14 of these sectors. In "Chemicals", the coefficient is positive in 6 out of 7 sectors, and positive and significant in 3. In contrast, the coefficient tends to be negative in the groups "Household Appliances and Electronics" (5 out of 6), "Electrical Machinery and Apparatus" (6 out of 7), and "Professional and Scientific Equipment" (5 out of 7). There is no single convincing explanation for the observed pattern of results. Since prices are measured with considerable error, if in the latter sectors most of the cross-country variation of export prices is due to quality differences and not to differences in production costs, then the information conveyed by cross-country variation in export prices not already contained in the variation of income may consist of mere noise. In that case, the income interaction might end up capturing most of the quality effect. Although in principle appealing, this explanation presumes—without evidence supporting it—that export prices reflect mostly quality instead of costs in these sectors. In addition, it fails to explain why the estimated coefficient is significantly negative in some sectors. The coefficient on the income interaction tends to be negative, as predicted, in groups such as "Food and Beverages" and "Textiles, Apparel, and Footwear", where it is plausible that lower income countries have a comparative advantage. It tends to be positive in groups such "Agricultural and Industrial Machinery" and "Electrical Machinery and Apparatus", where we expect higher income countries to have a comparative advantage.

Table 9 shows the results of estimating (19) for Reference-priced and Homogeneous sectors (the top panel replicates results for Differentiated sectors shown in Table 7). For Referenced-price sectors, the distribution of the estimated coefficient on the price interaction in terms of sign and significance is similar to the case of Differentiated sectors. The coefficient is positive in 2/3 of the sectors (35) and positive and significant in 1/3 (14). However, the median magnitude of the estimated coefficient almost doubles the median for Differentiated goods. This result is confirmed by the pooled regression estimates; the coefficient is positive and significant at the 1% level in both the unweighted and weighted regressions. The coefficient on the income interaction term is now more often negative than positive and the median magnitude is negative. This is consistent with the theoretical prediction if higher income is a source of comparative disadvantage in a higher proportion of Reference-priced sectors than of Differentiated sectors. Finally, the distance interaction gives stronger support to the Alchian-Allen conjecture. In sum, the results for Reference-priced sectors are consistent with the main theoretical prediction. But the theory would also predict weaker rather than stronger results than those for Differentiated sectors.

As in the previous section, the estimates are very different for Homogeneous goods. Both the coefficient on the price interaction and on the income interaction are in more sectors negative than positive. They are almost never significant. The distance term is negative in most sectors, but it is also not significant. In all three cases, the median coefficient is negative.

5 Conclusions and Further Comments

A substantial amount of theoretical work predicts that product quality plays an important role as a determinant of the direction of trade. This paper provides evidence supporting the empirical relevance of this prediction. A key aspect of the paper is its strategy for identifying unobserved cross-country differences in product quality. Exporter income per capita is first used as a proxy, yielding results that are consistent with the theoretical prediction in a majority of Differentiated-good sectors: rich countries tend to import relatively more from countries that produce high quality goods. These results can be interpreted as a sector-level confirmation of the Linder hypothesis. Furthermore, the inability of typical specifications using aggregate data to control for inter-sectoral determinants of comparative advantage explains the failure so far to find empirical support for this hypothesis.

Concerns about forces other than quality driving the results are addressed in two ways. First, still using income as proxy for quality, the estimation is performed on Referenced-priced sectors, where the theory can reasonably be expected to apply, and on Homogeneous sectors, where the theory should not apply. The results are strongly consistent with the predictions. Second, export price indices are used as indicators of quality. The results here are weaker, but they are still consistent with the predictions. An overall assessment of the evidence presented in the paper provides a compelling case for quality as a significant factor explaining global patterns of bilateral trade.

Further research will hopefully improve many aspects of the theoretical framework and empirical strategy used here. First, an advantage of the proposed demand system is its simplicity for capturing income effects on quality choice. However, it could be extended to allow for more flexible substitution patterns, in particular, closer substitutability between goods of similar quality. This possibility is ruled out here, which might explain why, in several sectors, the results contradict the theoretical prediction. Second, as suggested by the theoretical work on trade with vertical differentiation, it is not merely the mean but the entire distribution of income that matters as a determinant of international trade. Third, the accuracy and reliability of the export price indices used in this study is yet untested. Since unit values are likely to be the best, although indirect, available source of information on cross-country differences in quality levels covering a broad range of goods, further research focused on these indices seems necessary and promising.

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A Appendix: Methodology of construction of export price indices

A representative 2-digit *sector* z includes 10-digit *categories* $n = 1, ..., N$. Dividing the value by the quantity of imports in each of these categories, we obtain the unit value (average export price) p_{in} for country i in category n. Based on 10-digit-level prices p_{in}, I will construct multilateral price indices p_{iz} at the 2-digit level. Country i is "active" in category n if p_{in} is non-missing. Country i is active in sector z if it has at least two active categories. Otherwise, p_{iz} takes a missing value.

There is considerable measurement error in the source database. I use the following procedure to detect and remove outliers. For each category n, I calculate the geometric mean of unit values across countries, excluding the observations with maximum and minimum values. I then remove observations with unit values 4 times above or below the mean. Since observations with extreme unit values show disproportionately low export quantities, I remove observations with quantity below the minimum of 50 units or a quarter of the average quantity for the category.

I then take country j as a numeraire. For each other country i, I calculate the bilateral Fisher price index P_i^j between i and j, using only their common active categories (P_i^j takes a missing value if i and j do not have any common active category). As a result, I obtain a vector of bilateral price indices P^j, with country j as the numeraire. I repeat this procedure taking alternatively all countries as numeraire, and obtain vectors P^j, $j = 1, ..., C$, where C is the number of active countries in the sector. These vectors are separated into three groups. The first group contains vectors $j = 1, ..., C_1$, those with non-missing values. The second group contains vectors $j = C_1 + 1, ..., C_2$, with at most 5 missing values. The third group contains the remaining vectors $j = C_2 + 1, ...C$.

I then follow a three step procedure. I take the first group and normalize each vector to sum up to 1. Denote normalized vectors by $\widetilde{P}^j$. The geometric weighted average of these vectors is:

$$P_z^1 = \prod_{j=1}^{C} \left(\widetilde{P}^j\right)^{w^j}, \tag{20}$$

where w^j is the number of active categories of country j in sector z. In the second step, I take each vector P^j in the second group and normalize it to sum up to $1 - m^j$, where m^j is the sum of the entries in P_z^1 corresponding to the the missing elements in P^j. I then impute the values in P_z^1 to the missing elements in P^j, thus obtaining a normalized (to 1) vector $\widetilde{P}^j$. Using normalized vectors $\widetilde{P}^j, j = 1, ...C_2$, I recalculate (20) and obtain P_z^2. In the third step, I repeat the procedure for the remaining vectors. I finally calculate $p_z = \prod_{j=1}^{C} \left(\widetilde{P}^j\right)^{w^j}$, where each element is $p_{iz.}$

Table 1: Basic Results
OLS - Differentiated goods (114 Sectors)

	Regressions by Sector						Pooled Regression
	Sign		Significance (5%)				
	Pos.	Neg.	Pos.	Not Sig.	Neg.	Median	Coefficient
$\ln(y_i)*\ln(y_k)$	78	36	56	35	23	0.1218	0.0782*** (0.0230)
$\ln(\text{Distance}_{ik})$	0	114	0	0	114	-1.0451	
Border_{ik}	103	11	41	73	0	0.3260	
$\text{Common Language}_{ik}$	112	2	95	19	0	0.5366	
PTA_{ik}	95	19	61	51	2	0.3755	
$\text{Colonial Link}_{ik}$	110	4	89	25	0	0.8288	
$\text{Common Colony}_{ik}$	88	26	20	92	2	0.3351	

Notes: Heteroskedasticity-robust standard errors in all regressions. Clustering by country pair across sectors in pooled regression. Columns 2 and 3 provide a breakdown of the total number of sectors by sign of the estimated coefficient. Columns 4 to 6 provide a breakdown by sign and significance.

* Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level

Table 2: All Sectors
OLS - Coefficient on interaction term

	Regressions by Sector						Pooled Regression
	Sign		Significance (5%)				
	Pos.	Neg.	Pos.	Not Sig.	Neg.	Median	Coefficient
Differentiated Goods							
$\ln(y_i)*\ln(y_k)$	78	36	56	35	23	0.1218	0.0782***
							(0.0230)
Reference Priced Goods							
$\ln(y_i)*\ln(y_k)$	33	18	17	28	6	0.0776	0.0723***
							(0.0252)
Homogenous Goods							
$\ln(y_i)*\ln(y_k)$	18	20	3	29	6	-0.0498	-0.0453
							(0.0295)

Notes: Heteroskedasticity-robust standard errors in all regressions. Clustering by country pair across sectors in pooled regression. Columns 2 and 3 provide a breakdown of the total number of sectors by sign of the estimated coefficient. Columns 4 to 6 provide a breakdown by sign and significance.

* Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level

Table 3: Fixed Exporting Costs
MLE – Coefficient on interaction term

	Regressions by Sector					
	Sign		Significance (5%)			
	Pos.	Neg.	Pos.	Not Sig.	Neg.	Median
Differentiated Goods						
$\ln(y_i)*\ln(y_k)$	72	42	52	36	26	0.0797
Reference Priced Goods						
$\ln(y_i)*\ln(y_k)$	36	15	24	22	5	0.0661
Homogenous Goods						
$\ln(y_i)*\ln(y_k)$	12	26	3	24	11	-0.0372

Notes: Heteroskedasticity-robust standard errors in all regressions. Columns 2 and 3 provide a breakdown of the total number of sectors by sign of the estimated coefficient. Columns 4 to 6 provide a breakdown by sign and significance.

Table 4: Sectoral data: Alternative Linder Terms
OLS – Coefficient on Linder term (signs reversed)

	Regressions by Sector						Pooled Regression
	Sign		Significance (5%)				
	Pos.	Neg.	Pos.	Not Sig.	Neg.	Median	Coefficient
Differentiated Goods							
$\ln(y_i)*\ln(y_k)$	78	36	56	35	23	0.1218	0.0782***
							(0.0230)
$-\lvert y_i-y_k\rvert$	79	35	55	41	18	0.0118	0.0090***
							(0.0025)
$-\ln(\lvert y_i-y_k\rvert)$	77	37	51	44	19	0.0504	0.0343***
							(0.0129)
$-\lvert\ln(y_i)-\ln(y_k)\rvert$	78	36	58	36	20	0.1530	0.1033***
							(0.0273)
Reference Priced Goods							
$\ln(y_i)*\ln(y_k)$	33	18	17	28	6	0.0776	0.0723***
							(0.0252)
$-\lvert y_i-y_k\rvert$	32	19	16	28	7	0.0072	0.0070**
							(0.0028)
$-\ln(\lvert y_i-y_k\rvert)$	33	18	14	33	4	0.0327	0.0307**
							(0.0143)
$-\lvert\ln(y_i)-\ln(y_k)\rvert$	32	19	16	29	6	0.0968	0.0826***
							(0.0302)
Homogenous Goods							
$\ln(y_i)*\ln(y_k)$	18	20	3	29	6	-0.0498	-0.0453
							(0.0295)
$-\lvert y_i-y_k\rvert$	15	23	5	26	7	-0.0079	-0.0067**
							(0.0034)
$-\ln(\lvert y_i-y_k\rvert)$	18	20	5	29	4	-0.0097	-0.0152
							(0.0182)
$-\lvert\ln(y_i)-\ln(y_k)\rvert$	17	21	4	27	7	-0.0860	-0.0712**
							(0.0357)

Notes: Heteroskedasticity-robust standard errors in all regressions. Clustering by country pair across sectors in pooled regression. Columns 2 and 3 provide a breakdown of the total number of sectors by sign of the estimated coefficient. Columns 4 to 6 provide a breakdown by sign and significance.

* Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level

Table 5: The Aggregation Bias
An artificial example

Exporter	Importer: Machinery Sweden (S)	Machinery Domin. Rep. (DR)	Machinery Total Exports	Apparel Sweden (S)	Apparel Domin. Rep. (DR)	Apparel Total Exports	Total Sweden (S)	Total Domin. Rep. (DR)	Total Total Exports
UK	150	300	450	150	50	200	300	350	650
Lebanon (L)	50	150	200	300	150	450	350	300	650
Total Imports	200	450	650	450	200	650	650	650	1300
Ratio UK/L	3	2		0.5	0.33		0.86	1.17	
Ratio of Ratios $(UK/L)^{S}/(UK/L)^{DR}$	1.5			1.5			0.73		

Table 6: Aggregate data - Failure of Standard Test of the Linder Hypothesis
OLS - Coefficient on Linder term (signs reversed)

	Linder Term			
	$\ln(y_i)*\ln(y_k)$	$-\lvert y_i-y_k\rvert$	$-\ln\lvert y_i-y_k\rvert$	$-\lvert\ln(y_i)-\ln(y_k)\rvert$
Differentiated Goods	-.1812***	-0.0203***	-0.0893***	-0.1953***
	(0.0321)	(0.0035)	(0.0197)	(0.0386)
Reference Priced Goods	-0.0267	-0.0045	-0.0206	-0.0254
	(0.0384)	(0.0041)	(0.0210)	(0.0453)
Homogenous Goods	0.0726	0.0062	0.0110	0.0690
	(0.0489)	(0.0054)	(0.0271)	(0.0560)
Total (All Sectors in Sample)	-0.0447	-0.0068**	-0.0378**	-0.0574*
	(0.0298)	(0.0034)	(0.0175)	(0.0349)
Total (All Sectors)	-0.0371	-0.0082**	-0.0286	-0.0406
	(0.0311)	(0.0034)	(0.0176)	(0.0358)

Notes: Heteroskedasticity-robust standard errors in all regressions. The coefficients and standard errors in the third column are multiplied by 1,000.

* Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level

Table 7: Price as Indicator of Quality
IV - Differentiated goods

	Regressions by Sector						Pooled Regression	
	Sign		Significance (5%)					
	Pos.	Neg.	Pos.	Not Sig.	Neg.	Median	Coefficient (unweighted)	Coefficient (weighted)
Price Only								
$\ln(P_i)*\ln(y_k)$	75	39	44	54	16	0.1880	0.1056** (0.0441)	0.1016** (0.0462)
Price and Income								
$\ln(P_i)*\ln(y_k)$	75	39	33	66	15	0.1858	0.0648 (0.0541)	0.0981* (0.0579)
$\ln(y_i)*\ln(y_k)$	66	48	35	51	28	0.1016		
Price, Income, and Distance to US								
$\ln(P_i)*\ln(y_k)$	75	39	36	64	14	0.1923	0.0877 (0.0553)	0.1304** (0.0596)
$\ln(y_i)*\ln(y_k)$	66	48	35	51	28	0.0823		
$\ln(Dist_i^{US})*\ln(y_k)$	53	61	11	87	16	-0.0181		

Notes: The lagged export price index (93-94) is used as instrument for the current index (95-96). Heteroskedasticity-robust standard errors in all regressions. Clustering by country pair across sectors in pooled regression. Columns 2 and 3 provide a breakdown of the total number of sectors by sign of the estimated coefficient. Columns 4 to 6 provide a breakdown by sign and significance.

* Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level

Table 8: Robustness
IV - Differentiated goods

	Regressions by Sector						Pooled Regression	
	Sign		Significance (5%)					
	Pos.	Neg.	Pos.	Not Sig.	Neg.	Median	Coefficient (unweighted)	Coefficient (weighted)
<u>OLS</u>								
Price, Income, and Distance to US								
$\ln(P_i)*\ln(y_k)$	69	45	34	68	12	0.1582	0.0958** (0.0393)	0.1405*** (0.0455)
$\ln(y_i)*\ln(y_k)$	69	45	47	39	28	0.1113		
$\ln(Dist_i^{US})*\ln(y_k)$	57	57	14	84	16	0.0006		
<u>GDP – no PPP adjustment</u>								
Price, Income, and Distance to US								
$\ln(P_i)*\ln(y_k)$	73	41	36	64	14	0.1322	0.0472 (0.0351)	0.0720* (0.0382)
$\ln(y_i)*\ln(y_k)$	66	48	34	52	28	0.0228		
$\ln(Dist_i^{US})*\ln(y_k)$	54	60	11	87	16	-0.0125		
<u>Distance to closest US coast</u>								
Price, Income, and Distance to US								
$\ln(P_i)*\ln(y_k)$	75	39	36	65	13	0.1894	0.0891 (0.0554)	0.1315** (0.0597)
$\ln(y_i)*\ln(y_k)$	66	48	35	52	27	0.0803		
$\ln(Dist_i^{US})*\ln(y_k)$	54	60	13	85	16	-0.0086		

Notes: The lagged export price index (93-94) is used as instrument for the current index (95-96). Heteroskedasticity-robust standard errors in all regressions. Clustering by country pair across sectors in pooled regression. Columns 2 and 3 provide a breakdown of the total number of sectors by sign of the estimated coefficient. Columns 4 to 6 provide a breakdown by sign and significance.

* Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level

Table 9: All sectors
IV Estimation

	Regressions by Sector						Pooled Regression	
	Sign		Significance (5%)					
	Pos.	Neg.	Pos.	Not Sig.	Neg.	Median	Coefficient (unweighted)	Coefficient (weighted)
<u>Differentiated Goods</u>								
Price, Income, and Distance to US								
$\ln(P_i)*\ln(y_k)$	75	39	36	64	14	0.1923	0.0877 (0.0553)	0.1304** (0.0596)
$\ln(y_i)*\ln(y_k)$	66	48	35	51	28	0.0823		
$\ln(Dist_i^{US})* \ln(y_k)$	53	61	11	87	16	-0.0181		
<u>Reference Priced Goods</u>								
Price, Income, and Distance to US								
$\ln(P_i)*\ln(y_k)$	35	16	14	33	4	0.3608	0.3066*** (0.0679)	0.3868*** (0.0771)
$\ln(y_i)*\ln(y_k)$	23	28	9	32	10	-0.0291		
$\ln(Dist_i^{US})* \ln(y_k)$	19	32	5	35	11	-0.0436		
<u>Homogeneous Goods</u>								
Price, Income, and Distance to US								
$\ln(P_i)*\ln(y_k)$	17	21	0	37	1	-0.1355	-0.0839 (0.1494)	-0.0709 (0.1519)
$\ln(y_i)*\ln(y_k)$	12	26	0	36	2	-0.1369		
$\ln(Dist_i^{US})* \ln(y_k)$	10	28	1	35	2	-0.1186		

Notes: The lagged export price index (93-94) is used as instrument for the current index (95-96). Heteroskedasticity-robust standard errors in all regressions. Clustering by country pair across sectors in pooled regression. Columns 2 and 3 provide a breakdown of the total number of sectors by sign of the estimated coefficient. Columns 4 to 6 provide a breakdown by sign and significance.

* Significant at the 10% level
** Significant at the 5% level
*** Significant at the 1% level

Table A1
Geometric Mean of Sectoral Price Indices

Country	GDP per Capita (PPP)	Differentiated Goods	Reference Priced Goods	Homogenous Goods
Switzerland	25,475	1.64	1.79	1.00
Norway	24,693	1.46	1.47	1.23
Japan	23,211	1.48	1.92	1.31
Canada	23,085	1.00	1.00	1.00
Denmark	22,947	1.51	1.48	1.58
Belgium-Lux.	22,700	1.45	1.41	0.97
Singapore	22,270	1.09	1.26	1.17
Hong Kong	22,166	0.79	1.28	1.06
Austria	22,089	1.43	1.71	1.16
Germany	21,478	1.46	1.49	1.14
Australia	21,267	1.29	1.36	1.00
Netherlands	20,812	1.41	1.39	1.20
Italy	20,512	1.33	1.41	1.25
France	20,492	1.54	1.64	1.42
Sweden	20,030	1.46	1.56	1.49
United Kingdom	19,465	1.39	1.47	1.25
Finland	18,764	1.60	1.39	1.24
New Zealand	17,705	1.30	1.39	0.95
Israel	17,394	1.33	1.57	1.27
Ireland	17,264	1.46	1.76	1.13
Spain	15,163	1.29	1.21	0.93
Portugal	13,613	1.20	1.24	1.12
South Korea	13,502	0.91	1.25	1.28
Taiwan	13,335	0.81	1.38	1.20
Greece	13,147	1.10	1.20	1.13
Saudi Arabia	10,766	1.12	1.27	1.13
Argentina	10,736	1.02	1.10	1.00
South Africa	8,581	1.11	1.19	1.02
Malaysia	8,145	0.94	1.14	1.04
Uruguay	7,831	1.04	0.79	1.02
Chile	7,544	1.00	0.98	1.19
Mexico	7,061	0.74	0.95	1.02
Poland	6,605	0.86	1.11	1.09
Brazil	6,572	0.89	1.07	1.07
Romania	6,430	0.81	0.72	1.02
Thailand	6,217	0.79	1.15	0.96
Colombia	6,151	0.87	1.04	1.11
Venezuela	5,979	0.73	0.89	0.82
Costa Rica	5,940	0.97	1.18	0.92
Turkey	5,803	0.93	1.33	0.98
Bulgaria	5,608	0.91	0.86	0.79
Tunisia	4,870	1.02	1.36	1.36
Paraguay	4,598	0.83	0.48	0.83
Peru	4,329	1.02	1.06	0.98
Dominican Rep.	3,997	0.87	0.93	0.89
Lebanon	3,964	0.94	1.13	1.13
Philippines	3,518	0.89	1.06	0.92
Guatemala	3,444	0.87	0.98	0.90
Syria	3,211	1.06	1.40	0.93
Ecuador	3,162	0.89	1.02	0.89
Morocco	3,052	0.94	1.34	2.37*
Indonesia	2,869	0.80	1.01	0.88
Egypt	2,869	1.05	0.88	0.68
Sri Lanka	2,741	0.70	1.06	1.11
China	2,560	0.63	1.02	1.06
India	1,877	0.82	0.97	0.87
Pakistan	1,733	0.82	0.70	0.81
Vietnam	1,478	0.70	1.02	0.65
Bangladesh	1,253	0.76	1.34	0.58
Nigeria	832	0.81	0.97	0.73
Average correlation b/w sectoral index and GDP Per Capita		0.45	0.36	0.23

Note: The bottom row gives the average across sectors of the correlation between PPP GDP per capita and the price index.
* Morocco has price indices for only two sectors.

Table A2. List of 3-digit SITC sectors included Differentiated sample (some 4-digit sectors may be excluded)

Sector	*Description*	*Sector*	*Description*
34	Fish,fresh (live or dead),chilled or frozen	727	Food processing machines and parts
48	Cereal prepar. & preps. Of flour of fruits or veg.	728	Mach.& Equipment specialized for particular ind.
56	Vegetab.,roots & tubers,prepared/preserved,n.e.s.	736	Mach.tools for working metal or met.carb., Parts
73	Chocolate & other food preptns. Containing cocoa	741	Heating & cooling equipment and parts
98	Edible products and preparations n.e.s.	742	Pumps for liquids.liq.elevators and parts
111	Non alcoholic beverages,n.e.s.	743	Pumps & compressors,fans & blowers,centrifuges
248	Wood,simply worked,and railway sleepers of wood	744	Mechanical handling equip.and parts
431	Animal & vegetable oils and fats,processed & waxes	745	Other non-electrical mach.tools,apparatus & parts
533	Pigments,paints,varnishes & related materials	749	Non-electric parts and accessories of machines
541	Medicinal and pharmaceutical products	751	Office machines
551	Essential oils,perfume and flavour materials	752	Automatic data processing machines & units thereof
553	Perfumery,cosmetics and toilet preparations	759	Parts of and accessories suitable for 751--or 752-
554	Soap,cleansing and polishing preparations	761	Television receivers
591	Disinfectants,insecticides,fungicidesweed killers	762	Radio-broadcast receivers
598	Miscellaneous chemical products,n.e.s.	764	Telecommunications equipment and parts
611	Leather	771	Electric power machinery and parts thereof
612	Manufactures of leather/of composition leather nes	772	Elect.app.such as switches,relays,fuses,pwgs etc.
621	Materials of rubber(e.g.,pastes.plates,sheets,etc)	773	Equipment for distributing electricity
625	Rubber tyres,tyre cases,etc.for wheels	774	Electric apparatus for medical purposes,(radiolog)
628	Articles of rubber,n.e.s.	775	Household type,elect.& Non-electrical equipment
635	Wood manufactures,n.e.s.	776	Thermionic,cold & photo-cathode valves,tubes,parts
642	Paper and paperboard,cut to size or shape	778	Electrical machinery and apparatus,n.e.s.
651	Textile yarn	781	Passenger motor cars,for transport of pass.& Good
652	Cotton fabrics,woven	782	Motor vehicles for transport of goods/materials
653	Fabrics,woven,of man-made fibres	783	Road motor vehicles,n.e.s.
654	Textil.fabrics,woven,oth.than cotton/man-made fibr	784	Parts & accessories of 722-,781--,782-,783-
655	Knitted or crocheted fabrics	785	Motorcycles,motor scooters,invalid carriages
656	Tulle,lace,embroidery,ribbons,& other small wares	786	Trailers & other vehicles,not motorized
657	Special textile fabrics and related products	791	Railway vehicles & associated equipment
658	Made-up articles,wholly/chiefly of text.materials	792	Aircraft & associated equipment and parts
659	Floor coverings,etc.	793	Ships,boats and floating structures
661	Lime,cement,and fabricated construction materials	812	Sanitary,plumbing,heating,lighting fixtures
662	Clay construct.materials & refractory constr.mate	821	Furniture and parts thereof
663	Mineral manufactures,n.e.s	831	Travel goods,handbags,brief-cases,purses,sheaths
665	Glassware	842	Outer garments,mens,of textile fabrics
666	Pottery	843	Outer garments,womens,of textile fabrics
667	Pearls,precious& semi-prec.stones,unwork./worked	844	Under garments of textile fabrics
673	Iron and steel bars,rods,angles.shapes & sections	845	Outer garments and other articles,knitted
678	Tubes,pipes and fittings,of iron or steel	846	Under garments,knitted or crocheted
679	Iron & steel castings,forgings & stampings;rough	847	Clothing accessories of textile fabrics
691	Structures& parts of struc.;iron,steel,aluminium	848	Art.of apparel & clothing accessories,no textile
692	Metal containers for storage and transport	851	Footwear
694	Nails,screws,nuts,bolts etc.of iron.steel,copper	871	Optical instruments and apparatus
695	Tools for use in hand or in machines	872	Medical instruments and appliances
696	Cutlery	874	Measuring,checking,analysing instruments
697	Household equipment of base metal,n.e.s.	881	Photographic apparatus and equipment,n.e.s.
699	Manufactures of base metal,n.e.s.	882	Photographic & cinematographic supplies
711	Steam & other vapour generating boilers & parts	884	Optical goods,n.e.s.
713	Internal combustion piston engines& parts	885	Watches and clocks
714	Engines & motors,non-electric	892	Printed matter
716	Rotating electric plant and parts	893	Articles of materials described in division 58
721	Agricultural machinery and parts	894	Baby carriages,toys,games and sporting goods
722	Tractors fitted or not with power take-offs, etc.	895	Office and stationery supplies,n.e.s.
723	Civil engineering & contractors plant and parts	896	Art,collectors pieces & antiques
724	Textile & leather machinery and parts	897	Jewellery,goldsmiths and other art. Of precious m.
725	Paper & pulp mill mach.,mach for manuf.of paper	898	Musical instruments,parts and accessories
726	Printing & bookbinding mach.and parts	899	Other miscellaneous manufactured articles

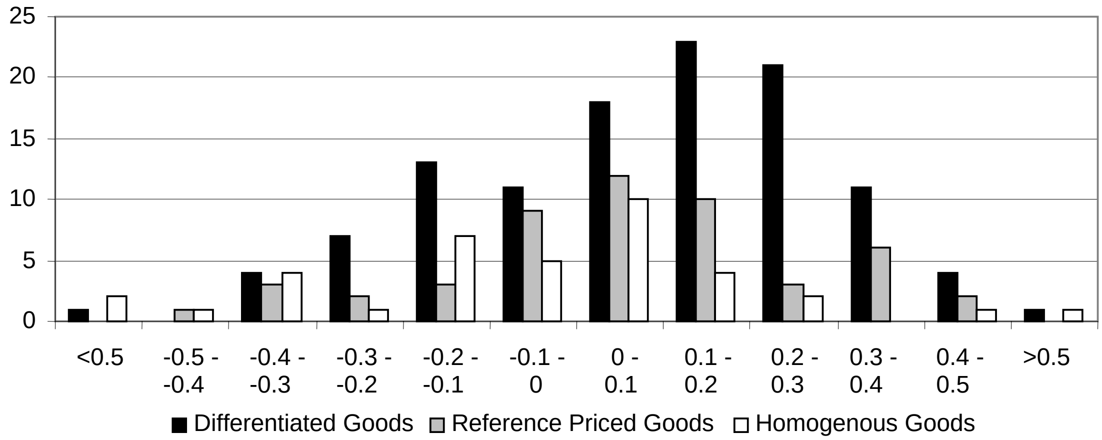
Table A3. List of 3-digit SITC sectors included in Reference-priced sample (some 4-digit sectors may be excluded)

Sector	*Description*	*Sector*	*Description*
11	Meat, edible meat offals, fresh, chilled or frozen	524	Radio-active and associated materials
14	Meat& edib. offals, prepjpres., fish extracts	533	Pigments, paints, varnishes & related materials
34	Fish, fresh (live or dead),chilled or frozen	541	Medicinal and pharmaceutical products
36	Crustaceans and molluscs, fresh, chilled, frozen etc	562	Fertilizers, manufactured
37	Fish, crustaceans and molluscs, prepar. or preserv.	582	Condensation, polycondensation & polyaddition prod
54	Vegetab.,fresh, chilled, frozen/pres.; roots, tubers	583	Polymerization and copolymerization products
57	Fruit & nuts (not includ. oil nuts),fresh or dried	592	Starches, inulin &wheat gluten; albuminoidal subst.
58	Fruit, preserved, and fruit preparations	634	Veneers, plywood, improved or reconstituted wood
62	Sugar confectionery and other sugar preparations	641	Paper and paperboard
81	Feed.stuff for animals(not incl.unmilled cereals)	642	Paper and paperboard, cut to size or shape
112	Alcoholic beverages	651	Textile yarn
122	Tobacco manufactured	652	Cotton fabrics, woven
233	Synth.rubb.lat.; synth. rubb.& reclaimed; waste scrap	653	Fabrics, woven, of man-made fibres
266	Synthetic fibres suitable for spinning	661	Lime, cement, and fabricated construction materials
278	Other crude minerals	662	Clay construct .materials & refractory constr. mate
334	Petroleum products, refined	671	Pig iron, spiegeleisen, sponge iron, iron or steel
335	Residual petroleum products, nes.& relat. materials	672	Ingots and other primary forms, of iron or steel
341	Gas, natural and manufactured	673	Iron and steel bars, rods, angles. shapes & sections
511	Hydrocarbons nes, & their halogen.& etc.derivatives	674	Universals, plates and sheets, of iron or steel
512	Alcohols, phenols, phenol-alcohols,& their derivat.	677	Iron/steel wire/wheth/not coated, but not insulated
513	Carboxylic acids,& their anhydrides, halides, etc.	678	Tubes, pipes and fittings, of iron or steel
514	Nitrogen	682	Copper
515	Organo-inorganic and heterocyclic compounds	684	Aluminum
516	Other organic chemicals	699	Manufactures of base metal, n.e.s.
522	Inorganic chemical elements, oxides & halogen salts	778	Electrical machinery and apparatus, n.e.s.
523	Other inorganic chemicals		

Table A4. List of 3-digit SITC sectors included in Homogeneous sample (some 4-digit sectors may be excluded)

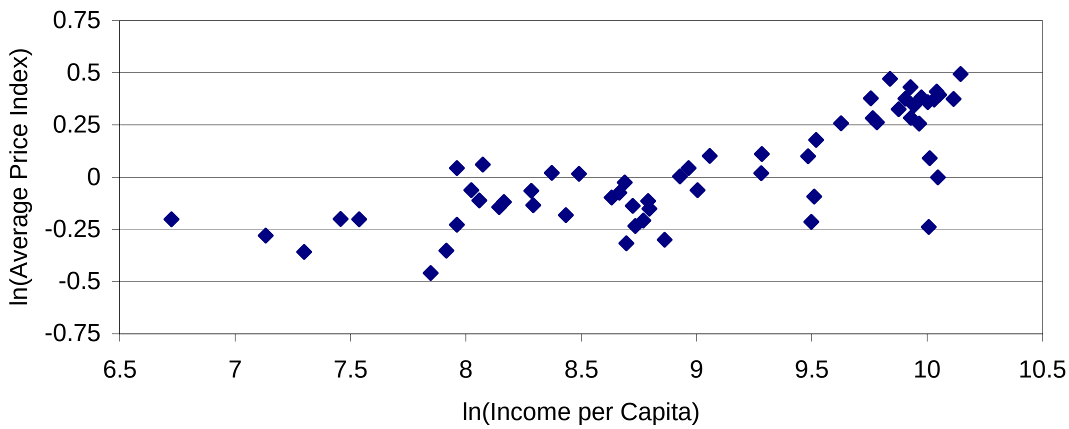
Sector	*Description*	*Sector*	*Description*
11	Meat, edible meat offals, fresh, chilled or frozen	268	Wool and other animal hair (excluding wool tops)
22	Milk and cream	281	Iron ore and concentrates
23	Butter	282	Waste and scrap metal of iron or steel
24	Cheese and curd	287	Ores and concentrates of base metals, n.e.s.
41	Wheat (including spelt) and meslin, unmilled	288	Non-ferrous base metal waste and scrap, n.e.s.
42	Rice	333	Petrol.oils & crude oils obt.from bitumin. minerals
43	Barley, unmilled	334	Petroleum products, refined
44	Maize (corn), unmilled	423	Fixed vegetable oils, soft, crude, refined/purified
54	Vegetab., fresh, chilled, frozen/pres.; roots, tubers	424	Other fixed vegetable oils, fluid or solid, crude
57	Fruit & nuts (not includ. oil nuts),fresh or dried	522	Inorganic chemical elements, oxides & halogen salts
58	Fruit, preserved, and fruit preparations	634	Veneers, plywood, improved or reconstituted wood
61	Sugar and honey	651	Textile yarn
71	Coffee and coffee substitutes	667	Pearls, precious & semi-prec.stones,unwork./worked
121	Tobacco, unmanufactured; tobacco refuse	681	Silver, platinum & oth. metals of the platinum group
222	Oil seeds and oleaginous fruit, whole or broken	682	Copper
232	Natural rubber latex; nat.rubber & sim.nat.gums	684	Aluminum
247	Other wood in the rough or roughly squared	686	Zinc
251	Pulp and waste paper	689	Miscell. non-ferrous base metals employ.in metallgy
263	Cotton	971	Structures& parts of struc.; iron, steel, aluminum

Graph 1:
Histogram of OLS Estimates of Interaction Term Coefficient

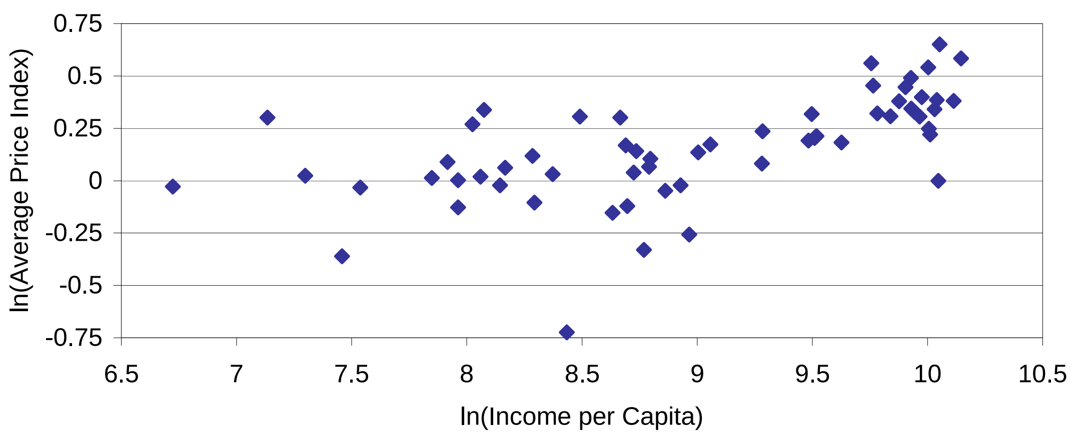


Graphs 2a-2c:
Relationship Between Average Price Indices and Income per Capita

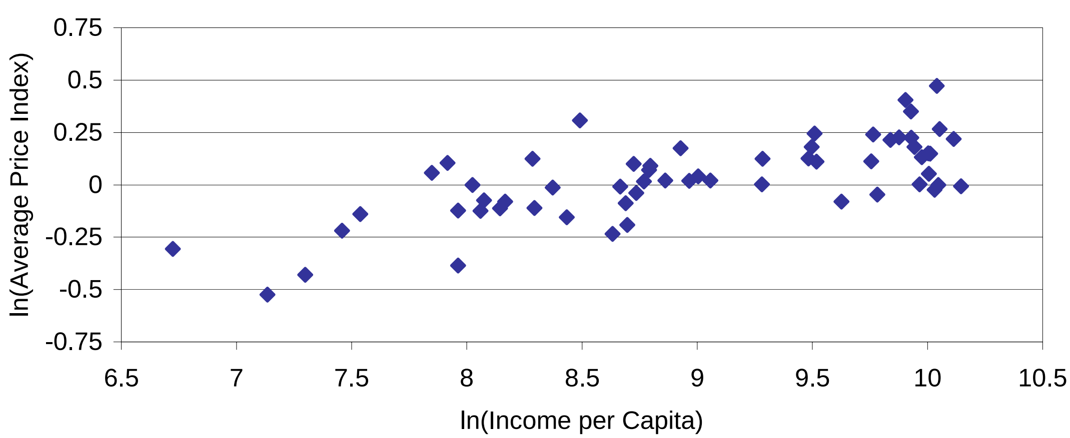
Differentiated Goods



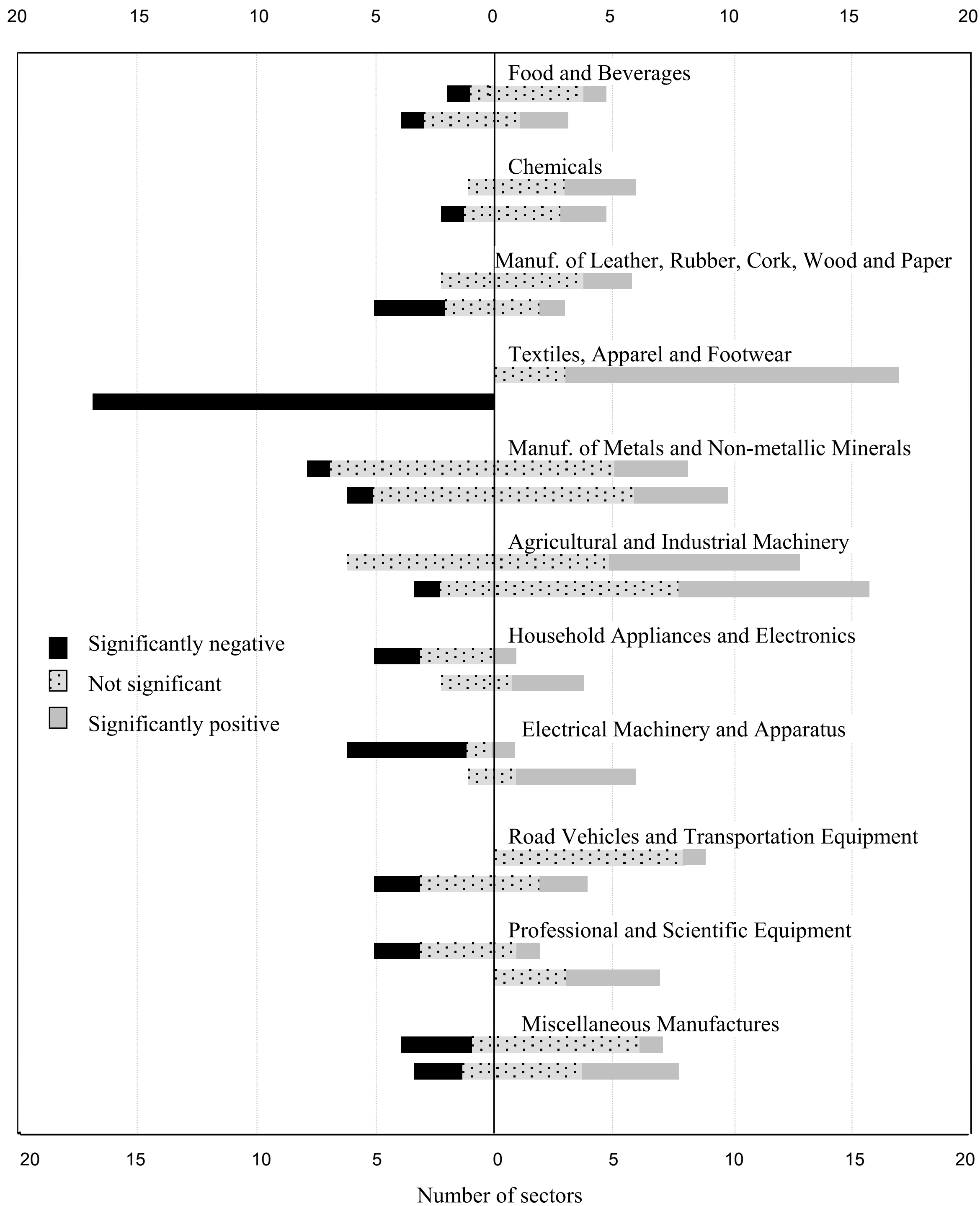
Reference Priced Goods



Homogenous Goods



Graph 3:
Distribution of Coefficients by Group



Note: The upper and lower bars in each group show the distribution of the coefficients on the price and income interactions by size and significance levels, respectively.