Quality Differentiation in Trade: Theory and Evidence

Ana Cecília Fieler†

Department of Economics, University of Pennsylvania

December 2012

Abstract

I develop a Ricardian model of trade with non-homothetic preferences, a continuum of vertically-differentiated goods and an arbitrary number of countries. I find conditions under which unit prices increase with exporter and importer income per capita and rich countries demand relatively more goods from other rich countries. I analyze the effects of several types of technical progress. For example, global technical progress in the form of quality upgrading benefits all consumers, but it does not change relative wages, relative prices or trade flows. Hence, it cannot be observed in the data. I use data on bilateral trade of approximately 160 countries in 13 years (1995 to 2007) to document systematic patterns within product categories. A 10% increase in income per capita is associated with a 1.6% increase in export prices and a 0.6% increase in import prices. I calibrate the model to match key moments of the data.

* I am grateful to Jonathan Eaton for his guidance and support. I also thank George Alessandria, Flavio Cunha, Juan Carlos Hallak, Peter Schott Kyungchul Song.
† Department of Economics, University of Pennsylvania, McNeil Building, 3718 Locust Walk, Philadelphia, PA, 19104, afieler@econ.upenn.edu
Evidence that goods are vertically differentiated within finely defined product categories in trade now abounds. First, unit prices increase systematically with importer and exporter income per capita, suggesting that rich countries produce and consume goods of higher quality. Second, the volume of trade within categories increases with the similarity between importer and exporter income per capita.\footnote{See Choi et al. (2009), Hallak (2006), Hummels and Klenow (2005), Schott (2004) for unit prices, and Hallak (2010) for the Linder hypothesis.} This pattern is generally interpreted as evidence of vertical differentiation because of Linder’s (1961) canonical explanation for it: Firms in any country produce goods suited for the domestic market and sell them in other countries with similar demand patterns. Since demand for quality-differentiated goods is mostly determined by income, trade should be more intensive among countries with similar income levels.

These empirical regularities are important because if rich and poor countries demand, supply and trade different types of goods, shocks to the global economy affect their patterns of specialization and welfare differently. I develop a general equilibrium Ricardian model of trade that delivers systematic patterns of trade within industries. Specifically, I extend the model of trade in vertically-differentiated goods of Flam and Helpman (1987) to several countries and a continuum of goods, in the spirit of Dornbusch, Fischer and Samuelson (1977), Eaton and Kortum (2002) and Wilson (1980). Goods are differentiated by quality. Consumers buy zero or one unit of each good and choose its quality level. Markets are perfectly competitive, labor is the only factor of production, and its efficiency varies across countries, goods and quality levels. With this extension, I study conditions under which unit prices increase in importer and exporter per capita income, conditions which can only be established in a multi-country model. I also analyze technology shocks that are not easily characterized by existing models and show how the model can be taken structurally to data.

The conditions guaranteeing that unit prices increase in exporter income per capita are weak: If a country has an absolute advantage over another in producing a certain good, then that advantage must hold for all quality levels and it must increase with quality. Similar conditions are satisfied by a wide range of models.\footnote{For example, see Flam and Helpman (1987), Kremer (1993) and Stokey (1991).} On the demand side, preferences are non-homothetic, and within a country, rich consumers always demand goods of higher quality and prices than
poor consumers do. Yet, the conditions guaranteeing that prices increase in importer income per capita are very restrictive. First, trade costs from all exporters must be the same across destinations. Otherwise, variations in unit prices arise because of the location of importers, not because of their income per capita—an importer may demand high-quality versions of a good because its location makes all low-quality versions expensive. Second, to compare prices within the same exporter across different importers, there must be no income inequality within countries. Otherwise, an exporter may sell high-quality goods to rich consumers in poor countries, and low-quality to poor consumers in rich countries. Similarly restrictive conditions guarantee that rich countries import relatively more goods from other rich countries.

I study two types of technology shocks. First, a decrease in the labor requirement to produce all quality levels of a certain good and country expands the range of quality levels that the country produces. As a result, countries that used to sell goods in that range loose market share. As countries move away from that range, the price and quality of their exports become more polarized—rich countries increase the quality of their exports, and poor countries decrease it.

Second, I consider global technological improvements that take the form of decreases in the labor requirement to produce some goods. Under some symmetry assumptions (section 1.6), these improvements do not change equilibrium relative wages, prices and volumes of trade flows, but it increases the quality level of goods consumed. So, an econometrician who observes wages, prices and quantity of trade flows would not observe the technological improvements unless he observed quality directly. If these global technology shocks occur repeatedly, cycles of production, demand and trade arise. Typically, production and demand of the highest-quality good first appears in rich countries and shifts to less and less developed countries over time as new higher-quality goods emerge. This pattern is similar to Vernon (1966), but there cycles occurred to industries, while here they occur to quality levels within industries. And because relative wages and trade flows within industries remain constant throughout the cycle, an econometrician would observe it only if he directly observed measures of quality.

I use data on bilateral trade of approximately 160 countries and 13 years (1995 to 2007) to test the predictions of the theory. I revisit the data despite previous work establishing these
regularities for two reasons. First, I extend previous findings to a larger data set. The evidence above mentioned is either from a single country (the United States) or from several countries and one year. Second, I tailor the empirical specification to theory. For example, some studies compare export prices by aggregating across importers, but a relation with exporter income per capita arises only within importers in theory. Comparisons between import and export prices are also difficult because previous papers all focus on either one or the other. I report patterns symmetrically and, in line with the theory, variations in unit prices with exporter income per capita are larger and more robust than with importer income per capita: Pooling the data, a 10% increase in income per capita is associated with a 1.4% increase in export price and 0.6% increase in import price. Analyzing product categories separately, unit prices increase with exporter income per capita in 86% of categories and with importer income per capita in 67%.

Using a functional form example, I calibrate the model to match quantitatively some key moments of the data, relating unit prices to importer and exporter income per capita, and the average income per capita of exporters to a destination’s income per capita. I also analyze numerically the general equilibrium effects of a technology shock in a large country. A technology shock in a rich country shifts its demand away from low-quality goods, thereby decreasing poor countries’ terms of trade. A technology shock in a poor country, in turn, may shift its production toward high-quality goods, thereby decreasing rich countries’ terms of trade. So, a shock in rich countries may hurt poor countries and vice-versa. The model then justifies the fears that news stories of China competing in markets of high-quality goods arise in rich countries and the fears of poor countries of being left behind as the world economy grows.

Overall, the paper generalizes and puts together previous theoretical results and complements them with novel findings. The characterization of product cycles here is akin to Grossman and Helpman (1991, ch 12), where in a steady state relative wages, quantities and values of trade flows do not change. I extend their result to several countries and goods—accentuating its empirical implications—and to include demand patterns, while leaving out endogenous growth. Previous models of trade in vertically-differentiated goods with non-homothetic preferences, such as Fajgelbaum et al. (2009), Flam and Helpman (1987) and Stokey (1991), also feature rich countries importing and exporting goods of higher quality and price, but these papers
have only one differentiated good and often only two countries.\footnote{Fajgelbaum et al. (2009) extend their model to several countries and characterize trade flows only under restrictive assumptions on countries’ relative income distributions. Their objective is different—to study the home-market effect in quality-differentiated goods. Other models of trade and non-homothetic preferences include Bergstrand (1990), Fieler (2011), Markusen (1986) and Matsuyama (2000). None of these have vertical differentiation.} My generalization allows for a characterization of an empirical specification and its underlying assumptions.

The empirical section relates to papers that use data to infer the quality content of trade flows. The model delivers a one-to-one relation between quality and prices within a country and product, and I take unit prices as proxies for quality in the data. While this approach is common, it has been criticized and alternative measures of quality have been proposed. Typically, these measures combine data on prices with data on quantities, trade deficits, firm characteristics or import restrictions.\footnote{Hallak and Schott (2010) use trade deficits; Khandelwal (2010), quantities; Kugler and Verhoogen (2009, 2010), Manova and Zhang (2010) and Verhoogen (2008), firm-level data, and Aw and Roberts (1986), Boorstein and Feenstra (1987) and Feenstra (1988), quotas. See also Johnson (2010) who infers the role of quality in selection of firms across destinations using trade data.} They have the advantage of allowing for horizontal product differentiation and the disadvantage of ruling out non-homothetic preferences. Section 1 presents the model and theoretical results. The empirical analysis is in section 2. Section ?? studies an example with specific functional forms, and section 3 concludes.

1 Theory

The economy has $N$ countries and a set of goods $\Omega = [0, 1]$. Each good $\omega \in \Omega$ is differentiated by quality levels $q \in \mathbb{R}_+$. In the empirical section, a good $\omega$ is interpreted as a product category, potentially differentiated by quality levels. I refer to a specific quality-good pair $(q, \omega)$ as a variety. I describe endowments in section 1.1, technologies in section 1.2, preferences in section 1.3 and define an equilibrium in section 1.4. Section 1.5 presents an example with specific functional forms, and section 1.6 presents the theoretical results.

1.1 Endowments

Labor is the unique factor of production. It is mobile across sectors and immobile across countries. The population of country $n$ is $L_n$. Labor endowments are distributed according to...
the cumulative distribution function \( F_n \), with a continuous density \( f_n \) over a compact support \( E_n \subset \mathbb{R}_+ \), and with mean equal to one so that wage equals income per capita.\(^5\) We allow for inequalities within countries in order to compare unit prices of different exporters selling the same good to the same importer. Without income inequalities, each country would buy a good from only one exporter because each consumer demands only one quality level of each good and buys only from the lowest cost exporter.

1.2 Technologies

Technologies differ across goods, quality levels and countries. The cost of producing good \( \omega \) of quality \( q \) in country \( i \) is \( w_i a_i(q, \omega) \), where \( w_i \) is the wage rate and \( a_i(q, \omega) \) is the labor requirement. Trade costs are of the iceberg type: Delivering the good to country \( n \) costs \( p_{ni}(q, \omega) = d_{ni} w_i a_i(q, \omega) \). Assume \( d_{ii} = 1 \) and \( d_{ni} \leq d_{nk}d_{ki} \) for all \( n, i, k \). I refer to \( w_{ni} = d_{ni} w_i \) as country \( i \)'s effective wages in country \( n \). With perfect competition, the price of variety \((q, \omega)\) in country \( n \) is

\[
p_n(q, \omega) = \min\{p_{ni}(q, \omega) : i = 1, ..., N\}
\]

I refer to the following assumptions on \( a_i \):

**Assumption 1**

(i) \( a_i(q, \omega) \) is twice continuously differentiable.

(ii) \( a_i(0, \omega) = 0 \) for all \( i \) and \( \omega \).

(iii) \( \frac{\delta}{\delta q} a_i(q, \omega) > 0 \) and \( \frac{\delta^2}{\delta q^2} a_i(q, \omega) > 0 \) for all \( i, q \) and \( \omega \).

**Assumption 2** Whenever \( a_i(q, \omega) < a_j(q, \omega) \) for some \( i, j, q \) and \( \omega \), then

(i) \( a_i(q', \omega) < a_j(q', \omega) \) for all \( q' > 0 \),

(ii) \( \frac{a_i(q, \omega)}{a_j(q, \omega)} \) is strictly decreasing in \( q \).

Assumption 1 helps with the existence of equilibria. Part (ii) is not necessary, but it is a useful simplification. Assumption 2 states that whenever country \( i \) has an absolute advantage in producing good \( \omega \) of quality \( q \) over country \( j \), then it has an absolute advantage in producing

---

\(^5\)The assumption on the mean is only needed for linking theory to data.
all quality levels of good $\omega$ (part (i)), and the difference in efficiency between the two countries widens with quality (part (ii)).

A wide range of previous models satisfy assumption 2.\(^6\) It implies that, whenever more than one country produces the same good $\omega$ to the same destination $n$, the country with the highest effective wage $w_{ni}$ sells the highest quality level. Figure 1 illustrates this point. There are two countries, North ($N$) and South ($S$), and no trade costs. Wages are $w_S = 1$ and $w_N > 1$. Each graph depicts labor requirement and unit cost curves as a function of quality for the two countries in a good $\omega$. In graph (a), the South has an absolute advantage in all quality levels. Since it has the lowest wages, it is also the lowest cost producer. In graph (b), the North has an absolute advantage in producing all quality levels, but the difference between North and South labor requirements is small for low-quality levels. As a result, producing low-quality varieties is cheaper in the South, and high-quality ones, in the North.

1.2.1 Examples

Examples of functional forms for $a_i(q, \omega)$ that satisfy assumptions 1 and 2 are:

(i) \[ a_i(q, \omega) = (q + 1)^{1/z_i(\omega)} - 1 \quad \text{where } z_i(\omega) \in (0, 1) \]

(ii) \[ a_i(q, \omega) = \exp(q/z_i(\omega)) - 1 \quad \text{where } z_i(\omega) > 0. \]

(iii) \[ a_i(q, \omega) = q^\beta_1 + q^\beta_2 / z_i(\omega) \quad \text{where } \beta_2 > \beta_1 \geq 1 \text{ and } z_i(\omega) > 0 \]

(iv) \[ a_i(q, \omega) = qc(\omega) + q^2 / z_i(\omega) \quad \text{where } c(\omega) > 0 \text{ and } z_i(\omega) > 0 \]

In all cases, parameter $z_i(\omega)$ governs absolute advantage—labor requirement $a_i$ decreases with $z_i(\omega)$. The cases differ on how comparative advantage changes with quality. For any two countries 1 and 2 with $z_1 > z_2$ ($\omega$ is omitted), $\lim_{q \to 0} \frac{a_1(q)}{a_2(q)} = \frac{z_2}{z_1}$ and $\lim_{q \to \infty} \frac{a_1(q)}{a_2(q)} = 0$ in cases (i) and (ii). Country 1 is more efficient than country 2 in producing arbitrarily low-quality levels, and this difference grows unboundedly with quality. The lowest-cost provider of low-quality goods in country $n$ is the country with lowest value for $w_{ni}/z_i$, and of high-quality goods in country $n$ is the country with highest value for $w_{ni}/z_i$.  

\(^6\)For example, see Flam and Helpman (1987) and Stokey (1991), and Kremer (1993) if goods with more tasks in his formulation are associated with higher quality. It is also akin to Fiefer (2011) where goods consumed more intensively in rich countries present more heterogeneous technologies.
goods is the country with the highest parameter $z_i$. In cases (iii) and (iv), $\lim_{q \to a} \frac{a_1(q)}{a_2(q)} = 1$ and $\lim_{q \to \infty} \frac{a_1(q)}{a_2(q)} = \frac{z_2}{z_1}$. Countries have similar technologies for producing low-quality goods, differences in efficiency increase with quality, but they are always bounded. The lowest-cost provider of low-quality goods is the country with the lowest effective wage $w_{ni}$, and of high-quality goods is the country with lowest $w_{ni}/z_i$. The cases also differ in the extensive margin of consumer demand (below). Section ?? calibrates the model to case (iv).

1.3 Demand

All consumers in the world have identical non-homothetic preferences. They buy zero or one unit of each good $\omega$ and choose quality level $q(\omega)$ to maximize utility. Let $x(\omega) = 1$ if the consumer buys good $\omega$ and $x(\omega) = 0$ otherwise. A consumer in country $n$ with labor endowment $e$ (income $ew_n$) chooses $\{x(\omega), q(\omega)\}_{\omega \in \Omega}$ to solve

\[
\max \int_{\omega \in \Omega} q(\omega)x(\omega)d\omega
\]

subject to $\int_{\omega \in \Omega} p_n(q(\omega), \omega)x(\omega)d\omega \leq ew_n$.

The two key assumptions are that utility is additively separable across goods and that consumers buy zero or one unit of each good. The latter is a common assumption in models of trade and non-homothetic preferences.\(^7\) Linearity is not important—since quality is an ordinal property, we can always re-scale it to make utility concave and adjust cost functions accordingly.

As the consumer’s income increases, she increases the quality level and possibly the range of goods consumed. Figure 2 illustrates consumer choice. Each of the three convex curves is the cost curve $p_n(q, \omega)$ of a producing country $i$—the higher the curve, the higher the effective wage, $w_{ni}$. The price schedule $p_n(q, \omega)$ is the lower envelope of these cost curves, but the consumer only chooses quality levels in the convex hull.\(^8\) She chooses the point where the convex hull has slope $1/\lambda_n$, where $\lambda_n$ is the Lagrange multiplier of problem (1). The richer is the consumer, the lower is the multiplier, and the higher is the quality chosen. If the slope of $p_n(q, \omega)$ at zero is

\(^7\)See, for example, Flam and Helpman (1987), Matsuyama (2000), Stokey (1991).

\(^8\)See lemma 2 in the appendix A.1.
greater than $1/\lambda_n$, the consumer does not buy the good.

The examples of section 1.2.1 imply different patterns of trade because they differ in the lowest-cost providers of low- and high-quality goods (as shown above) and in the extensive margin of demand. In cases (i) and (ii), \( \frac{\delta p_n(0, \omega)}{\delta q} = \min \left\{ \frac{w_{ni}}{z_i(\omega)} \right\} \). If parameters \( z \) vary sufficiently across goods, rich consumers demand a wider range of goods \( \omega \) than poor consumers do. In case (iii), \( \frac{\delta p_n(0, \omega)}{\delta q} = 0 \) for all \( z \), and all consumers demand all goods. In case (iv), \( \frac{\delta p_n(0, \omega)}{\delta q} = c(\omega) \min_i \{ w_{ni} \} \).

If \( c(\omega) \) varies sufficiently across goods, then rich consumers demand a wider range of goods than poor consumers do, and if \( c(\omega) \) is constant, all consumers demand all goods.

### 1.4 Equilibrium

Let \( \{ x_n(\omega, e), q_n(\omega, e) \} \in \Omega \) be an allocation for a consumer with endowment \( e \) in country \( n \), and \( \Omega_{ni}(e) \subset \Omega \) be the set of goods she demands from country \( i \), \( \bigcap_{i=1}^{N} \Omega_{ni}(e) = \emptyset \). The value of country \( n \)’s imports from country \( i \) (if the integrals exist) is

\[
X_{ni} = L_n \int_{E_n} \int_{\Omega_{ni}(e)} p_{ni}(q_n(\omega, e), \omega) d\omega dF_n(e). \tag{2}
\]

**Definition 1** An equilibrium is a set of wages \( w \), allocations \( \{ x_n(\omega, e), q_n(\omega, e) \} \in \Omega \) and subsets \( \Omega_{ni}(e) \) that satisfy:

(i) \( \{ x_n(\omega, e), q_n(\omega, e) \} \in \Omega \) solves the consumer’s problem (1) for all \( e \in E_n \) and all \( n \).

(ii) For all \( e \in E_n \) and \( \omega \in \Omega_{ni}(e) \), \( p_{ni}(q_n(\omega, e), \omega) \leq p_{nk}(q_n(\omega, e), \omega) \) for \( k = 1, \ldots, N \).

(iii) The labor market clears: \( w_i L_i = \sum_{n=1}^{N} X_{ni} \) for all \( i = 1, \ldots, N \).

### 1.5 An Example

I explore the properties of the model with specific functional forms that will be used to estimate the model in section 2.3 and to analyze welfare in section 2.4. All derivations are in appendix ??.

Preferences and equilibrium are defined as above. Assume labor endowments of all individuals in all countries are equal to one, and let

\[
a_i(q, \omega) = q \left( c + \frac{q}{z_i(\omega)} \right)
\]
where \( c \geq 0 \) and \( z_i(\omega) > 0 \) is a country- and good-specific productivity parameter. Parameter \( c \) governs how comparative advantage changes with quality levels. Consider a good \( \omega \) and any two countries 1 and 2 with \( z_1(\omega) < z_2(\omega) \). If \( c = 0 \), the ratio of labor requirements is
\[
\frac{a_1(q,\omega)}{a_2(q,\omega)} = \frac{z_2(\omega)}{z_1(\omega)},
\]
constant in quality \( q \). If \( c > 0 \), as \( q \) increases from zero to infinity, the ratio of labor requirements increases from one to \( \frac{z_2(\omega)}{z_1(\omega)} \). As in assumption 2, technologies to produce low-quality goods are similar across countries, and to produce high-quality goods, more dispersed.

I follow Eaton and Kortum (2002) and assume \( z_i(\omega) \) is distributed according to a Fréchet distribution: The measure of goods in country \( i \) with \( z_i(\omega) \leq z \) is
\[
F_i(z) = \exp \left( -T_i z^{-\theta} \right),
\]
where \( \theta > 1 \) is common across countries and \( T_i \) is country-specific. The role of parameters \( \theta \) and \( T_i \) is well-known: An increase in \( \theta \) decreases the variance of the distribution, and an increase in \( T_i \) increases the measure of high, efficient parameters \( z_i(\omega) \).

Country \( n \) imports goods from country \( i \) only if \( \lambda_n \leq c w_{ni} \), where \( \lambda_n \) is the representative consumer’s Lagrange multiplier. Let \( N_{ni} \) be the number of goods that country \( n \) imports from country \( i \) and \( X_{ni} \) (as before) be the value of country \( n \)'s imports from country \( i \). Then, whenever \((N_{ni}, N_{nk}) \gg 0\),
\[
\frac{N_{ni}}{N_{nk}} = \frac{T_i(w_{ni})^{-\theta}}{T_k(w_{nk})^{-\theta}} \left[ 1 - \frac{\lambda_n c w_{ni}}{1 - \lambda_n c w_{nk}} \right]^{2\theta}, \tag{3}
\]
\[
\frac{X_{ni}}{X_{nk}} = \frac{T_i(w_{ni})^{-\theta}}{T_k(w_{nk})^{-\theta}} \left[ 1 + \frac{\lambda_n c w_{ni}}{1 + \lambda_n c w_{nk}} \left( 1 - \frac{\lambda_n c w_{ni}}{1 - \lambda_n c w_{nk}} \right)^{2\theta-1} \right]. \tag{4}
\]
If \( c = 0 \), trade shares are
\[
\frac{N_{ni}}{N_{nk}} = \frac{X_{ni}}{X_{nk}} = \frac{T_i(w_{ni})^{-\theta}}{T_k(w_{nk})^{-\theta}}. \tag{9}
\]
They do not depend on importer per capita income, because relative labor requirements \( \frac{a_i(q,\omega)}{a_k(q,\omega)} \) are constant in quality. If \( c > 0 \) and \( w_{ni} > w_{nk} \), then the terms in square brackets in equations (3) and (4) are strictly smaller than one. All countries demand relatively more goods from countries with low wages \((w_{nk})\), because

\(^9\)This is the expression for trade flows in Eaton and Kortum (2002), which they show delivers the gravity equation. See Fieler (2011) for a discussion on its empirical implications.
technologies are more similar across countries when \( c > 0 \) than when \( c = 0 \). But the similarity in technologies decreases with quality, and as \( q \) tends to infinity, technologies become as dispersed as when \( c = 0 \). Accordingly, the terms in brackets increase with consumer income and they tend to one as income tends to infinity (\( \lambda_n \) tends to zero). So, as country \( n \) gets richer, it demands relatively more goods from rich country \( i \) than from poor country \( k \).

The ratio of the average price of country \( n \)’s imports from country \( i \) and from country \( k \) is

\[
\frac{\bar{p}_{ni}}{\bar{p}_{nk}} = \left( \frac{1 + \lambda_n cw_{ni}}{1 - \lambda_n cw_{ni}} \right) \left( \frac{1 - \lambda_n cw_{nk}}{1 + \lambda_n cw_{nk}} \right) > 1.
\]

Within the same importer, the average price of rich countries’ exports is higher than poor countries’ exports. Average import prices are trivially increasing in income per capita—since all consumers are demand all goods and goods are of measure one, the average unit price in a consumer’s basket is his income \( w_n \).

1.6 Theoretical Results

The appendix A.2 establishes the existence of an equilibrium that is not necessarily unique.\(^\text{10}\) Uniqueness does not hold in general for models of trade and non-homothetic preferences because proofs of uniqueness generally require the demand for a country’s labor to decrease with its wages. With non-homothetic preferences, however, an increase in a rich country’s wages makes its consumers richer and may increase the demand for goods with high income elasticity (high-quality here). If the country has a comparative advantage in producing these goods, the demand for its own labor may increase and multiple equilibria may arise.\(^\text{11}\)

The propositions below hold for any equilibrium. Propositions 1, 2 and 3 describe its properties—propositions 1 and 2 refer to unit prices, and proposition 3, to the volume of trade.

\(^{10}\)The difficulty in proving existence is that demand functions for any individual good is discontinuous in income. The proof consists of showing that, when integrating over goods, demand for each country’s labor is continuous and tends to infinity as its wage tends to zero.

\(^{11}\)Multiple equilibria, I conjecture, are more likely to arise in economies with few countries. With a rich enough set of countries, consumers of a high-income country whose wages increase may shift their demand toward higher-quality goods, but they will likely shift it to goods from other high-income countries, whose wages and costs have not increased.
Propositions 4 and 5 refer to technology shocks. Proofs are in appendix.\textsuperscript{12}

**Proposition 1** Under assumptions 1 and 2, if country $n$ imports good $\omega$ from countries $i$ and $k$, then the price of all varieties good $\omega$ exported from country $i$ to country $n$ is higher than those exported from country $k$ to country $n$ if $w_{ni} > w_{nk}$.

**Proposition 2** Assumption 1 holds and countries $n$ and $k$ have identical import costs, i.e., $d_{ni} = d_{ki}$ for all $i = 1,...N$.

(i) All individuals in countries $n$ and $k$ are endowed with one unit of labor and $w_n > w_k$. Then, whenever countries $n$ and $k$ demand the same good $\omega$ from country $i$, country $n$ imports a variety of higher quality and price.

(ii) The distribution of income ($w_n e$) in country $n$ first-order stochastically dominates that of country $k$. Then, for any good $\omega$ with $x_k(\omega,e) = 1$ for all $e \in E_k$, the distribution of prices of the varieties demanded by country $n$ stochastically first order dominates that of country $k$.

Proposition 1 states that among different exporters selling to the same importer, exporters with higher effective wages $w_{ni}$ sell at higher unit prices (see explanation in section 1.2 above). The conditions in proposition 2 guaranteeing that unit prices increase in importer per capita income are much more restrictive. For one, trade costs must be equal across destinations. Comparing exporters within a destination is possible because the price of all varieties is kept constant, but comparing importers generally involves changes in relative prices due to trade costs. Demand for quality will then not be monotonic in income if, for example, a low-income country demands high-quality versions of a good because its location makes low-quality versions expensive.

Furthermore, to compare prices across importers within a given exporter, proposition 1(i) assumes away income inequality within destinations. Otherwise, the result would be violated if an exporter sold low-quality goods to poor consumers in a rich country and high-quality goods to rich consumers in a poor country. Part (ii) allows for income inequality, but the statement is on the whole distribution of prices. Testing it empirically requires data on domestic prices, which

\textsuperscript{12}I assume throughout that labor requirement functions $a_i(q,\omega)$ vary sufficiently across goods and countries so that, for any $w \in \mathbb{R}_+^N$, the set of goods for which any consumer is indifferent between two or more quality levels has zero measure. See appendix A.1 for a discussion. Wilson (1980) similarly assumes that the set of goods for which two countries have the same price is negligible.
are not available in trade data.\textsuperscript{13} Income inequality does not affect export prices in proposition 2 because labor is homogeneous and thus inequalities within countries do not affect supply.\textsuperscript{14}

**Proposition 3** Assumptions 1 and 2 hold. Countries \( n \) and \( k \) have identical import costs, \( d_{ni} = d_{ki} \) for all \( i = 1, \ldots, N \), and the distribution of income \( w_n \) in country \( n \) first order stochastically dominates that of country \( k \). Then, for any good \( \omega \) with \( x_k(\omega, e) = 1 \) for all \( e \in E_k \), country \( n \) imports varieties from countries with higher effective wages on average than country \( k \)—i.e.,

\[
\int_{E_n} \sum_{i=1}^{N} w_{ni} 1 \{ \omega \in \Omega_{ni}(e) \} dF_n(e) \geq \int_{E_k} \sum_{i=1}^{N} w_{ki} 1 \{ \omega \in \Omega_{ni}(e) \} dF_k(e).
\]

Rich importers demand relatively more goods from rich exporters. This result is reminiscent of the Linder hypothesis, but here it is not the similarity of income per capita between importer and exporter that matters—it is the ranking of income per capita. For example, if a group of poor countries have a comparative advantage in producing a certain good, rich countries still buy the good from the richer countries among poor producers. As in Hallak (2010), patterns arise within goods, not necessarily on the overall volume of trade.\textsuperscript{15}

I now consider technology shocks in the form of downward shifts in the labor requirement curves. The positive effects of a technology shock affecting all goods in a country are implicit in propositions 1–3: Since wages typically increase in the country, the quality and price of its production and demand increase, and its relative demand for goods from rich countries increases.\textsuperscript{16} Its welfare effects are analyzed through numerical simulations in section ?? below.

**Proposition 4** considers a technology shock in a particular good and country. Since goods are of zero measure, the shock does not change relative wages. Proposition 4 admits shifts in labor

\textsuperscript{13}Choi et al. (2009) and Fajgelbaum et al. (2010) also assume that there are no trade costs to compare import prices. Choi et al. (2009) test their model with trade data even though a proper test also requires data on domestic prices.

\textsuperscript{14}Inequalities affect specialization in Grossman and Maggi (2000) and Vogel and Costinot (2009) where workers of different skill levels are imperfect substitutes.

\textsuperscript{15}The relation arises in the aggregate here only if all consumers demand one unit of all goods. The model lacks the home-market effect on which Linder built his theory. To my knowledge, the only paper with this effect is Fajgelbaum et al. (2010).

\textsuperscript{16}A technology shock may decrease a country’s wages for reasons akin to the multiplicity of equilibria problem discussed above. A poor country may become more efficient at producing low-quality goods, and because these goods have a low income elasticity of demand, the demand for its labor may decrease and its wages decrease to compensate. Bhagwati (1958) formalizes this phenomenon of inmiserizing growth.
requirement curves of any shape. Proposition 5 makes specific assumptions on these shifts and considers the general equilibrium effect of a technology shock in all countries and goods.

**Proposition 4** If assumptions 1 and 2 hold, then an increase in the labor efficiency of country \( i \) in all quality levels of good \( \omega \) has the following effects on the market for good \( \omega \):

(i) The quantity of country \( i \)'s exports to all countries increases.

(ii) The value, quantity and range of quality levels that country \( k \neq i \) exports to all countries decrease.

(iii) If \( d_{ni}w_i < d_{nk}w_k \), then the average unit price of country \( k \)'s exports to country \( n \) increases, and if \( d_{ni}w_i > d_{nk}w_k \), the average unit price decreases.

Proposition 4 is illustrated in figure 3. The cost of delivering good \( \omega \) from country \( i \in \{1, 3\} \) to country \( n \) is \( p_{ni}(q, \omega) \). The cost from country 2 is initially \( p^0_{n2}(q, \omega) \) and it decreases to \( p^1_{n2}(q, \omega) \).

The initial convex hull of \( p_n(q, \omega) \), where consumers’ choices are observed, is in black and bold, and the final convex hull is in red and extra-bold. The shock expands the set of goods that country 2 potentially produces and shrinks the set of countries 1 and 3. The richer country 3 is pushed toward specializing in higher-quality goods and country 1, in lower-quality.

More broadly, as its costs decrease, country \( i \) dominates the market of a range of quality levels. Countries that previously sold goods in that range lose the most market share, and the price of other exporters becomes more polarized around country \( i \)'s price. I looked for these two effects in the data but did not find them, which is perhaps not surprising given that there are only 13 years of data and technology shocks are not readily observable.\(^{17}\)

**Definition 2** Two global economies, 1 and 2 (superscripts), have the same set of countries, population \( L \), trade costs \( d \) and endowment distributions \( F \). Economy 2 is a **global reduction in costs** with respect to economy 1 if there exists a set of non-negative numbers \( \varepsilon(\omega) \geq 0 \) such

\(^{17}\)These predictions are akin to Bloom et al. (2011) whose findings suggest that European firms upgrade product quality to escape competition from Chinese low-quality goods. Details of the empirical exercises on proposition 4 are available upon request.
that for all $i$ and $\omega$,

\[
\begin{align*}
    a_i^2(q, \omega) &= a_i^1(q - \varepsilon(\omega), \omega) & \text{if } q \geq \varepsilon(\omega) \\
    a_i^2(q, \omega) &= a_i^1(0, \omega) & \text{otherwise}.
\end{align*}
\]

**Proposition 5** Let economy 2 be a global reduction in costs with respect to economy 1, and let $w^1, \Omega^1_{n_i}(e), x^1_n(\omega, e)$ and $q^1_n(\omega, e)$ be an equilibrium of economy 1 where $(x^1_n(\omega, e), q^1_n(\omega, e)) \gg 0$ for all $e \in E_n$ and all $n$, $\omega$. Then $w^1, \Omega^1_{n_i}(e), x^1_n(\omega, e)$ and $q^2_n(\omega, e) = q^1_n(\omega, e) + \varepsilon(\omega)$ is an equilibrium of economy 2. Moreover, prices satisfy $p^1_n(q^1_n(\omega, e), \omega) = p^2_n(q^2_n(\omega, e), \omega)$, and equilibrium utility in economy 2 is $\int_{\Omega} \varepsilon(\omega)d\omega$ larger than in economy 1.

A global reduction in costs is a shift in the labor requirement curves of all countries by $-\varepsilon(\omega)$ along the quality dimension.\(^{18}\) Because utility is linear, consumers’ problems do not change. So, relative wages, prices and trade flows do not change, even though the quality level of goods consumed increases. All consumers benefit from the shock, but an econometrician who sees only wages, prices and trade flows cannot observe it.

Cycles of demand, supply and trade arise in the model if growth is mechanically introduced as a series of global reductions in costs—i.e., as shifts in the labor requirement curves along the quality dimension with the same speed across countries and possibly different speeds across goods. These cycles have patterns similar to Vernon (1966), but in Vernon cycles occur to industries (goods $\omega$), while here they occur to varieties $(q, \omega)$ within goods $\omega$. By assumption 2, the lower is the quality of a variety, the more similar are the technologies to produce it across countries. Hence, successive global decreases in costs imply that technologies to produce a specific variety $(q, \omega)$ become more similar over time—a high-quality variety $(q, \omega)$ will have tomorrow the same technology as the lower-quality variety $(q - \varepsilon(\omega), \omega)$ has today. Wages are then important determinants of the costs of older varieties, whose technologies are similar across countries. Country-specific technologies mostly determine the cost of newer varieties. So, typically, when a high-quality good first appears in the economy, it is produced and demanded

\(^{18}\)The second line of the definition is just a technicality to define $a_i^2$ for quality levels $(q - \varepsilon) < 0$. It’s only needed because quality is bounded from below. The proposition is easily generalized to $\varepsilon(\omega) \in \mathbb{R}$ by applying it twice, once for the set of goods with $\varepsilon(\omega) \geq 0$ and once for $\varepsilon(\omega) \leq 0$. 

14
by rich countries. Over time, as technologies become standardized across countries, production
shifts to middle-income and eventually to poor countries.\textsuperscript{19}

Gagnon and Rose (1995) find no evidence of Vernon’s product cycles across product cat-
egories in trade data. For most categories, countries remained either net exporters or net
importers over all 29 years of their data. But the strong evidence for specialization within cat-
egories (e.g., Schott (2004)) suggests that cycles may occur to quality levels within categories.
Proposition 5 states that these cycles are not observable without direct measures of quality.\textsuperscript{20}

\section{Empirical Analysis}

I use trade data to test propositions 1 through 3 above. Section 2.1 describes the data, and
section 2.2 presents the approach and results.

\subsection{The Data}

I use data on bilateral trade flows from 1995 through 2007 collected by the United Nations, and
compiled and cleaned by Gaulier and Zignago (2009).\textsuperscript{21} The data are categorized into six-digit
Harmonized System (HS) classification codes. Data on income and income per capita are from
the World Bank (2010), and data on distance between countries’ most populated cities are from
Mayer and Zignago (2006).\textsuperscript{22}

The screening of the data is as follows: (i) I discard observations with missing quantity or
with quantity equal to one. (ii) I discard observations of less than US$25,000, because small
transactions are more prone to measurement errors. (iii) I keep only observations where the GDP

\textsuperscript{19}Under assumption 2, proposition 1 implies that, if several countries produce the same good $\omega$ to the
same destination, production of a variety $(q, \omega)$ must start with the richest producer and move toward
the poorest following a strict ordering of effective wages $w_{ni}$. Demand also follows a strict ordering if
there are no trade costs, as in proposition 2.

\textsuperscript{20}Feenstra and Rose (2000) find evidence that goods that first appear in international trade data are
typically produced by rich countries.

\textsuperscript{21}Gaulier and Zignago (2009) cleaned the data precisely for the study of unit prices. Quantity units
are the same within product categories and all prices are on a free on board (FOB) basis. They construct
indices to gauge the reliability of countries’ data. For each transaction where both importer and exporter
reports are available, they average these reports using as weights country reliability indices.

\textsuperscript{22}For robustness, I used dummies for contiguity and common language, and the results do not change.
Data on income for Taiwan are from CEIC Data (http://www.ceicdata.com/).
and GDP per capita of the importer and exporter are known. (iv) For each product category and year, I discard observations with unit prices greater than ten times or smaller than one-tenth of the geometric average. On average each year, step (i) eliminates 5% of the value of trade; step (ii), 0.3%; step (iii), 4%, and (iv) 4.5%. The final data then account for 86% of the original trade and comprise about 160 countries per year, listed on table 1. In linking theory to data, a six-digit product category is interpreted as a good $\omega$, and I refer to such categories as products. Standard errors are clustered by importer, exporter, product and year, when applicable.\(^{23}\)

2.2 Testing the theory

2.2.1 Proposition 1: Unit prices and exporter income per capita

In proposition 1, unit prices are increasing in exporter income per capita after controlling for trade costs and within each good and importer. I regress unit prices on exporter income per capita and on the distance between the importer and exporter separately for each year, product and importer. All variables are in logs. Panel 1 of table 2 summarizes the results. In 2007, the coefficient on exporter income per capita is positive at a 10% significance level in 53% of product-importer pairs. In a typical product-importer, a 10% increase in exporter income per capita is associated with a 1.8% increase in unit price.

Panel 1 of table 3 summarizes the corresponding pooled regressions of unit prices on exporter income per capita, distance and year-product-importer dummies under different specifications. In row 1, observations are not weighted and the coefficient on exporter income per capita, 0.18, is close to the median coefficient of table 2. Weighting observations by value decreases the coefficient to 0.14 (row 2). Controlling for total income does not change the results (row 3).\(^{24}\) Row 4 repeats the regression of row 2 using only manufacturing goods. The coefficient on income per capita increases to 0.18 suggesting that these goods are more vertically differentiated.\(^{25}\) Row

\(^{23}\)I use the formula of multi-dimensional clustering in Cameron et al. (2010) and Thompson (2006).

\(^{24}\)The coefficient on total GDP is small and statistically insignificant -0.005 (standard error 0.01). Controlling for total GDP does not change the results of any of the specifications (not shown).

\(^{25}\)I convert six digit HS code into four digit SITC codes using the UN Comtrade conversion table found at http://unstats.un.org/unsd/tradekb/Knowledgebase/UN-Comtrade-Conversion-table-from-HS2007-to-SITCRev.3. I then classify goods in industries 5, 6, 7 and 8 as manufacturing. Using Rauch’s (1999) classification is not feasible because, to my knowledge, the codes cannot be matched.
adds the interaction of exporter income per capita with time. The coefficient on the interaction term is small and negative (-0.004, standard error 0.0003). So, contradicting theory, there is no evidence that fast growing countries experience relative increases in the price of their exports.

2.2.2 Proposition 2(i): Unit prices and importer income per capita

Panel 2 on tables 2 and 3 is analogous to panel 1, but the roles of importer and exporter are reversed. In proposition 2(i), unit prices increase in importer income per capita only under restrictive assumptions on trade costs and income distribution. Accordingly, the results on panel 2 are much weaker than those on panel 1. For regressions run separately for each year, product and exporter (table 2), the coefficient on importer income per capita is positive and statistically significant in 32% of regressions, 19% less than in panel 1. In the pooled regressions (table 3), the coefficient on importer income per capita is statistically significant at a 1% level in all specifications, but it ranges from 0.04 to 0.06, about a third of the coefficient on exporter income per capita on panel 1.

2.2.3 Propositions 2(ii) and 3: More on importer income per capita

In proposition 2(ii), an increase in income per capita increases the average unit price of imports. I calculate the average unit price for each importer, product and year, and regress it on importer income per capita and product-year dummies. The coefficient on income per capita is 0.06 (standard error 0.01). Similarly in proposition 3, an increase in income per capita increases the average income per capita of the exporters from which the country sources its varieties. I calculate the weighted average exporter income per capita for each importer, product and year, and regress it on importer income per capita and product-year dummy. The coefficient on importer income per capita is 0.06 (standard error 0.02). Although these positive coefficients are consistent with theory, a proper test of propositions 2(ii) and 3 is not available because it requires data on the domestic market.

\[26\text{Choi et al. (2009) report other moments of the distribution of prices. They find that similarities in the distribution of importing prices across countries reflect similarities in the distribution of income per capita. There is no way to control for trade costs, and the coefficients are biased upward if similar countries are located close to each other.}\]
To summarize, a country often imports varieties in the same product category from several exporters, and it systematically pays higher unit prices for varieties from richer countries. Similarly, the same exporter tends to sell varieties at higher unit prices to importers with higher income per capita. But unit prices in trade increase more with exporter than with importer per capita income. This finding is not necessarily evidence against non-homothetic preferences. In the theory, although unit prices within countries are perfectly correlated with consumer income, differences in geography may lead countries with a low income per capita to buy some goods at a higher unit price. The data also support the hypothesis that rich countries demand relatively more varieties from other rich countries.

2.3 Calibration

2.4 Welfare and technology changes

The model yields an ambiguous answer to the long-standing question in development economics of whether rich countries benefit from technology shocks in poor countries or vice-versa. Using the functional form above, I simulate technology shocks in the form of increases in country-specific parameters $T_i$. In an economy with two countries, North (rich) and South (poor), a technology shock in the North may hurt the terms of trade of the South because, as consumers in the North get richer, they shift their consumption away from the low-quality goods produced in the South. A technology shock in the South, in turn, may hurt consumers in the North because an increase in $T$ yields a disproportionate increase in the productivity of high-quality goods. As a result, the price of some low-quality goods consumed in the North may increase because wages in the South increase and the technologies to produce low-quality do not change much ($w_S^{N} a_i(q, \omega)$ increases for low $q$).

This ambiguity contrasts with the literature which considers only Hicks-neutral technology shocks in the South and concludes that the North always benefits from a technology shock in the South. A bias towards high-quality goods is, however, reasonable because, in the product cycle analogy above, technologies to produce high-quality goods are not yet standardized and
may thus present greater scope for improvements.\footnote{Flam and Helpman (1987) and Stokey (1991) make similar analogies between product cycles and their model, but they disregard potential bias when analyzing technology shocks. In gravity-type models, a technology shock in one country generally benefits all other countries.}

3 Conclusion

I develop a Ricardian model of trade with quality differentiation and non-homothetic preferences. The theory generalizes and puts together several previous results, while the empirical analysis extends previous findings to a larger data set with 160 countries and 13 years. A key feature of the model is that it allows for an arbitrary number of countries and a continuum of goods. This feature renders possible quantitative analysis and the study of conditions under which empirically-verifiable patterns of trade emerge within industries: Prices increase in exporter and importer income per capita, and rich countries demand relatively more goods from other rich countries.

The model lends itself for the analysis of several types of technological progress. A country that experiences productivity increases in a good expands the range of quality that it produces. As other countries move away from this range, prices become more polarized: Rich countries shift toward higher quality and poor countries, toward lower quality. Global technology shocks increase welfare but they need not change relative wages, prices and quantities of trade flows. If these global shocks occur repeatedly, product cycles analogous to Vernon (1966) occur to quality levels within industries. Because these shocks cannot be observed without direct measures of quality, the model explains the difficulties that researchers have found in establishing systematic, dynamic patterns using trade data.

There are two natural extensions of the model. The first is endogenous growth. The model is static and introducing growth by exogenously shifting labor requirement curves along the quality dimension (as in proposition 5) precludes the effects of demand and trade on growth.\footnote{Matsuyama (2002) and Foellmi and Zweimüller (2006) study demand-induced growth in closed economies. Models of trade and endogenous growth have homothetic preferences.} The second is horizontal product differentiation. Hallak and Schott (2010) and Khandelwal (2010) propose theory-based methods to estimate quality in bilateral trade data. They allow for
horizontal product differentiation but rule out demand effects. A measure that allows for both horizontal differentiation and non-homothetic preferences is yet to be developed.\textsuperscript{29}

\textsuperscript{29}The difficulty in combining the two approaches is qualifying goods that sell small quantities at high prices. With non-homothetic preferences, these goods could be of high quality catering only to the elites, and with horizontal differentiation, these goods could have low quality and high production costs. A potential way to distinguish the two cases, without observing the profits of producing firms, is to consider where the good sells to: The high-price, high-quality good should sell to several destinations, while the high-price, low-quality good should sell to few destinations.
References


[34] UNITED NATIONS (2008), UN Commodity Trade Statistics Database (UN Comtrade), accessed in June, 2008 at http://comtrade.un.org/


<table>
<thead>
<tr>
<th>Country</th>
<th>Country</th>
<th>Country</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albania</td>
<td>Djibouti</td>
<td>Kyrgyz Republic</td>
<td>Rwanda</td>
</tr>
<tr>
<td>Algeria</td>
<td>Dominica</td>
<td>Lao PDR</td>
<td>Sao Tome and Principe*</td>
</tr>
<tr>
<td>Angola</td>
<td>Dominican Republic</td>
<td>Latvia</td>
<td>Saudi Arabia</td>
</tr>
<tr>
<td>Antigua and Barbuda*</td>
<td>Ecuador</td>
<td>Lebanon</td>
<td>Senegal</td>
</tr>
<tr>
<td>Argentina</td>
<td>Egypt, Arab Rep.</td>
<td>Lesotho</td>
<td>Seychelles</td>
</tr>
<tr>
<td>Armenia</td>
<td>El Salvador</td>
<td>Liberia</td>
<td>Sierra Leone</td>
</tr>
<tr>
<td>Aruba*</td>
<td>Equatorial Guinea</td>
<td>Libya</td>
<td>Singapore</td>
</tr>
<tr>
<td>Australia</td>
<td>Eritrea</td>
<td>Lithuania</td>
<td>Slovak Republic</td>
</tr>
<tr>
<td>Austria</td>
<td>Estonia</td>
<td>Macao</td>
<td>Slovenia</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>Ethiopia</td>
<td>Macedonia</td>
<td>Solomon Islands</td>
</tr>
<tr>
<td>Bahamas, The</td>
<td>Fiji</td>
<td>Madagascar</td>
<td>South Africa</td>
</tr>
<tr>
<td>Bahrain*</td>
<td>Finland</td>
<td>Malawi</td>
<td>Spain</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>France</td>
<td>Malaysia</td>
<td>Sri Lanka</td>
</tr>
<tr>
<td>Barbados</td>
<td>French Polynesia*</td>
<td>Mali</td>
<td>St. Kitts and Nevis</td>
</tr>
<tr>
<td>Belarus</td>
<td>Gabon</td>
<td>Malta</td>
<td>St. Lucia</td>
</tr>
<tr>
<td>Belize</td>
<td>Georgia</td>
<td>Mauritania</td>
<td>Sudan</td>
</tr>
<tr>
<td>Benin</td>
<td>Germany</td>
<td>Mauritius</td>
<td>Suriname</td>
</tr>
<tr>
<td>Bermuda</td>
<td>Ghana</td>
<td>Mexico</td>
<td>Swaziland</td>
</tr>
<tr>
<td>Bhutan</td>
<td>Greece</td>
<td>Moldova</td>
<td>Sweden</td>
</tr>
<tr>
<td>Bolivia</td>
<td>Greenland*</td>
<td>Mongolia</td>
<td>Switzerland</td>
</tr>
<tr>
<td>Bosnia and Herzegovina</td>
<td>Grenada</td>
<td>Morocco</td>
<td>Syrian Arab Republic</td>
</tr>
<tr>
<td>Botswana</td>
<td>Guatemala</td>
<td>Mozambique</td>
<td>Taiwan*</td>
</tr>
<tr>
<td>Brazil</td>
<td>Guinea</td>
<td>Namibia</td>
<td>Tajikistan</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>Guinea-Bissau</td>
<td>Nepal</td>
<td>Tanzania</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>Guyana</td>
<td>Netherlands</td>
<td>Thailand</td>
</tr>
<tr>
<td>Burundi</td>
<td>Haiti</td>
<td>New Caledonia*</td>
<td>Togo</td>
</tr>
<tr>
<td>Cambodia</td>
<td>Honduras</td>
<td>New Zealand</td>
<td>Tonga</td>
</tr>
<tr>
<td>Cameroon</td>
<td>Hong Kong, China</td>
<td>Nicaragua</td>
<td>Trinidad and Tobago</td>
</tr>
<tr>
<td>Canada</td>
<td>Hungary</td>
<td>Niger</td>
<td>Tunisia</td>
</tr>
<tr>
<td>Cape Verde</td>
<td>Iceland</td>
<td>Nigeria</td>
<td>Turkey</td>
</tr>
<tr>
<td>Cayman Islands*</td>
<td>India</td>
<td>Norway</td>
<td>Turkmenistan</td>
</tr>
<tr>
<td>Central African Republic</td>
<td>Indonesia</td>
<td>Oman*</td>
<td>Uganda</td>
</tr>
<tr>
<td>Chad</td>
<td>Iran, Islamic Rep.</td>
<td>Pakistan</td>
<td>Ukraine</td>
</tr>
<tr>
<td>Chile</td>
<td>Iraq*</td>
<td>Palau</td>
<td>United Arab Emirates*</td>
</tr>
<tr>
<td>China</td>
<td>Ireland</td>
<td>Panama</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>Colombia</td>
<td>Israel</td>
<td>Papua New Guinea</td>
<td>United States</td>
</tr>
<tr>
<td>Comoros</td>
<td>Italy</td>
<td>Paraguay</td>
<td>Uruguay</td>
</tr>
<tr>
<td>Congo, Rep.</td>
<td>Japan</td>
<td>Philippines</td>
<td>Vanuatu</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>Jordan</td>
<td>Poland</td>
<td>Venezuela, RB</td>
</tr>
<tr>
<td>Cote d'Ivoire</td>
<td>Kazakhstan</td>
<td>Portugal</td>
<td>Vietnam</td>
</tr>
<tr>
<td>Croatia</td>
<td>Kenya</td>
<td>Puerto Rico*</td>
<td>Yemen, Rep.</td>
</tr>
<tr>
<td>Cyprus</td>
<td>Kiribati</td>
<td>Qatar</td>
<td>Yugoslavia*</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Korea, Rep.</td>
<td>Romania</td>
<td>Zambia</td>
</tr>
<tr>
<td>Denmark</td>
<td>Kuwait</td>
<td>Russian Federation</td>
<td>Zimbabwe*</td>
</tr>
</tbody>
</table>

* Countries with some years missing.

Table 1: List of countries
<table>
<thead>
<tr>
<th>year</th>
<th>panel 1: regressions by importer-product-year</th>
<th>panel 2: regressions by exporter-product-year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>number of regressions</td>
<td>% of positive coefficients on per capita GDP</td>
</tr>
<tr>
<td>2007</td>
<td>62,204</td>
<td>86</td>
</tr>
<tr>
<td>2006</td>
<td>59,622</td>
<td>85</td>
</tr>
<tr>
<td>2005</td>
<td>56,495</td>
<td>86</td>
</tr>
<tr>
<td>2004</td>
<td>48,434</td>
<td>87</td>
</tr>
<tr>
<td>2003</td>
<td>43,290</td>
<td>87</td>
</tr>
<tr>
<td>2002</td>
<td>38,828</td>
<td>86</td>
</tr>
<tr>
<td>2001</td>
<td>36,597</td>
<td>86</td>
</tr>
<tr>
<td>2000</td>
<td>37,941</td>
<td>85</td>
</tr>
<tr>
<td>1999</td>
<td>35,799</td>
<td>87</td>
</tr>
<tr>
<td>1998</td>
<td>36,218</td>
<td>87</td>
</tr>
<tr>
<td>1997</td>
<td>35,378</td>
<td>86</td>
</tr>
<tr>
<td>1996</td>
<td>33,555</td>
<td>87</td>
</tr>
<tr>
<td>1995</td>
<td>30,123</td>
<td>88</td>
</tr>
</tbody>
</table>

The first set of columns summarizes the results of OLS regressions of the log of unit prices on the log of exporter per capita income and distance, run separately for each importer-product-year. The second set reverses the roles of importer and exporter and runs OLS regressions of unit prices on importer per capita income and distance, separately for each exporter-product-year. I use only regressions with more than 15 observations, which implies on average dropping 11% of trade flows per year.

Table 2
### Panel 1: Regressions with year-product-importer dummies

<table>
<thead>
<tr>
<th></th>
<th>exporter GDP per capita</th>
<th>R2</th>
<th>weighted by value</th>
<th>other controls/specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.18</td>
<td>0.38</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.14</td>
<td>0.45</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.14</td>
<td>0.45</td>
<td>yes</td>
<td>control for exporter total GDP</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.18</td>
<td>0.45</td>
<td>yes</td>
<td>manufacturing goods only</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.17</td>
<td>0.45</td>
<td>yes</td>
<td>interaction between exporter per capita income and year</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Panel 2: Regressions with year-product-exporter dummies

<table>
<thead>
<tr>
<th></th>
<th>importer GDP per capita</th>
<th>R2</th>
<th>weighted by value</th>
<th>other controls/specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0.06</td>
<td>0.41</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.04</td>
<td>0.48</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0.04</td>
<td>0.48</td>
<td>yes</td>
<td>control for importer total GDP</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0.06</td>
<td>0.47</td>
<td>yes</td>
<td>manufacturing goods only</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0.07</td>
<td>0.48</td>
<td>yes</td>
<td>interaction between importer per capita income and year</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lines 1-5 present OLS regressions of unit prices on exporter per capita income and product-year-importer dummies, and lines 6-7, OLS regressions of unit prices on importer per capita income and product-year-exporter dummies. All regressions include controls for distance between the importer and exporter. All variables are in logs. Standard errors in parenthesis are clustered by importer, exporter, product and year. There are 33,234,556 observations in all regressions, except in lines 4 and 9, where there are 27,347,559 observations.

Table 3
The table compares two numerical examples of the model with data. In example 1, $\mu = -2.2$ and $\sigma = 2.5$, and in example 2, $\mu = 4$ and $\sigma = 0.5$.

### Table 4

<table>
<thead>
<tr>
<th>dependent variable</th>
<th>data</th>
<th>model example 1</th>
<th>model example 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>average importer price</td>
<td>0.06</td>
<td>0.98</td>
<td>0.06</td>
</tr>
<tr>
<td>average exporter price</td>
<td>0.14</td>
<td>0.14</td>
<td>1.4</td>
</tr>
<tr>
<td>average income per capita of exporters from</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>where the country sources its goods</td>
<td>0.06</td>
<td>0.06</td>
<td>-0.001</td>
</tr>
</tbody>
</table>

The table compares two numerical examples of the model with data. In example 1, $\mu = -2.2$ and $\sigma = 2.5$, and in example 2, $\mu = 4$ and $\sigma = 0.5$. 

Table 4
Figure 1: Examples of labor requirement and cost curves of two countries, North (N) and South (S). The cost curve of the North is in dashed lines, and the two curves of the South coincide.
Figure 2: The choice of the quality of good $\omega$ for a consumer in country $n$ with endowment $e$. The curves $p_{ni} (q, \omega)$ for $i=1,2,3$ are the cost of delivering one unit of good $\omega$ in country $n$ from country $i$ as a function of quality $q(\omega)$. The price the consumer faces is the lower envelope of these curves: $\min\{p_{ni} (q, \omega): i = 1,2,3\}$, but he always chooses quality levels in the convex hull of prices, along the bold curves. The Lagrangean multiplier of the consumer illustrated is $\lambda_n(e)$. He chooses quality level $q_n^*(e)$, the point of tangency of the convex hull of prices and a line with slope $1/[\lambda_n(e)]$. 
Figure 3: A technology shock in good \( \omega \) in country 2. The initial cost of delivering good \( \omega \) to country \( n \) is curve \( p_{ni}(q, \omega) \) from countries \( i=1,3 \), and \( p_{n2}^0(q, \omega) \) from country 2. The shock in country 2 decreases its cost curve to \( p_{n2}^1(q, \omega) \). Consumers choose quality levels in the intersection of the convex hull and the minimum cost curve \( p_n(q, \omega) = \min\{p_{ni}(q, \omega) : i = 1,2,3\} \). The initial set is the black bold curves and the final set, the red, extra-bold curves. The set of goods that the rich country 3 potentially produces shrinks to the upper portion of its initial set—it specializes in higher quality. Poor country 1 specializes in lower quality. The set of consumers that buy from country 2 increases with the shock, because there is a wider range of Lagrangean multipliers \( \lambda_n(e) \) for which the slope of the new convex hull equals \( 1/\left[\lambda_n(e)\right] \) at \( p_{n2}^1(q, \omega) \). Changes in the range of quality levels \( q(\omega) \) and in the value of trade flows from country 2 to country \( n \), however, is ambiguous.