Markups, International Specialization, and the Gains from Trade

Ahmad Lashkaripour*

Job Market Paper

Abstract

This paper accounts for three well-established patterns in international trade that have yet to be unified into one model: (i) rich countries trade more intensively, (ii) rich countries export goods with higher unit values, and (iii) higher trade costs induce exporters to specialize in goods with higher unit values, i.e. “shipping the good apples out.” The framework developed in this paper explains these facts simultaneously with minimal deviation from standard assumptions in the new trade theory—preferences are homothetic (nested CES) and trade costs are symmetric and of the iceberg type. This makes the framework tractable and easy to quantify. I extend Krugman [1980] by allowing the elasticity of substitution (and hence markups) to vary across product categories. The resulting pattern is that different countries specialize in different sets of products, which exhibit different markups. I show that accounting for across-product variation in elasticities greatly magnifies the gains from trade. The model is fitted to data in two steps. First, I estimate elasticities for various product categories using disaggregated US import data and find that patterns of US imports are consistent with the predictions of the model. Then, using the estimated elasticities I calibrate the model to aggregate trade flows to perform a counterfactual welfare analysis. The main empirical findings are the following: (1) US employment in highly differentiated (i.e low elasticity) industries is largely insulated from import penetration by low-wage countries, (2) the welfare gains from trade (relative to autarky) are bigger, by a large margin, in the new model compared to the baseline Krugman model, and (3) iceberg trade costs are estimated to be 52% larger in the new model relative to the baseline, which implies that potential gains from eliminating trade costs could also be larger than predicted by traditional models.

JEL-Classification: F12, F14, O15, L25

Keywords: Price, elasticity, quality, markups, international trade, income per capita

*I owe a debt of gratitude to my advisors Jonathan Eaton and Stephen Yeaple for their invaluable guidance, encouragement, and support. I am also grateful to James Tybout for encouragement and various discussions on the topic. I wish to thank Russell Cooper, Alexandros Fakos, Farid Farnokhi, Paul Grieco, Kala Krishna, Konstantin Kucheryavyy, Peter Newberry, and Neil Wallace for helpful comments and suggestions. All errors are my own. Correspondence: azl153@psu.edu, http://www.personal.psu.edu/azl153.
1 Introduction

New trade theory has laid out a tractable framework for analyzing trade among countries with similar levels of income. Lately, there has been a growing interest in expanding the boundaries of new trade theory to incorporate some well-established facts of first order importance:

i. Rich countries export (and import) a higher share of their GDP (Fieler [2011]; Waugh [2010]).

ii. Exporters “ship the good apples out,” i.e. within a set of comparable goods only the most expensive ones are exported to the far corners of the world (Hummels and Skiba [2004]; Baldwin and Harrigan [2011]).

iii. When rich and poor countries export goods from the same industry, the richer countries sell goods with higher unit value (Hallak and Schott [2011]; Hummels and Klenow [2005]).

To account for these facts, existing models have inevitably imposed extra structure on the standard theories. For example, to explain trade across rich and poor countries it is assumed that demand is non-homothetic or trade costs are asymmetric. To explain “shipping the good apples out,” trade costs are assumed to be additive rather than iceberg. Furthermore, missing in the literature is a unified framework that accounts for these facts simultaneously.

This paper proposes a theory that incorporates facts (i)-(iii) while maintaining the key assumptions that make new trade theory tractable and easy to quantify. In particular, I maintain the assumptions that demand is homothetic (nested CES) and trade costs are iceberg and symmetric. While the existing literature attributes price variation to across-product differences in quality, I argue that price variation can be alternatively explained by accounting for across-product differences in demand elasticity.

I build upon the multi-country monopolistic competition model of trade with homogeneous firms, developed by Krugman [1980]. I depart from this baseline model along three dimensions: (1) I allow for multi-product firms that pay a per-product fixed cost for each product category they export, (2) I allow the elasticity of substitution to vary across product categories, and (3) I allow for quality differentiation across-countries, but not across-products. Some countries manufacture all the products at a higher level of quality than others. Putting it differently, some countries are endowed with highly skilled labor such that

1 Another documented pattern regarding the unit value of traded goods is that when a country imports goods in an industry from several sources, the expensive goods are imported disproportionately from the higher-income countries (Hallak [2006]). This fact is somehow incorporated in fact (iii) and has been a subject of interest in some recent studies, e.g. Fajgelbaum, Grossman, and Helpman [2011].


3 Hummels and Skiba [2004] in line with Alchian and Allen [1983] explain shipping the good apples out with additive trade costs.
consumers around the world value their products more than those of other countries.\textsuperscript{4}

In the model, the aggregate country-specific quality does not affect prices directly as all countries employ the same production technology, i.e. all countries employ the same amount of labor to produce one unit of each product. The main determinant of price is the level of differentiation and a product is said to be highly differentiated if it is subject to a low elasticity of substitution. Highly differentiated products, therefore, exhibit higher markups and have higher prices within any subset of comparable products, e.g. products belonging to the same industry.

As noted earlier, firms incur a per-product fixed cost for each product category they export. Exporting highly differentiated-high markup products is more likely to generate enough profits to cover the per-product fixed cost of exporting. Highly differentiated products are, therefore, traded more intensively. Relatedly, as iceberg trade costs become higher, exporting remains profitable only for the most differentiated products, which exhibit the highest markups. The intuition is as follows. Exporters who incur high shipping costs, face a higher marginal cost and will charge a higher c.i.f price for their varieties. The high price charged by these exporters affects demand to a lesser extent in the highly differentiated (i.e. low elasticity) product categories. The combination of higher markups and less price-elastic demand make highly differentiated products profitable to export even for the disadvantaged exporters that face high trade costs. Therefore, within every industry, exporters ship only the most expensive and differentiated products to the far corners of the world.\textsuperscript{5}

When a country produces all products at a higher quality, there is more demand for its varieties in equilibrium. This results in more demand for labor in high-quality countries, which translates into higher wages. Two factors determine trade flows in equilibrium: effective wage (which reflects in the final price) and quality. In less-differentiated product categories import volumes are very sensitive to the high-wage of rich countries. As products become more differentiated, the effect of wage on trade flows diminishes while quality remains important (the relative importance of quality rises). Consequently, rich countries have competitive advantage in highly differentiated products where competition is centered around quality rather than price. Therefore, rich countries would specialize in highly differentiated products, which exhibit the highest price within each industry.\textsuperscript{6}

Low-wage/low-quality countries have competitive advantage in less-differentiated (and less price sensitive) product categories because of their low wages and lower final prices. However, as noted earlier,

\textsuperscript{4}One unit of labor in every country produces one unit of a product (e.g. car). However, the one unit of product is more valued by consumers, universally, when coming from high-skill countries (e.g. Japan, Germany, etc.). I refer to this extra value attached to products that are manufactured in high-skill countries, as the country-specific quality—so skill and quality are synonyms in my model.

\textsuperscript{5}Putting it differently, in remote markets exporters specialize in high markup-highly differentiated products.

\textsuperscript{6}Specialization refers to a country exploiting its competitive advantage in a product by predominantly, but not exclusively, exporting that product.
less-differentiated products are less profitable to export because they exhibit low markups; the profits from exporting the less-differentiated products are unlikely to cover the per-product fixed cost of exporting. Therefore, poor countries will not trade as much as rich countries in equilibrium—firms from poor countries will exploit their competitive advantage in low markup products by selling predominantly in their domestic markets where they do not pay fixed (exporting) costs. Rich countries, on the other hand, have competitive advantage in highly differentiated-high markup products that are more profitable to export, gross of fixed costs. This results in intensive export activity by rich countries.

After building a theoretical model that is consistent with both the patterns of trade across rich and poor countries and general price patterns in international trade, I fit the model to data in two steps. In the first step, I use disaggregated US import data to estimate demand (i.e. trade) elasticities for various HS-10 product categories. After estimating trade elasticities in step one, I calibrate the general equilibrium model to aggregate bilateral trade volumes and wages. So instead of imposing structure on elasticities to identify aggregate trade costs, I use the elasticities estimated in step one to measure the unobservable aggregate trade costs in step two (calibration).

The estimation (i.e. step one) yields several interesting results. First, the estimated elasticity varies considerably across different HS-10 product categories. Second, both the f.o.b price (within an industry) and the number of imported varieties are significantly higher in more differentiated product categories. The positive association between differentiation and price, within an industry, could be important given that existing models of across-product quality differentiation struggle to find a positive link between product-specific quality and price at the same level of disaggregation. Finally, similar to Helpman, Melitz, and Rubinstein [2008] (but using a different methodology) I show that not controlling for hidden varieties (the extensive margin of trade) can result in over-estimating trade elasticities by a relatively large margin.

Import penetration by low-wage countries is found to be significantly lower among industries with high levels of differentiation, which confirms my theory. The model also predicts that due to patterns of competitive advantage, US employment in highly differentiated industries is largely insulated from import penetration by low-wage countries. I test this prediction using US employment data at the industry level. The results suggest that, over time, industry-level employment in the US is negatively associated with low-wage import penetration. However, employment is significantly less sensitive to low-wage import

---

7Step one of my empirical inquiry is similar to Broda and Weinstein [2006]. However, unlike Broda and Weinstein [2006] I control for the extensive margin of trade (or hidden varieties). Moreover, I use a more standard identification strategy when estimating the product-specific micro-gravity equations.

8A product category in the data is a 10-digit HS-10 product code belonging to the Harmonized System developed by the World Customs Organization (WCO).

9An industry is a set of products that are close substitutes. In the data an industry is characterized by a 5-digit SITC (Standard International Trade Classification) code which comprises of multiple, closely related, HS-10 product categories.

10Khandelwal [2010] for example finds a negative effect of quality on f.o.b prices at the HS-10 product level.
penetration in the more differentiated industries.

The new model improves upon the baseline Krugman-Armington model in terms of fitting the aggregate bilateral trade flows. Furthermore, it significantly outperforms the baseline model in terms of fitting the (out of sample) unit value data. The most striking result, however, is the big gap in competitiveness between rich and poor countries in highly differentiated products. For example, in the least differentiated product category, China has a quality-adjusted wage (i.e. marginal cost per unit of quality) that is less than half of the US. This gives China a slight edge over the US in terms of producing and exporting the least-differentiated products. Nevertheless, in the most differentiated category, the quality-adjusted wage in China is 33.8 times higher than the US. This implies that the US has a tremendous advantage over China in highly differentiated product categories. Since demand for highly differentiated products is less price-sensitive, the competitive advantage of the US over China is also largely immune to wage/price movements in China.

The main finding of the paper is that accounting for cross-product variation in elasticities greatly magnifies the estimated gains from trade. In the new model, opening to trade from autarky results, on average, in a 15% increase in real wages. In the baseline Krugman-Armington model the gains are only 1% of the real wage. The intuition is that in the new model, after opening up to trade, trade activity happens more intensively (and extensively) in highly differentiated product categories, e.g. countries tend to import cars rather than flip-flops. Since the elasticity of substitution is low in highly differentiated product categories, the gains from trading those products are quite sizable. Ossa [2012] makes a similar argument, but the contribution of this paper is endogenizing the high level of imports in highly differentiated industries (or products). Ossa [2012] fixes expenditure shares on industries to an exogenous share by assuming a cross-industry Cobb-Douglas utility function.\footnote{Costinot and Rodríguez-Clare [2013], for example, argue that in Ossa [2012] the exogenously fixed expenditure shares (for highly differentiated industries) generate the high gains from trade. This paper argues that the high intensity of imports (or high expenditure on foreign varieties) in differentiated industries is an endogenous outcome in equilibrium.}

The gains from trade are also asymmetric across product categories. Trade can result in the number of available varieties to fall in the less-differentiated product categories. This happens because multi-product exporters crowd out multi-product domestic firms, but they supply only the differentiated products, while the domestic firms are supplying all the products. This happens more so in poor countries where exporters have no chance of competing with local firms in less-differentiated product categories, e.g. German firms can not compete with local firms in Pakistan when it comes to selling soccer balls. Nevertheless, purchasing power rises dramatically in differentiated categories in all countries and even more so in poor countries, e.g. consumers in Pakistan gain access to German cars, which are substantially more appealing than domestically-built cars. This generates large aggregate gains in all countries.
Finally, the calibrated iceberg trade costs are 52% lower in the baseline Krugman-Armington model relative to the new model. This happens because the baseline model restricts the elasticity of substitution between firms within a country to be the same as the across-country elasticity. The restriction amounts to saying that firm-level varieties possess the same degree of horizontal differentiation regardless of their country of origin. If so, unless trade costs are very low, the market will be crowded only by low-cost domestic firms and trade will be very scarce. Consequently, to match the trade flow data, one would estimate low trade costs. This suggests that even though the realized gains from trade are substantial, there is room left for much further gains; since trade barriers are larger than once thought, the gains from eliminating them could be actually much greater than what traditional theories predict.

2 Related Literature

The theory developed in this paper relates to three strands of literature that have provided us with an invaluable first step in understanding facts (i)–(iii) in the introduction. In the following paragraphs, I will first briefly describe these three bodies of literature. Then, I will discuss how this paper contributes to the existing theories.

It is well documented in the empirical literature that poor countries trade much less than rich countries, both with each other and with the rest of the world. There has been a recent surge in the literature to account for this observation theoretically. Fieler [2011] builds a Ricardian model with non-homothetic preferences, while Markusen [2013] assumes non-homotheticity in a model with imperfect competition. Waugh [2010] argues that the higher intensity of trade among rich countries is due to asymmetric trade costs with rich countries facing systematically lower trade costs.

A second well established fact in the empirical literature is the big gap between rich and poor countries in terms of export unit values. Schott [2004], Hallak and Schott [2011], and Hummels and Klenow [2005] show that when rich and poor countries export goods from the same industry, the richer countries sell goods with higher unit values. Hallak [2006] documents that when a country imports goods in an industry from several sources, the expensive goods are imported disproportionately from the higher-income countries. Flam and Helpman [1987] and Fajgelbaum et al. [2011] are among the many papers that provide theoretical foundation for the aforementioned patterns. Both studies rely on quality heterogeneity across products and the assumption that high-quality products are more expensive to produce. Moreover, both papers assume non-homotheticity to achieve their results. The theory is that when preferences are non-homothetic, rich countries self select into production of high quality products.

The “Washington apples” effect or “shipping the good apples out” has been documented extensively at
both the country level (Hummels and Skiba [2004]) and the firm level (Bastos and Silva [2010]). The most favored explanation is the Alchian-Allen conjecture. This explanation relies on products being vertically differentiated and trade costs being additive rather than iceberg (Hummels and Skiba [2004]). There is an alternative explanation proposed by Baldwin and Harrigan [2011]. They introduce quality differentiation into the Melitz [2003] framework and assume that higher quality products are more expensive, but the extra utility from consuming high quality products offsets the effect of their high price. This makes high-price firms more competitive (in general) and enables them to export to remote markets.

What the literature is missing, so far, is a theory that incorporates all the above facts simultaneously. The theoretical model presented in this paper provides a unifying framework that fills this void. However, the central contribution of the paper is accounting for these facts with minimal deviation from the standard assumptions in trade theory, i.e. demand is homothetic and trade costs are iceberg and symmetric. This makes the model tractable and easy to quantify. Moreover, the paper develops a framework in the context of new trade theory for analyzing North-South trade.

In the trade literature measuring demand (i.e. trade) elasticities has been a vibrant area of research. The first step of my empirical inquiry is closely related to this literature. Among the existing studies, Feenstra [1994], Feenstra, Obstfeld, and Russ [2012] and Broda and Weinstein [2006] are examples of papers that estimate elasticities at the disaggregated level. This paper is closest to Broda and Weinstein [2006] since they also estimate a separate elasticity for each HS-10 product code. My paper contributes to their findings in the following way: I allow for varieties manufactured in the same country to be imperfect substitutes, while Broda and Weinstein [2006] assume a representative firm in every country which implicitly implies that varieties from the same country are perfectly substitutable. My estimation is, therefore, less restrictive than Broda and Weinstein [2006]. As in Helpman et al. [2008], I argue that restricting a country to be a single firm and not accounting for hidden varieties, results in over-estimating elasticities. I also propose a simple and standard identification strategy different from the one implemented by Broda and Weinstein [2006].

Finally, my paper contributes to an active area of ongoing research that measures the gains from trade. Arkolakis, Costinot, and Rodriguez [2012] and Arkolakis, Klenow, Demidova, and Rodriguez-Clare [2008]

12This paper is the first, to my knowledge, that introduces patterns of competitive advantage across rich and poor countries into a new trade framework. In my model rich countries have competitive advantage in highly differentiated (i.e. low elasticity) products, while poor countries have competitive advantage in less-differentiated products. Previous studies like Kraay and Ventura [2007] have modeled comparative advantage of rich countries in high-skilled low elasticity industries. However, these models fall into the category of specific factors models, in which rich countries trade per-dominantly with poor countries and vice versa.

13The paper is also related to a rich body of empirical literature that estimates demand elasticities. In the IO literature estimating demand elasticities for individual products, using highly disaggregated consumer data has always been a topic of interest. Theses researches need not to impose any restriction on elasticities since they usually have rich enough market data to back out elasticities for individual varieties. However, the finding that expensive products have a lower elasticity implicitly exists in their finding. Berry, Levinsohn, and Pakes [1995] for instance, estimate demand elasticities for the U.S. car market, and their findings (figure 20 in appendix D) suggest a low elasticity for expensive luxury cars and a high elasticity for cheap economy cars.

are among papers that argue that the gains from trade are relatively small. Costinot and Rodriguez-Clare [2013] and Ossa [2012] show that the gains can be larger in a multi-sector model of trade. They assume that the upper-tier utility across industries is Cobb-Douglas. This means that, inevitably, a fixed fraction of the consumers’ spending will be on industries with low elasticities of substitution, which implies larger gains from trade.

The present paper too, argues that the gains from trade are larger when I account for cross-product variation in elasticities. This paper contributes to the existing studies by endogenizing the large share of spending on low elasticity products after trade. I argue that the entry decision by firms generates the large aggregate gains from trade. Furthermore, the model yields one extra result: When I quantify the model, iceberg trade costs are measured to be larger than standard models which assume the same elasticity across all products. Therefore, compared to the traditional models, the new framework implies larger potential welfare gains from eliminating the large-scale iceberg trade costs.

3 Theory

In this section I will introduce the main ingredients of my general equilibrium model. The world economy consists of $N$ asymmetric countries denoted by $C = \{1, 2, \ldots, N\}$. Countries differ in endowments of labor and the general quality of their products. Each country $i \in C$ is populated with a mass $L_i$ of identical agents. Each agent is endowed with one unit of labor, and labor is the only factor of production. Geography is reflected in two kinds of barriers between countries: variable iceberg trade costs, and the fixed cost of exporting in a product category. There is a continuum of product categories and every product comes in many varieties. Firms in every country are multi-product and homogenous. I assume a market structure characterized by monopolistic competition and free entry.

In the following sections I will further lay out the environment; I start with a description of the commodity space and demand in the next subsection. Then, I turn to supply and the problem of the firms.

3.1 Commodity Space

There are two types of commodities: (i) manufactured and (ii) non-manufactured. The non-manufactured commodity is homogenous and non-tradable. The manufactured commodity is differentiated, tradable, and comes in many varieties. A variety is characterized by (i) the product category it belongs to, (ii) the country it was manufactured in, and (iii) the firm that manufactured it. For example, a 40” Samsung TV is a variety that falls in the 40” TVs category, is manufactured in Korea by Samsung. Mathematically, the
commodity space can be expressed as

\[ \Xi = H_{\text{Product}} \times C_{\text{Country}} \times \Omega_{\text{Firm}} \]

where \( H = [0, H] \) is the continuum of product categories, \( C = \{1, 2, ..., N\} \) is the set of countries, and \( \Omega_j \) is the set of firms (a continuum) in country \( j \in C \). Variety \( \omega j h \) denotes a manufactured commodity that belongs to product category \( h \in H \), is manufactured in country \( j \in C \) by firm \( \omega \in \Omega_j \). A simple illustration of the commodity space is provided in figure 1.

Figure 1: The commodity space

A product category in the data is a 10-digit HS-10 product code belonging to the Harmonized System developed by the World Customs Organization (WCO). A group of closely substitutable products constitute an industry: \( H = \bigcup_{s \in S} H_s \) where \( S \) is the set of industries and \( H_s \subset H \) is a subset of products that belong to industry \( s \in S \). In trade data an industry is classified by a 5-digit SITC (Standard International Trade Classification) code. Figure 2 displays an example of an SITC-5 industry in the US import data (compiled by Feenstra, Romalis, and Schott [2002])—the industry displayed in figure 2 is classified as (the 5-digit number) 71620 and comprises of various categories of DC generators and motors.

The product space \( H \), therefore, can be divided into groups of products (i.e. \( H_s \subset H \)), which are comparable. The reason I emphasize this is that the present framework, generates patterns regarding the unit value of traded goods. Theses patterns should always be thought of as within-industry patterns. Comparing prices (i.e. unit value) within an industry, basically, guarantees that we are comparing apples to apples.\(^\text{15}\)

\(^{15}\)The evidence documented in the data regarding unit values is also confined to within group comparisons of products, i.e. prices are compared across a narrowly defined group of comparable products.
3.2 Demand

As noted earlier, each country is populated with a mass $L_i$ of identical consumers. Preferences are a generalization of the Dixit-Stiglitz preferences (Dixit and Stiglitz [1977]) and each consumer maximizes the following utility function

$$V = U_M Q_N^{1-\alpha}$$

where $Q_N$ is the quantity consumed of the non-manufactured product which is non-tradable. Thus, $\alpha$ denotes the expenditure share on manufactured products. $U_M$ is the utility from consumption of manufactured products and is given by the following CES formulation

$$U_M = \left[ \int_{h \in H} C_h^{\frac{1}{\epsilon_i}} \, dh \right]^{\frac{\epsilon_i}{\epsilon_i - 1}}$$

where $C_h$ is the sub-utility derived from the consumption of manufactured product $h$, and $\epsilon$ is the elasticity of substitution between the various composite products in $H$. In the background, products are implicitly nested within various industries in $S$ with the assumption that $\epsilon_s = \epsilon$ for all $s \in S$, i.e. the across-product elasticity of substitution is the same in all industries.\footnote{Suppose the set of industries, $S$, is discrete. Every product $h \in H$ belongs to some industry $s \in S$ (i.e. $h \in H_s$) and the upper-tier}
The lower tier sub-utility $C_h$ takes the following form

$$C_h = \left[ \sum_{j \in C} \mu_j \frac{\sigma_{h-1}^2}{Q_{jh} \sigma_h} \right]^{\frac{\sigma_h}{\sigma_{h-1}}}$$

where $\mu_j$ is the aggregate country-specific quality of varieties manufactured in country $j$, i.e. Armington demand shifter. For the sake of tractability I assume that the country-specific quality is the same for all sets of products (industries). $^\text{17}$ $\mu_j$, in essence, is a function of some underlying characteristic of country $j$, most importantly the skill (i.e. educational attainment) of the labor-force in country $j$.

$\sigma_h > 1$ is the elasticity of substitution among composite country-level varieties of product $h$. I will refer to $\sigma_h$ as the cross-country elasticity, which varies by product category. $\frac{1}{\sigma_h}$, therefore, denotes the level of differentiation in product category $h$. There is a one-to-one mapping from the product space to the level of differentiation

$$\frac{1}{\sigma_h} : [0, \bar{h}] \rightarrow [0, \frac{1}{\sigma}]$$

The composite imported variety $Q_{jh}$ has the following construction

$$Q_{jh} = \left[ \int_{\omega \in \Omega_j} \frac{2\sigma_{h-1}^2}{q_{\omega jh} \sigma_h} d\omega \right]^{\frac{\gamma_h}{\sigma_{h-1}}}$$

where $q_{\omega jh}$ is the quantity of variety $\omega jh$ that consumers consume. $\gamma_h > 1$ is the elasticity of substitution across firm varieties within a country in product category $h$. I will refer to $\gamma_h$ as the within-country elasticity. The restriction I impose on the within-country elasticity is that it has the same ordering as $\sigma_h$ across all products, i.e. if $\sigma_h > \sigma_{h'} \implies \gamma_h > \gamma_{h'}$. In other words, I need to rule out the possibility that for some products the country-level varieties are very differentiated, but the firm-level varieties within a country utility can be written as

$$U_M = \left[ \sum_{s \in S} \left\{ \int_{h \in H_s} C_h^{\frac{s-1}{s}} \right\}^{\frac{s-1}{s}} \right]^{\frac{s}{s}}$$

where $\epsilon_s$ is the elasticity of substitution within industry $s$ and $\epsilon$ is the elasticity of substitution across industries. $H_s \subset H$ is the set of products in industry $s$. Assuming $\epsilon_s = \epsilon$ for all $s \in S$, then

$$U_M = \left[ \sum_{s \in S} \left\{ \int_{h \in H_s} C_h^{\frac{s-1}{s}} \right\}^{\frac{s-1}{s}} \right]^{\frac{s}{s}} = \left[ \int_{h \in H} C_h^{\frac{s-1}{s}} \right]^{\frac{s}{s}}$$

$^\text{17}$To be more precise, the sub-utility $C_h$ has the following form

$$C_h = \left[ \sum_{j \in C} \mu_j \frac{\sigma_{h-1}^2}{Q_{jh} \sigma_h} \right]^{\frac{\sigma_h}{\sigma_{h-1}}} , h \in H_s$$

Where $s \in S$ is any given industry which consists of products that are comparable in terms of their price and quality. The above formulation is somehow similar to Hallak and Schott [2011]. They, however, assume the same elasticity of substitution across all varieties in the same 2-digit sector. The assumption I impose, to maintain generality, is that $\mu_{jh} = \mu_j$ for all $s \in S$. 


possess a very low level of differentiation relative to one another. To incorporate this in a tractable way, I assume that \( \{\gamma_h\}_{h \in H} \) is a linear transformation of \( \{\sigma_h\}_{h \in H} \). Later, when I fit the model to data I will show that this assumption is borne out in the data.

**Assumption 1.** \( \{\gamma_h\}_{h \in H} = \{\eta \sigma_h\}_{h \in H} \), with \( \eta > 1 \)

The restriction that \( \eta > 1 \) is required to rule out trade equilibria with only one country supplying to each market.\(^{18}\) This restriction is also found to hold when I fit the model to data. A simple depiction of the patterns of product substitution is displayed in figure 3.

Each of the \( L_i \) consumers in country \( i \) are endowed with one unit of labor and therefore will have an income equal to the wage in \( i \), which I denote by \( w_i \). Utility maximization implies that the quantity demanded in country \( i \) of variety \( \omega' jh \) at price \( p_{\omega' jh}^i \) is

\[
q_{\omega' jh}^i = \mu_j \left( \frac{p_{\omega' jh}^i}{P_j^i} \right)^{-\eta \sigma_h} \frac{1}{\eta \sigma_h} \left( \frac{P_h^i}{P_j^i} \right)^{-1} \alpha \omega' L_j^i \frac{1}{p_{\omega' jh}^i} \tag{1}
\]

where \( P^i \) is the aggregate price index in country \( i \), while \( P_h^i \) is the price index of product \( h \) and \( P_j^i \) is the price index of country \( j \) within product \( h \) in country \( i \). The price indices are given by

\[
P_{jh}^i = \left\{ \int_{\omega' \in \Omega_{jh}^i} (p_{\omega' jh}^i)^{-1-\eta \sigma_h} d\omega' \right\}^{-\frac{1}{1-\eta \sigma_h}} \tag{2}
\]

\[
P_h^i = \left\{ \sum_{k \in C} \mu_k (p_{kh}^i)^{-1-\sigma_h} \right\}^{-\frac{1}{1-\sigma_h}} \tag{3}
\]

\(^{18}\) If \( \eta \leq 1 \) then as we will see later on, firms from the lowest price country will absorb all the revenues in the market.
\[ P^i = \left\{ \int_{h \in H} (P^h_i)^{1-\epsilon} \, dh \right\}^{\frac{1}{1-\epsilon}} \]  (4)

where \( \Omega^i_{jh} \) is the set of firms exporting to country \( i \) from country \( j \) in code \( h \). As a rule of thumb, the superscript refers to the country that is importing the variety, and the subscript refers to the variety (e.g. \( \omega_{jh} \)) that is being traded.

In the following subsection, I turn to describing the supply side of the global economy.

### 3.3 Supply

On the supply side, every country is populated with a big pool of homogenous multi-product firms. Each firm can potentially enter various markets, and sell all the products in \( H \). The market entry procedure is the following:

i. Every firm pays a per-market entry cost \( f^e \) (separately) for every market \( j \in C \) it enters. This includes the domestic market. For example, if a firm enters the domestic market and one other foreign market it has to pay the per-market entry cost twice.

ii. After entering a foreign market, the firm has to pay a per-product (and per-market) fixed exporting cost \( f \) to export each product \( h \). Firms do not pay the per-product fixed cost for domestic sales.

Eaton, Kortum, and Kramarz [2011] make a similar assumption in terms of entry, while the second assumption on the per-product fixed cost is also adopted by Arkolakis and Muendler [2010]. However, unlike these studies, both the per-market entry cost \( (f^e) \) and the per-product exporting cost \( (f) \) are paid in terms of labor in the country of origin. Moreover, the fixed and entry costs are not product or country-specific; the same cost is incurred for all markets and all products. Paying the entry cost per market rather than once (for all markets) is not critical for the results of the paper. The entry cost (regardless of how it is paid) gives rise to economies of scope, which creates rents for firms that can profitably export a wider scope of products.\(^{19}\)

The per-market entry is a conservative assumption in terms of the gains from trade (shown later), since it results in less firm entry into markets. The per-product fixed exporting costs are, however, critical to the results of the paper.\(^{20}\)

\(^{19}\) As I will show later, firms from high-wage countries have a wider scope of exports and benefit from these rents.

\(^{20}\) In the data, multi-product firms dominate domestic production and international trade. In the United States, firms manufacturing more than one product account for more than 90 percent of total manufacturing shipments, while firms that export multiple products represent more than 95 percent of total exports (Bernard, Redding, and Schott [2006b]). Apart from multi-production being a realistic stance, the reason I assume multi-product firms is two-folded. First, “shipping the good apples out,” is documented as a within-firm behavior, and one goal of the model is account for this regularity. Second, it gives rise to economies of scope which (as we will see later) creates some rents for firms in wealthy countries. Trade data suggests that trade activity is much more intense among rich countries. Within my model, economies of scope could be one channel, among others, to explain the gap between North and South in the international trade scene.
All the firms in a country share the exact same production technology. For firms in country \( j \), the cost of producing \( q \) units of product \( h \) and selling them in country \( i \) is

\[
c^j_{\omega jh}(q) = c^j_i(q) = \tau_{ji}w_jq + w_jf, \quad \forall \omega \in \Omega_j, \forall h \in H
\]

\( \tau_{ji}w_j \) is the marginal cost of production, which is the same for all products in \( H \)—the marginal labor requirement of production all is one. \( \tau_{ji} \) is the iceberg transportation cost from country \( j \) to \( i \); and \( \tau_{ji} = 1 \). The marginal labor requirement of production is the same for all countries and all firms. However, with one unit of labor some countries produce higher quality varieties. Putting it differently, with one unit of labor all countries produce a single quantity of the manufactured good, but the single good contains a country-specific amount of utils.

For domestic firms in country \( i \) the cost of producing \( q \) units and selling them domestically would be

\[
c^i_{\omega ih}(q) = w_iq, \quad \forall \omega \in \Omega_i, \forall h \in H
\]

Domestic firms pay neither the per-product fixed cost nor the iceberg transportation cost, but they do pay the entry cost. As noted before, the per-market entry cost is paid upfront. Post entry, firms decide on which products to sell and what prices to charge. Potentially, firms from country \( j \) can sell all the products (in \( H \)) after entry. The (incremental) product-specific profit they collect conditional on selling product \( h \) in country \( i \) will be

\[
\pi^i_{\omega jh} = \max_{p^i_{\omega jh}} \left[ p^i_{\omega jh} - \tau_{ji}w_j \right] q^i_{\omega jh} - w_jf
\]

where \( p^i_{\omega jh} \) is the price that firm \( \omega \) from \( j \) charges for variety \( \omega jh \) in country \( i \). The profit maximizing firms would charge a product-specific markup over the marginal cost

\[
p^i_{\omega jh} = p^i_{jh} = \frac{\eta \sigma_h}{\eta \sigma_h - 1} \tau_{ji}w_j, \quad \omega \in \Omega^i_{\omega jh}, \quad j \in C, \quad h \in H
\]

The markup \( \left( \frac{\eta \sigma_h}{\eta \sigma_h - 1} \right) \) is decreasing in \( \sigma_h \), so firms charge a higher markup for products with a higher level of differentiation, i.e., lower \( \sigma_h \). Price being higher for more differentiated products is an endogenous outcome and a key ingredient of the model. The current literature attributes higher prices to higher product-specific quality. In my model, however, a higher price reflects a higher level of differentiation. The underlying argument of the paper will be that what we see in the data regarding the price of traded goods could be largely explained with differences in markups across products. Note, again, that whenever I compare
prices across products, I will be considering subsets of products that belong to the same industry, and have comparable prices.

Note that firms from country \( j \) all charge the same price and make the same product-specific profit conditional on selling the product, i.e. \( \pi^i_{\omega hj} = \pi^i_{\omega hj} = \pi^i_{\omega hj} \forall \omega, \omega' \in \Omega^i_{\omega hj} \) where \( \Omega^i_{\omega hj} \) is the set of firms from \( j \) who who enter market \( i \) and sell product \( h \) (among other products). The total profits collected by firm \( \omega \) from country \( j \) gross of entry cost will then be \( \int_{h \in H^i_{\omega hj}} \pi^i_{\omega hj} dh \), where \( H^i_{\omega hj} \) is the set of products the firm could profitably sell after entering market \( i \). In the next subsection I will describe the free entry condition in detail.

The pure price (as Hallak and Schott [2011] put it) of variety \( \omega j h \) is

\[
\frac{p^i_{\omega hj}}{\mu^1_j (\sigma_n - 1)} = \frac{\eta \sigma_h}{\eta \sigma_h - 1} \tau^i_{\omega hj}, \quad \omega \in \Omega^i_{\omega hj}, \; j \in C, \; h \in H
\]

Pure price is price per unit of utils rather than price per unit of quantity. The pure price is what consumers care about, and determines demand for every variety (in equation (1)). Similarly, \( \tau^i_{\omega hj} \) could be thought of as the effective pure wage of country \( j \) in product category \( h \). The product-specific effective pure wage determines a country’s competitiveness in the global markets in each product category.

Finally, The market for the non-manufactured product is assumed to be perfectly competitive. The marginal labor requirement for producing one unit of the manufacturing product is one. Hence, the price of the non-traded non-manufactured product in country \( i \) is \( w^i \), and a share \((1 - \alpha)\) of labor in country \( i \) will be allocated to production of the non-manufactured product in equilibrium.

### 3.4 Equilibrium

I denote the mass of firms that enter country \( i \)'s market from country \( j \) as \( M^i_j \). When a firm pays the per-market entry cost it can sell each product in that market conditional on paying an additional per-product exporting fixed cost. Of the mass \( M^i_j \) of firms who pay to enter market \( i \) from \( j \), some or all of them will sell product \( h \) up to point that there are either no profits left for additional firms or all the entrants are already selling. Let \( M^i_{jh} \) denotes the measure of firms who sell \( h \in H \) in country \( i \) from \( j \). It is very clear that \( M^i_{jh} < M^i_j \) given that there can not be more firms selling a product than the measure of firms who paid the entry cost. If \( M^i_{jh} \) firms sell product \( h \) in \( i \) then each of them will collect a product-specific profit equal to

\[
\pi^i_{jh} = \frac{1}{\eta \sigma_h} (M^i_{jh})^{\frac{\sigma_h - 1}{\sigma_n - 1}} \left( \frac{p^i_{\omega hj}}{P^i_h} \right)^{1 - \sigma_h} \left( \frac{P^i_h}{P^i} \right)^{1 - \epsilon} \alpha w^i L^i - w^i f
\]
where $p^j_{jh}$ is the monopolistic competitive price given by equation (5). I would like to reiterate that after paying the per-market entry cost for market $i$, firms from $j$ will sell the products in $H$ to the point that either (1) no profits are left for extra sales (i.e. $\pi^i_{jh} = 0$), or (2) all the mass $M^i_j$ of entrants are already selling. Hence, from equation (6) the mass of firms from country $j$ selling product $h$ in market $i$ will be

$$M^i_{jh} = \min \left\{ M^i_j, \left[ \left( \frac{p^j_{jh}}{P^i_h} \right)^{1-\sigma_h} \left( \frac{\mu^i_h}{P^i_h} \right)^{1-\epsilon} \alpha w_i L_i \right] \frac{\eta \sigma_h - 1}{\sigma_h (\eta - 1)} \right\}$$  \hspace{1cm} (7)

The above property implies that for some products in $H$, firms from $j$ collect positive profits and $M^i_{jh} = M^i_j$, while for some others the firms crowd the market to the point that profits are zero and $M^i_{jh} \leq M^i_j$. The mass of entrants $M^i_j$ is itself pinned down by the free entry (FE) condition

$$\int_{h \in H} \pi^i_{jh} \nu^i_j(h) dh = w_j f^e \hspace{1cm} (FE)$$

where $\int_{h \in H} \pi^i_{jh} \nu^i_j(h) dh$ is the expected profits from entry to market $i$ (gross of entry cost) for a typical firm from country $j$. $\nu^i_j(h)$ is the fraction of mass $M^i_j$ (of firms that enter market $i$ from $j$) that sell product $h$.

$$\nu^i_j(h) = \frac{M^i_{jh}}{M^i_j} \in [0, 1]$$

I will refer to $\nu^i_j(h)$ as the participation rate. I will use the following terminology in this paper: if all the entrants from $j$ are selling product $h$ in $i$ (i.e. $\nu^i_j(h) = 1$) I will say that country $j$ is exporting $h$ at full intensity. There are products that only a small fraction of entrants from country $j$ will sell; in this case I will say that $j$ exports those products to $i$ at low-intensity.

Wages in country $i$ are pinned down by labor market clearing (LMC) condition

---

21 In the product categories that a fraction of firms sell, i.e. $\nu^i_j(h) < 1$, profits net of per-product fixed cost are zero, therefore, the expected profits from entry are the same for all firms from $j$. In other words, only the product that all the entrants from $j$ sell yield positive profits gross of entry cost.

22 The free entry condition can be rewritten as

$$\int_{h \in H^i_j} \pi^i_{jh} dh = w_j f^e \hspace{1cm} (FE)$$

where

$$H^i_j = \{ h \in H \mid \pi^i_{jh} > 0 \} = \{ h \in H \mid \nu^i_j(h) = 1 \}$$

Thus, when solving for equilibrium one can first solve for the mass of entrants, i.e. $M^i_j$, independent of $\nu^i_j(h)$ from the above (FE) condition—because only products for which $\nu^i_j(h) = 1$ yield positive profits net of per-product fixed cost. After solving for $M^i_j$, I can solve for $\nu^i_j(h)$ and $H^i_j$ using equation (7). Then, I can iterate over this until convergence is achieved.
\[ \alpha L^i = \left( M^i f^e + \int_{h \in H} q^{ih} M^i \nu^i(h) dh \right) + \left( \sum_{k \neq i} M^k f^e + \int_{h \in H} \left( \tau_{ik} q^{ih} + \bar{f} \right) M^k \nu^k(h) dh \right) \] (LMC)

The product market clearing condition is the following and clears by Walras’ law

\[ \sum_{k \in C} \int_{h \in H^i_k} p^{i}_{kh} q^{kh} M^i_k \nu^i_k(h) dh = \alpha w^i L^i \] (PMC)

Given the market clearing conditions, I can now define the global equilibrium.

**Definition.** Given \( \{L_i\}_{i \in C}, \{\tau_{ij}\}_{i,j \in C}, \{\mu_j\}_{j \in C}, f, f^e, \alpha, \eta, \epsilon \) and \( \{\sigma_h\}_{h \in H} \), a **global equilibrium** is a set of wages \( w_i \), mass of firms \( M^i_j \), a participation rate \( \nu^i_j(h) \), price indices \( P^i_h, P^i \), prices \( p^i_{j, h} \) and consumer allocations \( q^{i,jh} \), profits \( \pi^i_{j, h} \) and scope of production \( H^i_j \) such that

(i) Equation (1) is the solution of the consumers optimization problem.
(ii) \( p^i_{j, h} \) solves the firms’ profit maximization problem—equation (5).
(iii) \( \nu^i_j(h) = \frac{M^i_{j, h}}{M^i} \) where the mass of sellers \( M^i_{j, h} \) is given by equation (7).
(iv) \( P^i_h \) and \( P^i \) are given by equations (3) and (4) respectively.
(v) The free entry condition (FE) holds.
(vi) The labor market clearing condition (LMC) holds.

### 3.5 Gravity

The model gives rise to a two-tier gravity equation. Let \( X^i_{j, h} \) be total spending in country \( i \) on varieties from country \( j \) in product category \( h \), i.e. \( X^i_{j, h} = p^i_{j, h} q^{j, ih} M^i_{j, h} \). Then, the lower tier gravity equation for product \( h \) will be the following

\[ \chi^i_{j, h} = \frac{X^i_{j, h}}{\sum_{k \in C} X^i_{k, h}} = \frac{\mu_j \left( M^i_{j, h} \right)^{\frac{1}{\sigma_h - 1}} [w^i_j \tau_{ij}]^{(1 - \sigma_h)}}{\sum_{k \in C} \mu_k \left( M^i_{k, h} \right)^{\frac{1}{\sigma_h - 1}} [w^i_k \tau_{ki}]^{(1 - \sigma_h)}} \] \( i, j \in C \) (8)

\( \chi^i_{j, h} \) is the share of spending on varieties from country \( j \) within product category \( h \). One property of the above gravity equation is that the trade elasticities, i.e. elasticity of trade volumes with respect to iceberg trade costs, are lower in highly differentiated product categories.

The upper tier gravity equation captures the relative spending on various product categories in \( H \). Let \( X^i_h \) denote total spending in country \( i \) on product \( h \) (i.e. \( X^i_h = \sum_{k \in C} X^i_{k, h} \)), and let \( X^i \) be total spending in country \( i \) on manufactured products (i.e. \( X^i = \int_h X^i_h dh = \alpha w^i L^i \)). The share of spending on product \( h \) in
country $i$ will be

$$\lambda^i_h = \frac{X^i_h}{X^i} = \int_{h'} \left[ \frac{\eta^i}{\eta^{i'} - 1} \right] \left( \frac{1}{\sigma_h} \right) \left\{ \sum_{k \in H} \mu_k \left( M_{kh} \right)^{\sigma_k - 1} \left( \frac{w_{k} \tau_{ki}}{\tau_{ki}'} \right)^{1 - \sigma_h} \right\} \frac{1}{\sigma_h - 1} dh', \quad h \in H \quad (9)$$

A novel future of equation (9) is that love of variety is stronger in more differentiated product categories. Therefore, if the number of varieties in a country rises, spending will be redirected towards more differentiated products, so consumers can benefit from the extra variety. This result, which is explained thoroughly in appendix B, makes wealthy countries with big markets and many varieties spend relatively more on more differentiated and high-price products.

3.6 Patterns of Trade Across Exporters

Shipping the good apples out

One empirical regularity that conventional gravity models do not account for is that, within a comparable set of products, export f.o.b (free on board) unit values are positively related to trade costs, i.e. only the most expensive products are shipped to the far corners of the world. That is to say, as trade costs go up exporters lose their competitiveness disproportionately for cheap products and specialize in exporting expensive products.\(^{23}\) Here, I show how the present model accounts for this regularity. To isolate the effect of trade costs, consider two countries $i$ and $j$ that have similar aggregate qualities ($\mu_i = \mu_j$) and equilibrium wages ($w_i = w_j$).\(^{24}\) Suppose firms in country $j$ incur larger trade costs relative to firms in $i$ when delivering to a third market $k$, i.e. $\tau_{ik} < \tau_{jk}$. Then, from equation (8), the value of exports from $i$ relative to $j$ of product $h$ will be

$$\lambda^i_{h|kh} = \left( \frac{M^i_{kh}}{M^j_{kh}} \right)^{\sigma_h - 1} \left( \frac{\tau_{jk}}{\tau_{ik}} \right)^{1 - \sigma_h} \left( \frac{\tau_{ik}}{\tau_{ik}'} \right)^{\sigma_h - 1}, \quad h \in H_s \subset H, \quad k \neq i, j$$

where $H_s$ is a subset of products that belong the same industry $s$.\(^{25}\) It is straightforward to show that due to higher trade costs, relatively less firms from country $j$ would export to country $k$, i.e. $M^k_{jh} \leq M^i_{ih}$ for each $h \in H_s$.

In the above equation two factors determine trade flows: the mass of exporters and the iceberg trade costs, both of which work towards lowering relative trade flows from country $j$. As the level of differ-

\(^{23}\)Baldwin and Harrigan [2011] have a survey of the leading trade models and show that all leading models generate results that are inconsistent with this empirical regularity. As Hummels and Skiba [2004] show, the Alchian-Allen hypothesis can account for the effect of trade costs on price, assuming high quality products are more expensive and trade costs are additive. However, the fact that trade costs are additive can be disputed (Lashkaripour [2013]).

\(^{24}\)This will be the case if, for example, one country has a smaller population while the other country enjoys a better geographical location and lower trade costs.

\(^{25}\)Products that belong to the same industry have comparable units of measurement and comparable prices.
entiation rises (or as \( \sigma_h \) falls), both \( \frac{\sigma_h - 1}{\eta \sigma_h - 1} \) and \( \sigma_h - 1 \) fall. Hence, the disadvantage of country \( j \), which faces higher trade costs, would diminish with the level of differentiation; country \( j \) becomes relatively more competitive as products become more differentiated. Firms from country \( j \) will only export the most differentiated products at full intensity (i.e. \( \nu_j^h(h) = 1 \) only for products with very low \( \sigma_h \)). In the less-differentiated product categories, sales and markups collected by firms from country \( j \) are very low and only a small fraction of firms that enter market \( k \) from \( j \) will manage to sell the less-differentiated products (before profits are drawn to zero). Consequently, within an given industry, the export bundle of firms from country \( j \) will comprise of higher priced-high markup products. Furthermore, (considering the entire product space \( H \)) the scope of exports for the average firm from \( j \) will be narrower and concentrated towards highly differentiated products.\(^{26}\)

**North Versus South (The Big Divide)** When rich and poor countries export goods from the same industry, the richer countries sell goods with higher unit values (Schott [2004]; Hallak and Schott [2011]; Hummels and Klenow [2005]). Also, when a country imports goods in an industry from several sources, the expensive goods are imported disproportionately from the higher-income countries (Hallak [2006]).\(^{27}\) Moreover, rich countries export a higher share of their GDP relative to poor countries (Fieler [2011]; Waugh [2010]).

Now, I explain how my model accounts for these patterns of trade across rich and poor countries. To isolate the effect of country-specific quality (or wage) on patterns of trade, consider two geographically identical countries \( n \) (North) and \( s \) (South) that have the same population. North is endowed with a higher aggregate quality: \( \mu_n > \mu_s \). As a result, in equilibrium there is more demand for varieties produced in North, which results in higher equilibrium wages in North relative to South, i.e. \( w_n > w_s \). Form the gravity equation (8), the spending on varieties from North relative to varieties from South of product \( h \) (in country \( i \)) is

\[
\frac{\lambda_{n|h}}{\lambda_{s|h}} = \frac{\mu_n}{\mu_s} \left( \frac{M_{n|h}}{M_{s|h}} \right)^{\frac{\sigma_h - 1}{\eta \sigma_h - 1}} \left[ \frac{w_s}{w_n} \right]^{(\sigma_h - 1)}, \quad h \in H, \quad i \neq n, s
\]

Two factors control the competitiveness of North relative to South: the ratio of their wages \( \frac{w_n}{w_s} \) and ratio of their aggregate qualities \( \frac{\mu_n}{\mu_s} \). The level of differentiation \( \frac{1}{\sigma_h} \) controls the relative importance of these

\(^{26}\)This argument will still hold if I allow for product-specific quality differences between the product categories in \( H \). In this case, I will need the extra assumption that high quality products are also more differentiated.

\(^{27}\)Schott [2004] looks at variations within 2 and 3-digit SITC-5 industry variations in unit values. Hallak [2006] and Hallak and Schott [2011] look at variations within 2 and 3-digit SIC sectors. Each SIC sector and SITC industry consists of many narrowly defined products, which are characterized by a 10-digit HS code number. Khandelwal [2010] looks at within HS-10 code variations in unit values and his results indicate that the estimated quality and f.o.b unit values move in significantly opposite directions. My claim is that within a class of products, say SITC-5 industry, higher unit values from an exporter could indicate selection into more differentiated and expensive HS-10 categories, rather than higher quality categories.
two factors. In more differentiated product categories the importance of wage diminishes and the relative importance of aggregate quality increases. This effect is mirrored by the mass of entrants and \( \frac{M^L_i}{M^L_k} \), which will be non-decreasing in \( \frac{1}{\sigma_i} \), there are relatively more firms in highly differentiated categories from North.

Given these two channels, North has competitive advantage in high markup-highly differentiated products, while South has competitive advantage in low markup-less differentiated products.\(^{28}\) Firms from North specialize in highly differentiated product categories and, within each industry, their exports comprise an expensive mix of products that exhibit high markups.\(^{29}\)

The above argument is illustrated in figure 4. Figure 4 compares pure wages (\( \frac{w_i}{\mu_i/(1-\sigma)} \)) in North and South. As I argued earlier, pure wage represents the competitiveness of a country and varies with the level of differentiation in a product category. The lower the pure wage the more competitive a country. In the baseline Krugman-Armington model (\( \sigma_h = \sigma \) for all \( h \in H \), and \( \eta \rightarrow 1 \)), pure wage (\( \frac{w_i}{\mu_i/(1-\sigma)} \)) will be the same for all products an equalized across countries conditional on geography. Since two geographically similar countries will trade the same both in terms of prices and share of exports in GDP.

In the framework of the model, less-differentiated products are not traded intensively because firms charge low markups for those products, but have to pay the same per-product fixed cost to export them.\(^{30}\) This implies that poor countries have an edge over rich countries in products, which do not generate enough profits to be worth exporting. To demonstrate this, I redraw figure 4, this time for products that are traded intensively. The result is displayed in figure 5. As seen, that the scope of competitive advantage for South (low-wage countries) is very narrow when taking into account only products that are intensively traded. In fact, the majority of sales by firms located in low-wage countries would be domestic sales.

Proposition 1 summarizes the above results.

**Proposition 1.** For any two countries \( n \) (North) and \( s \) (South); ceteris paribus, if \( \mu_n > \mu_s \) then

(i) \( w_n > w_s \): wages in North (\( n \)) are higher than South (\( s \)).

(ii) North (\( n \)) exports on average more differentiated products (and higher-price products, within an industry) relative to South (\( s \)).

(iii) North (\( n \)) exports a larger share of its GDP relative to South (\( s \)).

**Proof.** see Appendix A.3

\(^{28}\)This result is in line with the existing literature in open macro about rich countries having comparative advantage in differentiated sectors (Kraay and Ventura [2007]). Apart from the fact that differentiation is conceptually different in this model, the big difference is that those models fall under the category of specific factors models. Rich countries in those models import predominantly from poor countries, which is at odds with the empirical evidence. What the present model brings to the table is embedding patterns of competitive advantage in a new trade model. As I will argue the willingness to trade with other countries of similar income is very well preserved in this model.

\(^{29}\)Mathematically, I can show that for every pair of countries \( i \) and \( j \) where \( \mu_i > \mu_j \), there exists a cutoff \( \frac{1}{\sigma_i} \) such that country \( i \) has competitive advantage (relative to \( j \)) in products with a level of differentiation above the cut-off, i.e. \( \frac{1}{\sigma_i} > \frac{1}{\sigma_j} \), and vice versa.

\(^{30}\)As noted before, by traded with low intensity I mean that only a small fraction of foreign firms sell the product post entry, i.e. \( \nu_j(h) < 1 \).
Figure 4: Patterns of competitive advantage between North ($n$) and South ($s$). Note that $\mu_n > \mu_s$ and $w_n > w_s$. 
To wrap up the section I will discuss one last implication of the model regarding North and South trade. It is well understood that the public’s fear of globalization is often rooted in the vulnerability of US jobs to low-wage competition. Bernard, Jensen, and Schott [2006a] provide evidence that the probability of US plant survival and employment growth are negatively associated with an industry’s exposure to import penetration, particularly from low-wage countries. Khandelwal [2010] argues that low-wage import penetration in the US will have less impact on employment and wages in industries where the quality ladder is long. Patterns of comparative advantage in my model suggest that industries with a high level of differentiation (i.e. low elasticity) will be largely insulated from wage movements in low-wage countries. Lower wages in the apparel sector in China can largely affect employment in the apparel sector in the US, but lower wages in the industrial machinery sector in China will have much less of an impact on employment in the US (given the high quality of US varieties). I will explore this implication of the model in more detail when I take the model to data in section 4.
3.6.1 Discussion

A rich body of studies has addressed the patterns of trade explained in the previous section. Hummels and Skiba [2004], and Baldwin and Harrigan [2011] have developed models to explain shipping the good apples out effect. Fajgelbaum et al. [2011] develop a model to explain why rich countries export high unit value products, and why a country imports high unit value products disproportionately from richer countries. Fierler [2011] and Waugh [2010] develop models to explain why rich countries export/import a higher share of their GDP relative to poor countries. The pioneering work of these studies has improved our understanding of international trade substantially. This paper itself was largely inspired by these studies. To achieve their results these papers have had to move away from some of the simplifying assumptions in mainstream trade theory. To explain patterns of trade across rich and poor countries it is assumed that demand is non-homothetic, and to explain “shipping the good apples out” trade costs are assumed to be additive.

The goal of this paper is to match these first order facts simultaneously with minimal deviation from the assumptions that make new trade theories tractable and easy to quantify. To this end, my model preserves the assumptions that demand is homothetic and trade costs are symmetric and of the iceberg type. However, there is more structure imposed on demand than in the baseline Krugman model. Some results of the model are immune to the extra structure and some are not. “Shipping the good apples” out depends only on heterogeneity in elasticities across products. It actually holds regardless of whether trade costs are additive or iceberg. Rich countries exporting high-price products relies on both heterogeneity in elasticities and inclusion of country-specific demand shifters. The result on rich countries trading a higher share of their GDP relies on heterogeneity in elasticities, country-specific demand shifters and the per-product fixed cost of exporting.

The results in this paper rely on firms incurring an entry cost. The results, however, do not depend on the entry cost being incurred per-market (as apposed to once for all markets). Also, the fact that entry and fixed costs are paid in terms of labor in the country of origin is not key to the results of the model; it magnifies the self-selection of firms from rich countries into highly differentiated products. However, the assumption is not necessary for the self-selection to happen.

31 Washington apples effect is another name used in the literature in reference to “shipping the good apples out.”
32 One exception is Waugh [2010] who assumes asymmetric trade costs to explain the high intensity of trade among rich countries. Markusen [2013] and Feenstra and Romalis [2012] are other papers that address the patterns of trade across countries with different levels of per capita income. Both papers assume non-homothetic preferences.
33 The result, however, does not depend on how the country-specific quality (demand shifter μj) enters the utility function.
34 The assumption does, however, simplify solving for the model numerically.
3.7 Trade Liberalization: More Gain than Pain

In this section I will briefly discuss the effects of trade liberalization on the number of varieties in different markets. Then, I will analyze the welfare implications of the model in some depth.

Lowering iceberg trade costs will lead to more foreign entry. Multi-product foreign firms will enter the market and crowd out a portion of the multi-product domestic firms. Consider a baseline setting in which $h = \sigma, \forall h$ and $\eta \to 1$.\(^{35}\) The total number of varieties in a given market will either drop or remain the same after lowering the trade costs in the baseline setting.\(^{36}\) In the main model, on the other hand, trade would always be more pro-variety relative to the baseline (I demonstrate the pro-variety effects of trade in the new model in detail in appendix A.1). As noted earlier, the market-entry procedure adopted in this paper is conservative in terms of the gains from variety. Adopting a conventional entry scheme (paying an entry cost once and for all markets) will assure that the total number of varieties do not drop after trade liberalization even in the baseline model.\(^{37}\) The results of the paper do not rely on the per-market entry procedure and the main reason I assume it, is to demonstrate how the model generates big gains from trade even under conservative entry assumptions.

To analyze the gains from trade I implement the approach proposed by Arkolakis et al. [2012].\(^{38}\) Small changes in real wage (i.e. indirect utility) as a result of slightly lowering the iceberg trade costs (or any exogenous shock) will be given by\(^{39}\)

$$d\ln \frac{w_i}{P_i} = -\int_h \frac{d\ln \lambda^i_{1/h}}{\sigma_h - 1} dh + \left[\int_h \frac{1}{\eta \sigma_h - 1} \lambda^i_h dh\right] d\ln M^i_t$$  \hspace{1cm} (11)

Using the free entry condition and some algebra the above equation can be re-written as\(^{40}\)

\(^{35}\)The outcomes of the model can be no-trade when $\eta \leq 1$. From here on by $\eta \to 1$, I mean $\eta$ approaches 1 from the right: $\eta \to 1^+$.\(^{36}\)In the absence of per-market fixed exporting costs ($f$) the total number of varieties in the baseline model does not change after lowering the iceberg trade costs. However, when fixed exporting costs are present the number of varieties in the market drops after lowering the iceberg costs. Finally, when entry cost is payed once and for all markets (which is the case in Krugman [1980] and Melitz [2003]) the total number of varieties in every market would increase after lowering the iceberg trade costs. See appendix A.1 for a formal argument on this.\(^{37}\)The intuition is simple; when the entry cost is paid multiple times instead of once and for all markets, there would be less incentive for firm entry.\(^{38}\)In this section when I talk about the gains from trade I am referring to the change in the indirect utility from consumption of the manufactured goods, i.e. $d\ln U_M$. The total change in welfare will therefore be $d\ln V = \alpha d\ln U_M$ where $\alpha$ is the share of spending on manufactured goods.\(^{39}\)For a derivation of equations (11) and (12) see appendix A.4. The second term, i.e. $\left[\int_h \frac{1}{\eta \sigma_h - 1} \lambda^i_h dh\right] d\ln M^i_t$, is negative in my model and would be zero if entry cost was paid once and for all markets as in Arkolakis et al. [2012]. What makes the entry procedure adopted in this paper more conservative in terms of the gains from trade, is allowing for the second term to be non-zero.\(^{40}\)As $\eta \to 1$ the model gives rise to special case equilibria with the possibility of no trade. For example, if the economy is symmetric such that the domestic varieties are the cheapest then $d\ln \lambda^i_{1/h} \to 0$. The other possibility that could arise is switching to cheapest alternative that could possibly be non-domestic and in that case $d\ln \lambda^i_{1/h} \to \infty$. The term in the braces disappears under two circumstances: (1) if $\eta \to \infty$ in which case every country would be one firm, or (2) when entry is once and for all markets (as in Arkolakis et al. [2012]) rather than per-market.
\[ d \ln \frac{w_i^i}{P_i^h} = \int_h -\frac{d \ln \lambda_{i|h}^i \lambda_i^h}{\sigma_i - 1} dh \left\{ 1 - \left[ \frac{\int_h \frac{1}{\sigma_i} \lambda_i^h dh}{\int_h \frac{1}{\sigma_i - 1} \lambda_i^h dh} \right] \right\} \]  

(12)

I can then break down the change in welfare and examine the effect per product. In particular, for every product \( h \) small changes in purchasing power will be given by \( 41 \)

\[ d \ln \frac{w_i}{P_i} = \frac{-d \ln \lambda_{i|h}^i}{\sigma_i - 1} + \frac{d \ln M_i^i}{\eta \sigma_i - 1} \]  

(13)

When trade costs are lowered, some multi-product domestic firms leave to create room for the multi-product foreign firms. The multi-product domestic firms sell all the products at full intensity because they do not pay the per-product fixed cost after entry. The multi-product foreign firms, on the other hand, only sell the expensive and differentiated products after they enter (only a very small portion of them will sell the less-differentiated products). \( 42 \) In the highly differentiated product categories the loss of domestic varieties (the second term on the RHS in equation (13)) is offset by extensive foreign entry in those products (the first term on the RHS in equation (13)). The overall gains are larger in the new model relative to the baseline (or the general setting proposed by Arkolakis et al. \([2012]\)) for the following reason: in equation (12) if \( \sigma_i < \sigma_i^h \), then \( -d \ln \lambda_{i|h}^i > -d \ln \lambda_{i|h}^i \). \( 43 \) Therefore, changes in the import flows (i.e. \( -d \ln \lambda_{i|h}^i = \sum_{j \neq i} d \lambda_{j|i}^i \)) are larger in more differentiated products where consumers benefit more from having the foreign varieties. Putting it differently, foreign varieties are concentrated where consumers want them to be.

The above result is closely related to two studies. Arkolakis et al. \([2008]\) argue that the gains from variety are not that much. \( 44 \) What my theory suggests is that after opening to trade, foreign varieties crowd the highly differentiated product categories (i.e. trade happens relatively more in differentiated products), and that is where consumers benefit the most from their availability. More precisely, observed aggregate trade flows are not sufficient statistics for measuring the gains from trade. We should break down aggregate flows into product-specific flows and weight them according to the level of differentiation in each product category. If one restricts elasticity to be the same across all products, the new foreign varieties that arrive (post trade liberalization) are evenly spread out across all categories. Consequently, the gains from these

\( 41 \) note that if entry was once and for all markets (as in Arkolakis et al. \([2012]\)) rather than per-market, then \( \frac{d \ln M_i^i}{\eta \sigma_i - 1} = 0 \).

\( 42 \) A reminder about the terminology I use in this paper: The firms from a country sell product \( h \) at full intensity if all of them participate in selling \( h \) after entry: \( \nu_i^i(h) = 1 \). If firms from a country are not selling at full intensity, it means a fraction of entrants from that country sell until the product-specific profit for product \( h \) is drawn down to zero.

\( 43 \) This is true in the symmetric equilibrium. In an asymmetric equilibrium this is true for the disconnected intervals on \( H \) i.e. if \( H = [0, \bar{h}] \) is sorted in terms of the level of differentiation then there exists a \( \bar{h} \) such \( \int_0^h -d \ln \lambda_{i|h}^i > \int_0^h -d \ln \lambda_{i|h}^i \), and the argument will still go through.

\( 44 \) Arkolakis et al. \([2008]\) use import data from Costa Rica, to show that the number of varieties increased a lot in Costa Rica when trade was liberalized. However, they claim that since the new varieties absorb very low market shares, the gains from variety are not significant. My theory suggests that the results in Arkolakis et al. \([2008]\) are driven by weighting the new varieties with a high aggregate elasticity.
new varieties would measure up to be small. Ossa [2012] makes a similar argument, but the contribution of this paper is that it endogenizes the high import shares of highly differentiated products (or industries). Ossa [2012] fixes expenditure shares on industries to an exogenous number by assuming a cross-industry Cobb-Douglas utility function.

To dig deeper, I look at what happens underneath the large aggregate gains from trade. As note earlier, the number of varieties in less differentiated product categories slightly drops when trade costs are lowered. This imposes a loss of purchasing power in those categories. In equation (13) if $\sigma_h$ is very large then $d\ln \lambda_t \simeq 0$ since there will be barely any foreign entry (in those products) and changes in welfare will be

$$d\ln \frac{w_i}{P_h} \simeq \frac{d\ln M_i^h}{\eta \sigma_h - 1} < 0$$

where $dM_i^h < 0$ is the small drop in the number of domestic firms in market $i$ (as a result of lowering trade costs). Even though consumers’ purchasing power drops for the least-differentiated products, overall the consumers gain substantially from trade.\(^{45}\) A simple depiction of how lowering iceberg trade costs affect purchasing power (i.e. $\frac{w_i}{P_h}$ for product $h$) along the product differentiation ladder is displayed in figure 6.

To conclude this section, I should note that $\eta$ also affects the gains from trade; the larger $\eta$ the bigger the gains from trade for two reasons. First, as $\eta$ increases the consumers will care less about the loss in domestic varieties after trade—the second term on the RHS in equation (11). Also, a higher $\eta$ would magnify the concentrated foreign entry in highly differentiated products which I discussed earlier. These effects are captured in equation (12) and it is easy to see that as $\eta$ approaches one, the welfare gains from trade approach zero. If $\eta = 1$ then if iceberg trade cost are sufficiently large there will be no foreign entry at all.\(^{46}\) The intuition is that if there are many firms from one source country in a market, when $\eta = 1$ consumers do not care if the next firm which enters the market is also from the same country. Thus, they will buy everything from the cheapest source.

In the next section I fit the model to data and quantify the gains from trade (relative to autarky). My results show that the gains associated with opening to trade from autarky are around %15 of the real wage in the new model. When I shut down heterogeneity in the level of differentiation, the gains are only around 5%. Further, when I also lower $\eta$ to (approximately) one the gains are only 1% of the real wage. Mathematically, I can show that if one fits the new model to match observed trade shares the underlying gains from

\(^{45}\)In the CES context the model implies gains from trade for all households. In general, the CES framework with identical consumers has no implications about the distribution of the gains from trade (since everyone gains the same). The CES interpretation behind the demand function in equation (1), is one extreme interpretation. The other extreme is the logit interpretation where every consumer draws taste from a GEV distribution and spends all of his income on only one variety. In appendix B I show that according to the logit interpretation, the model implies that when trade is liberalized, consumers of the cheap less differentiated products lose, while the consumers of expensive highly differentiated products gain substantially. It is worth mentioning that if the per-product cost of exporting--$f$--is lowered to zero, the pro-variety effects of trade and consequently the gains will be seen across all product categories.

\(^{46}\)The reason I define the baseline as a model in which $\eta \to 1$ (rather than $\eta = 1$) is to avoid the no-trade knife-edge equilibrium.
trade would be larger than the baseline model with no heterogeneity in demand elasticities. This result is summarized in proposition 2 for a symmetric global economy where all countries are similar.

**Proposition 2.** Conditional on (the same) observed import shares (i.e. $\sum_{j \neq i} \lambda^i_j = 1 - \lambda^i_i$), the underlying gains from trade are larger in the new model relative to the baseline Krugman-Armington model (in the baseline model $\eta \rightarrow 1$ and the cross-country elasticity is constant across all products and equal to the average economy-wide elasticity $\sigma = \int_h \sigma_h \lambda^i_h dh, \ \forall h \in H$).

**Proof.** see Appendix A.4

---

47 Extending proposition 2 to hold for a non-symmetric global economy follows the same intuition provided in the proof of proposition 2. However, it requires looking at many possible cases that arise in equilibrium one by one.

48 For proposition 2 to hold, the choice of weights when calculating the baseline $\sigma$ do not necessarily need to be expenditure shares in the trade equilibrium (i.e $\lambda^i_h$). They may, as well, be expenditure shares in the autarky equilibrium, i.e. $\sigma = \int_h \sigma_h \lambda^i_h, \ \forall h$. 

---

Figure 6: A simple demonstration of changes in purchasing power across different products $(\frac{w}{P_i})$ when a country opens up to trade from autarky.
4 Mapping the Model to Data

This section maps the model presented in Section 3 to data. First, I will describe the data and provide some preliminary evidence on product differentiation. Second, I will identify the core demand parameters by estimating a micro-gravity equation for individual manufactured product categories. Third, I will plug the estimated demand parameters into my general equilibrium model and calibrate it to global bilateral trade flows. I will then compare the explanatory power of the new model relative to the baseline Armington-Krugman model. Finally, I will analyze the predictions of the calibrated model and perform a counterfactual welfare analysis to quantify the gains from trade.

4.1 Step 1: Estimating Demand Elasticities

4.1.1 Data description and preliminary evidence

The dataset used in this paper is the publicly available US import data compiled by Schott [2008]. The data documents US import values and quantities from different source countries in various 10-digit HS10 product codes. Every HS-10 product belongs to a 5-digit SITC-5 industry, and every SITC-5 industry belongs to a two-digit SIC-2 sector. Since the original data does not report SITC-5 industry codes, I use the data compiled by Feenstra et al. [2002] to map the HS-10 codes into SITC-5 industries, and map SITC-5 industries into SIC-2 sectors. The data used in this paper spans from 1989 to 2011.

An observation in the data set is an import record for an HS-10 product, from a particular exporting country, in a given year to a given U.S. city.49 Each observation documents import quantities, values, and the number of individual export cards (invoices) associated with that observation. In addition, the data includes tariff and freight charges and the units in which the reported quantity was measured. For my estimation, I consider only manufacturing industries (SITC 5-8) that are differentiated according to the classification developed by Rauch [1999]. I take the aggregate economic variables (population, GDP, etc.) from the Penn world tables and distance data from the CEPII data set compiled by Morey and Waldman [1998].

49The layout of the data is illustrated in table 14 in appendix D.
<table>
<thead>
<tr>
<th>Sector (SIC-2)</th>
<th>Industry Products (SITC-5)</th>
<th>Average Skill (HS-10)</th>
<th>Capital Intensity (GDP)</th>
<th>Skill Intensity</th>
<th>Capital Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Food</td>
<td>8</td>
<td>37</td>
<td>16,881</td>
<td>0.39</td>
<td>81.4</td>
</tr>
<tr>
<td>22 Textile</td>
<td>85</td>
<td>1,642</td>
<td>13,304</td>
<td>0.15</td>
<td>48.7</td>
</tr>
<tr>
<td>23 Apparel</td>
<td>68</td>
<td>2,560</td>
<td>7120</td>
<td>0.18</td>
<td>11.2</td>
</tr>
<tr>
<td>24 Lumber</td>
<td>20</td>
<td>262</td>
<td>12,634</td>
<td>0.20</td>
<td>36.3</td>
</tr>
<tr>
<td>25 Furniture</td>
<td>5</td>
<td>72</td>
<td>11,849</td>
<td>0.25</td>
<td>22.1</td>
</tr>
<tr>
<td>26 Paper</td>
<td>38</td>
<td>216</td>
<td>19,766</td>
<td>0.30</td>
<td>126.0</td>
</tr>
<tr>
<td>27 Printing</td>
<td>16</td>
<td>55</td>
<td>17,574</td>
<td>0.87</td>
<td>33.2</td>
</tr>
<tr>
<td>28 Chemicals</td>
<td>231</td>
<td>2,588</td>
<td>20,094</td>
<td>0.75</td>
<td>166.1</td>
</tr>
<tr>
<td>29 Petroleum</td>
<td>7</td>
<td>21</td>
<td>10,952</td>
<td>0.51</td>
<td>509.1</td>
</tr>
<tr>
<td>30 Rubber and plastic</td>
<td>45</td>
<td>515</td>
<td>14,119</td>
<td>0.29</td>
<td>48.5</td>
</tr>
<tr>
<td>31 Leather</td>
<td>17</td>
<td>403</td>
<td>6088</td>
<td>0.19</td>
<td>18.6</td>
</tr>
<tr>
<td>32 Stone and ceramic</td>
<td>57</td>
<td>357</td>
<td>15,133</td>
<td>0.29</td>
<td>78.6</td>
</tr>
<tr>
<td>33 Primary metal</td>
<td>98</td>
<td>1,372</td>
<td>16,864</td>
<td>0.29</td>
<td>157.1</td>
</tr>
<tr>
<td>34 Fabricate metal</td>
<td>78</td>
<td>599</td>
<td>17,364</td>
<td>0.35</td>
<td>53.0</td>
</tr>
<tr>
<td>35 Industrial machinery</td>
<td>169</td>
<td>1,632</td>
<td>21,035</td>
<td>0.57</td>
<td>63.1</td>
</tr>
<tr>
<td>36 Electronics</td>
<td>100</td>
<td>1,325</td>
<td>15,551</td>
<td>0.56</td>
<td>57.7</td>
</tr>
<tr>
<td>37 Transportation</td>
<td>43</td>
<td>372</td>
<td>23,096</td>
<td>0.52</td>
<td>68.6</td>
</tr>
<tr>
<td>38 Instruments</td>
<td>60</td>
<td>715</td>
<td>21,843</td>
<td>0.96</td>
<td>45.3</td>
</tr>
<tr>
<td>39 Miscellaneous</td>
<td>76</td>
<td>375</td>
<td>10,804</td>
<td>0.38</td>
<td>29.7</td>
</tr>
</tbody>
</table>

Table 1: The table provides summary statistics for SIC-2 (1987 revision) sectors. Column 1 reports the number of SITC-5 (revision 2) industries. Column 2 reports the total number of HS-10 products. Column 3 reports the weighted average of exporter per capita GDP. Columns 4 and 5 report skill (ratio of production to non-production workers) and capital intensity. (Source: Khandelwal [2010])

I trim the data along two different dimensions. First, I drop all the observations reporting varieties in which the quantity imported is one unit or the imported value is less than $5000 in 1989 dollars. Second, since the sample stretches over 22 years, to identify $\sigma_h$ and $\gamma_h$ I need sufficient cross-country variation to avoid the incidental parameters problem. To achieve this, I drop all HS-10 products, which report less than five exporting countries. In total, I’m left with for 5,847 HS-10 products for which I estimate the demand parameters.

For the estimation I need the number of firms that export to the U.S. from each country in every HS-10 code. I do not directly see the number of firms, but I see the total number of firm-specific invoices,
i.e. individual export cards filled in by individual firms, associated with each observation. Since high number of export cards can be due to large quantity annual of sales, I take the total number of export cards per quantity exported by country $j$ in an HS-10 code as a proxy for the number of firms exporting to the U.S. from country $j$ in that HS-10 code (i.e. $M_{jh}$).

The above proxy is quite crude and I use it due to lack of access to better data. There are two issues that can arise from using the above proxy. First, the proxy does not differentiate between one firm shipping to multiple US cities, and multiple firms selling to the same US city. Second, a firm might export to the US multiple times during the year. As noted, the second concern can be partially addressed by running the estimation with the number of invoices per quantity sold as a proxy for the number of firms. Figure 7 shows a scatter plot that compares the number of cards reported in the public US import data and the number of exporting firms as reported in the Bangladesh firm-level export data. The correlation between the number of firms and the proxy is 0.415 (partly due to imperfect concordance between HS codes in the two data sets).

To compare the approach I am taking relative to the literature, note that Khandelwal [2010] uses population of the exporting country to control for the extensive margin of trade. Other studies that estimate gravity at the same level of disaggregation (HS-10 product level) to my knowledge do not account for the extensive margin of trade (e.g. Broda and Weinstein [2006]). At the aggregate level Helpman et al. [2008] control for the extensive margin of trade by imposing theoretical structure on firms entry. They find that not accounting for the extensive margin (or hidden varieties) can significantly bias the trade elasticity estimates.

4.1.2 Estimating $\sigma_h$ and $\gamma_h$

In this section I will identify and estimate demand elasticities $\sigma_h$ and $\gamma_h$, where $h$ is now an HS-10 product code. In the theory section, I assumed that $\gamma_h = \eta \sigma_h , \forall h \in H$. Here, I will identify and estimate $\gamma_h$ for each $h$ (i.e. HS-10 product) separately which will also enable me to evaluate my theoretical assumption. Then, I will look at how the elasticity varies by sector and how it is correlated with f.o.b prices and the number of varieties in an HS-10 product code. To this end, I estimate a micro-gravity (demand) equation separately for each HS-10 product in my sample.

From equation (1), total U.S. spending on varieties from country $j$ in HS-10 code $h$ will be

---

50] In the words of Hummels and Schaur [2012]: “When a firm exports into the US they electronically file a Shippers Export Declaration Form, and the data on that form constitute one record. The public use imports data remove firm identifiers and aggregate over all the records with the same characteristics (i.e. same exporter, HS10 product, US customs district, month, and transportation mode), but include a count of records as a variable in the data. At the most disaggregated level of the imports data, most monthly observations consist of a single shipment, though some have multiple records.”


52] $\epsilon$ can be estimated looking at cross-HS10 variations; I perform this estimation in the appendix.
Figure 7: Scatter plot of the number of cards reported in the public US import data and the number of exporting firms from the Bangladesh firm-level export data. The correlation between the cards and the number of firms is 0.415 and is significant at the 99% confidence level. For six of the HS-10 products, the Bangladesh export data reports multiple exporters while the US import data reports only one invoice (export card). This can be due to the fact that HS-8 codes in the Bangladesh export data do not map one-to-one into HS-8 codes in the US import data.
\[
X_{jht} = \mu_j M_{j}^{\frac{\sigma_{h}-1}{\gamma_{h}-1}} \left( \frac{p_{jht}}{P} \right)^{1-\sigma_{h}} \left( \frac{P_{h}}{P} \right)^{1-\epsilon} \alpha w_{US,t} L_{US,t} 
\]

(14)

where \( M_{j} \) is the number of firms from country \( j \) exporting product \( h \) to the U.S. market. \( p_{jht} \) is the c.i.f unit value set by these firms for variety \( jh \). \( P_{h} \) is the price index of HS-10 code \( h \) given by equation (3), and \( P \) is the aggregate price index in the US given by equation (4). Log-linearizing equation (14) and adding a time subscript, we will have

\[
\ln X_{jht} = \frac{\sigma_{h}}{\gamma_{h}-1} \ln M_{jht} - (\sigma_{h} - 1) \ln p_{jht} + \ln \left( \frac{P_{ht}}{P_{t}} \right)^{1-\epsilon} \alpha w_{US,t} L_{US,t} + \ln \mu_{jht} 
\]

(15)

where \( t \) refers to a year from 1989 to 2011. \( \psi_{h,t} \) is a year-product fixed effect. \( \ln \mu_{jht} \) is the quality associated with country \( j \) in year \( t \)-product \( h \). In theory section I assumed that \( \mu_{jht} = \mu_{jt} \) \( \forall h \), i.e. \( \text{Corr}[\mu_{jht}, \mu_{jht'}] = 1 \). For the theory to hold, however, I either need \( \mu_{jht} \)'s for each country \( j \) to be sufficiently correlated across different HS-10 codes, or the gap in quality (\( \mu_{jht} \)) between rich and poor countries to widen as products become more differentiated. After estimating the demand parameters, I show that it is the latter case in data. I allow for Heteroskedasticity in \( \mu_{jht} \) across countries, and I also allow for \( \mu_{jht} \) to be correlated within a (source) country across time, i.e. \( \text{Cov}[\mu_{jht}, \mu_{jht'}] > 0 \) for all \( t \) and \( t' \) in the sample.\footnote{Broda and Weinstein [2006] do not allow for the country-specific qualities \( \mu_{jht} \)'s to be clustered by country across time.}

For every HS-10 code I have a separate equation to estimate, but since the error term \( \ln \mu_{jht} \) is (most likely) correlated across HS-10 codes I have a system of seemingly unrelated regressions (SUR). Nevertheless, because the explanatory variables are the same across the equations, estimating each equation separately at the HS-10 product level will yield consistent and efficient estimates (Greene [2003] p.343).\footnote{Estimating each equation separately regardless of whether or not the explanatory variable are the same across equations will yield consistent estimates. However, in some cases one has to use all the information in the cross equation variance-covariance matrix to achieve efficient estimates. In the present case however, the independent estimates are both consistent and efficient.} I also would not be able to identify \( \epsilon \) (i.e. the elasticity of substitution across HS-10 codes) with equation (15) since I would be looking at only within HS-10 code variations. In appendix D, I estimate an alternative demand equation by looking at across HS-10 and within-SITC-5 variations, which allows me to identify and estimate \( \epsilon \).

4.1.3 Identification

To identify \( \sigma_{h} \) and \( \gamma_{h} \), I will take the standard approach, which requires using supply-shifters to identify the demand curve. The strategy is to find a vector of instruments \( z \) that is uncorrelated with the country-specific quality residual \( \ln \mu_{jht} \). Let \( \Theta_{h} = (\gamma_{h}, \sigma_{h}) \) be the vector of parameters I estimate for product \( h \), and
If there are data on $X_{jht}$, $M_{jht}$, and $p_{jht}$, then the moment condition will be the following:

$$E[zG(\Theta_h; Y_h)] = 0$$

(16)

where

$$G(\Theta_h; Y_h) = \ln X_{jht} - \frac{\sigma_h - 1}{\gamma_h - 1} \ln M_{jht} + (\sigma_h - 1) \ln p_{jht} - \psi_{h,t}$$

The above identification strategy is also taken by Khandelwal [2010], while Broda and Weinstein [2006] identify elasticities (by assuming a constant elasticity supply curve) under the assumption that the supply shock (productivity) is uncorrelated with the demand shock (quality) and by allowing for Heteroskedasticity. I estimate the $\Theta_h$ parameters, for each $h$ in my sample, using a GMM procedure

$$\hat{\Theta}_h = \arg \min_{\Theta} G(\Theta_h; Y_h)'z' \hat{W}_2 z G(\Theta_h; Y_h)$$

The optimal weighting matrix $\hat{W}_2$ is calculated in the conventional two-step procedure. As noted before, in constructing $\hat{W}_2$ (i.e. variance-covariance matrix) I allow $\ln \mu_{jht}$’s to be clustered by source country. I impose no extra restriction on the parameters when running the above estimation.

Since $\ln M_{jht}$ and $\ln p_{jht}$ are endogenous and correlated with $\ln \mu_{jht}$, I should find instruments that are correlated with these two variables but uncorrelated with $\ln \mu_{jht}$. To identify the price coefficient, I will instrument price with the tariff rate associated with each observation. As shown in section 3.6, ad-valorem trade cost (which include tariffs) are correlated with the degree of differentiation $\frac{1}{\sigma_h}$ which is constant across all observations when I’m estimating parameters for each $h$ separately. Therefore, within an HS-10 category tariff rates are not correlated with quality $\mu_{jht}$. I also include exchange rates and the interaction of distance to the US with oil prices as additional instruments; these instruments vary at the country-year level.

For $M_{jht}$, I use an additional instrument, which is population of country $j$ in year $t$. I also use the total number of export cards documented in year $t$ in product $h$ from all sources, and the number of exporting

---

55Prices (C.I.F) are calculated as value of shipment plus freight charges and duty charges divided by the quantity reported (in terms of the primary unit of measurement). iceberg trade costs ($t_{i,j}$) in theory include more than just freight and tariff charges. In my estimation if iceberg trade costs are tariff and freight plus some other unobserved costs (like information frictions) then, they will cancel out in the estimation if I assume they affect all exporters the same. This is because I am not including data on domestic sales when estimating equation (15)–I only include import data.

56Broda and Weinstein [2006] perform a restricted grid search to estimate $\sigma_h$’s. In particular, they evaluate the GMM objective function for values of $\sigma_h \in [1.05, 1.315]$ at intervals that are 5 percent apart.

57Higher tariff would result in firms selecting into highly differentiated HS-10 codes, regardless of quality $\mu_{jht}$.

58In my model, everything else the same, a larger population lowers the wages and increase the number of exporting firms from a country--due to the lower entry and fixed costs.
countries of product $h$ in year $t$ as additional instruments.\textsuperscript{59}

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Mean</th>
<th>Median</th>
<th>First quartile</th>
<th>Third quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_h$</td>
<td>1.675</td>
<td>1.524</td>
<td>1.344</td>
<td>1.818</td>
</tr>
<tr>
<td>$\frac{\gamma_h - 1}{\sigma_h - 1}$</td>
<td>3.464</td>
<td>3.300</td>
<td>2.731</td>
<td>3.999</td>
</tr>
<tr>
<td>Two-step GMM p-value, $\sigma_h$</td>
<td>.011</td>
<td>.001</td>
<td>.000</td>
<td>.012</td>
</tr>
<tr>
<td>Two-step GMM p-value, $\gamma_h$</td>
<td>.008</td>
<td>.000</td>
<td>.000</td>
<td>.004</td>
</tr>
</tbody>
</table>

| Observations per estimation | 336 | 262   | 167            | 421           |
| Estimation with stat. sig. $\sigma_h > 1$ | .72  |       |                |               |
| Observations with stat. sig. $\sigma_h > 1$ | .78  |       |                |               |
| Observations with stat. sig. $\gamma_h > 1$ | .91  |       |                |               |
| Total estimations | 5,847 |       |                |               |
| Total observations across all estimations | 1,980,018 |       |                |               |

Table 2: Summary of statistics from estimating equation (15) for 5,847 manufacturing HS-10 products.

Table 2 reports a brief summary of the estimation results. For 72% of the HS-10 products the price coefficient is statistically significant (at the 90% confidence level) and has the correct sign, i.e. $\sigma_h > 1$. For around 91% of the HS-10 products, the estimated $\gamma_h$ is bigger than $\sigma_h$ and statistically significant (at the 90% confidence level). This implies that for the vast majority of the HS-10 products, varieties produced in the same country are more substitutable which partially confirms assumption 1 in my theoretical model. Later in the subsection I show that the assumption is a near perfect approximation of what we observe in the data.

Since my theory relies on heterogeneity in trade elasticities across products, and I also disentangle the within-country elasticity from the cross-country elasticity, it is worth looking at both these patterns more closely. Table 3 provides a summary of statistics for the within-country and cross-country elasticities across the product space. First, there is a lot of heterogeneity in both the within-country and cross-country elasticities. Second, there is a big gap between the within-country and cross-country elasticity. Both of these observed patterns are in line with my theory. As I argued earlier, shutting down these effect in an aggregate model can lead to aggregation biases.

\textsuperscript{59}Khandelwal [2010] uses the number of exporting countries of product $h$ as an instrument (for conditional nest share) which proxies competition in code $h$. 
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>Median</th>
<th>percentile 5</th>
<th>percentile 10</th>
<th>percentile 90</th>
<th>percentile 95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within-country elasticity: $\gamma_h$</td>
<td>3.344</td>
<td>2.787</td>
<td>1.502</td>
<td>1.678</td>
<td>5.424</td>
<td>7.151</td>
</tr>
<tr>
<td>Confidence interval (95%)</td>
<td>(1.997, 3.577)</td>
<td>(1.273, 1.730)</td>
<td>(1.248, 2.109)</td>
<td>(4.051, 6.796)</td>
<td>(6.053, 8.250)</td>
<td></td>
</tr>
<tr>
<td>Cross-country elasticity: $\sigma_h$</td>
<td>1.675</td>
<td>1.524</td>
<td>1.175</td>
<td>1.226</td>
<td>2.236</td>
<td>2.578</td>
</tr>
<tr>
<td>Confidence interval (95%)</td>
<td>(1.478, 1.570)</td>
<td>(1.155, 1.194)</td>
<td>(1.196, 1.257)</td>
<td>(2.085, 2.388)</td>
<td>(2.478, 2.677)</td>
<td></td>
</tr>
<tr>
<td>Total elasticity (within + across)</td>
<td>5.009</td>
<td>4.326</td>
<td>2.691</td>
<td>2.924</td>
<td>7.6284</td>
<td>9.643</td>
</tr>
</tbody>
</table>

Table 3: The variation of elasticities across HS-10 product codes.

Figure 8: Scatter plot of the rank of an HS-10 code in terms of the estimated $\sigma_h$ against its rank in terms of the estimated $\gamma_h$. Each point refers to one HS-10 code. The black line represents the 45 degree line. The red line is the best linear fit and the shaded gray area indicates 95% confidence intervals for the best-fitted linear relationship.

Evaluating the Theoretical Assumptions  The theory presented in section 3 relies on $\{\sigma_h\}_{h \in H}$ and $\{\gamma_h\}_{h \in H}$ to have the same order type, i.e. if $\sigma_h > \sigma_{h'} \implies \gamma_h > \gamma_{h'}$. I modeled this condition by letting $\{\gamma_h\}_{h \in H}$ to be a linear transformation of $\{\sigma_h\}_{h \in H}$, i.e $\gamma_h = \eta \sigma_h \ \forall h$. To compare the ordering of $\{\gamma_h\}_{h \in H}$ to $\{\sigma_h\}_{h \in H}$, I plot the rank of each HS-10 code in terms of the magnitude of the estimated within-country elasticity $\gamma_h$ against its rank in terms of the cross-country elasticity $\sigma_h$. Figure 8 shows the resulting scatter plot. If $\{\gamma_h\}_{h \in H}$ and $\{\sigma_h\}_{h \in H}$ had the exact same ordering, then all the dots should lie on the 45-degree line. The points are tightly scattered around the 45-degree line which implies that $\{\sigma_h\}_{h \in H}$ and $\{\gamma_h\}_{h \in H}$ are ordered near identically. In other words, if an HS-10 product has a relatively high cross-country elasticity it also has a relatively high within-country elasticity.

Moreover, I can show that $\{\gamma_h\}_{h \in H}$ is approximately a linear transformation of $\{\sigma_h\}_{h \in H}$, which is what I assumed in theory. To show this, for each HS-10 product I plot the estimated $\gamma_h$ against the estimated $\sigma_h$. The resulting scatter plot is displayed in figure 9, and implies a linear relationship between $\gamma_h$ and $\sigma_h$. 


Finally, in my theory I assumed a country produces all products with the same level of quality

$$\mu_{jht} = \mu_{jht} = \mu_{j} \; \forall h, h' \in H$$

What my theory relies on is that high-quality countries should be more competitive in highly differentiated products. If the quality of a country’s varieties are the same across all products then that will be the case (as I demonstrated in the theory section). Obviously, it would also be the case if the quality gap between rich and poor countries increases as products become more differentiated. I will show that this is what happens in the data. To this end, I regress the estimated quality for each country in each product ($\ln \hat{\mu}_{jht}$), on per capita GDP ($w_{jt}$) and the level of differentiation in the product category ($\ln \frac{1}{\sigma_h}$) and also the interaction of these two variables.

$$\ln \hat{\mu}_{jht} = \beta_0 + \beta_1 \ln w_{jt} + \beta_2 \ln \frac{1}{\sigma_h} + \beta_3 \ln w_{jt} \times \ln \frac{1}{\sigma_h}$$

There are 1,320,268 observations in total, and the results are robust to including SITC-5 and year fixed effects. All the coefficients are significant at the 99% confidence level (the standard errors are reported in the parenthesis). The above regression implies that the gap in quality between rich and poor countries widens as products become more differentiated. Thus, the assumption of my theoretical model is on the conservative side—all the theoretical results would go through (and would be magnified) if the assumption on quality was adjusted to match the above observed pattern.

The following subsections discuss the estimation results in more detail. I first compare my estimation

\[ \text{ln } \hat{\mu}_{jht} \text{ is the residual from the micro-gravity estimation.} \]
results to the existing literature. Then, I demonstrate how the predictions of the model are borne out in the US import data.

4.1.4 Discussion of Results

Table 4 displays a ranking of the average elasticity for various SIC-2 sectors. A low elasticity indicates that either consumers allocate their spending more evenly across varieties of that product or imports are less sensitive to price and more sensitive to the country-specific quality residual. A high elasticity, in contrast, implies that consumers will spend mostly on the cheapest variety and will be price sensitive rather than quality sensitive. As expected, the ranking of sectors in terms of the within-country and cross-country elasticity is pretty much the same from my estimation. However, the ranking is somehow different from the one in Broda and Weinstein [2006] (lower left panel in Table 4). I find food and paper to be relatively less differentiated than Broda and Weinstein [2006], and industrial machinery and fabricated metals to be more differentiated.

Table 5 compares the average elasticity estimates to the existing studies. The closest study to mine (in terms of the patterns of product substitution) is Feenstra et al. [2012]. They estimate a micro-elasticity between foreign varieties in each SIC-2 sector, and a macro-elasticity between the composite imported good and the composite domestic good. They estimate the cross-exporter micro elasticity to be around 3.1 times higher than the macro elasticity. The ratio is somehow close to the relative scale of the within-country to cross-country elasticity in this paper, which is 2.15 on average.

It is not surprising that my estimates are the closest to Feenstra et al. [2012] among others—the estimated elasticities are quite lower than the remaining studies. Apart from the fact that their estimation methods differ substantially from this paper, the difference is due to the following. In these studies the mass of firms (varieties) from each country is exogenously assumed to be one—or the within-country elasticity is assumed to be infinity. The approach taken here is that the number of firms is an endogenous variable and I use data to approximate it when estimating the trade elasticities. The take-away message is that not controlling for hidden varieties (or the extensive margin of trade) could result in over-estimating trade elasticities. To see this, suppose we exogenously force $\gamma_h$ to be infinity so that $M_{jh} = 1 \forall j \in C$ and $\forall h \in H$. Then, instead of (15), I will be estimating the following micro-gravity equation

$$\ln X_{jht} = -(\sigma_h - 1) \ln p_{jht} + \psi_{h,t} + \mu_{jht}$$

A country with lower prices within an HS-10 product category will most likely have more exporting firms (or varieties). Suppressing the effect of varieties means we are matching trade flows with only price varia-
Table 4: This Table reports the average elasticity by manufacturing SIC-2 sector. The top panel is my estimates for the cross-country elasticity $\gamma_h$ and within-country elasticity $\sigma_h$. Total elasticity refers to $\gamma_h + \sigma_h$. My estimates are for a sample of differentiated manufacturing products as classified by Rauch [1999]. The bottom panel is the average estimated elasticity by SIC-2 sector from Broda and Weinstein [2006].
Table 5: Comparison of estimated trade elasticities to existing estimates in the literature. For studies that estimate elasticities at disaggregated product levels, the table reports the average estimated elasticity.

Table: | Study                    | Setting           | Structure                                           | Micro-elasticity | Macro-elasticity |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Feenstra et al. [2012]</td>
<td>Armington / Melitz</td>
<td>Micro: across foreign var.</td>
<td>3.1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Macro: between comp. domestic and comp. foreign var.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simonovska and Waugh [2011]</td>
<td>Ricardian</td>
<td>Trade elasticity: Pareto shape parameter $\theta$</td>
<td>3.79-5.46</td>
<td>–</td>
</tr>
<tr>
<td>Broda and Weinstein [2006]</td>
<td>Armington</td>
<td>Different elasticity for each HS-10 product</td>
<td>12.6</td>
<td>–</td>
</tr>
<tr>
<td>Imbs and Méjean [2010]</td>
<td>Armington / Melitz</td>
<td>different elasticity for each SIC-3</td>
<td>6.7</td>
<td>–</td>
</tr>
<tr>
<td>My estimates</td>
<td>Krugman</td>
<td>Micro: across firms within country</td>
<td>3.334</td>
<td>1.675</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Macro: between countries</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Even though I control for the extensive margin of trade (or hidden varieties), however, like most of the existing studies I do not control for selection of countries into HS-10 product codes. Helpman et al. [2008] find that the selection bias is small compared to the extensive margin bias. Moreover, the selection bias problem arises because I might not be controlling for all the variables influencing the import flows. There is no selection problem if every variable influencing selection is controlled in the outcome equation (15) (Achen [1986], pages 78-79). It is very likely that other variables apart from price and the mass of firms affect selection. To avoid selection bias I either have to add controls or make sure my instruments are not correlated with the omitted control variables.62

4.1.5 Product Differentiation and the Patterns of US Imports

Price and Variety The theory proposed by this paper is that prices in international trade can be largely explained with heterogeneity in demand elasticities. The idea is that price variations can be attributed to differences in markups across products. My estimation results have demonstrated that different products do have very different elasticities, but the question remains: “Are elasticities associated with f.o.b prices in the data?”. In theory, more differentiated products have higher markups and thus higher f.o.b prices. To

61 Helpman et al. [2008] make a similar argument, but implement their argument differently. Their estimates also indicate a upward bias in traditional elasticity estimates.

62 This paper is in the process of development. I plan to rerun the estimation with additional controls and examine how robust the results are to these variations.
confirm this association in my estimates, I scatter the degree of differentiation ($\frac{1}{\sigma_h}$) in a HS-10 product code against the average f.o.b price of imported goods in that same HS-10 code (normalized by the average price in SITC-5 industry to control for different units of measurement). The result is displayed in figure 10; HS-10 products that are more differentiated have on average a higher f.o.b price in the U.S. import data.

As noted earlier, the main explanation behind price patterns in the literature is quality differentiation. The above result serves significance because a positive association between f.o.b prices and quality at the level of disaggregation used in this paper has yet to be established. Khandelwal [2010], to my knowledge, is the only study that structurally estimates quality at the HS-10 level of disaggregation. He finds a negative correlation between his estimated qualities and f.o.b prices.\(^{63}\)

A more evident result arising from the estimation is the strong positive association between product differentiation and the number of imported varieties. My theory indicates that the gains from variety are mostly due to highly differentiated products that are subject to low elasticities of substitution. To assess my claim, I plot the number of country-specific varieties per dollar imported in each HS-10 product code against the estimated level of differentiation in that HS-10 code (i.e. $\frac{1}{\sigma_h}$). As the results presented in figure 11 suggest, for every dollar the US imports the imported bundle contains more country-specific varieties for HS-10 products that are more differentiated and more f.o.b expensive. Given that the gains from variety (post trade liberalization) are proportional to $\frac{1}{\sigma_h}$, figure 11 suggests that the gains from removing trade barriers would be larger in a model where differences in the level of differentiation are taken into account.

\(^{63}\)In an earlier version of the paper (available at http://www.personal.psu.edu/azl153/) I estimate demand allowing for
Figure 11: The co-movement of product differentiation (in logs) and the number of country-specific varieties per dollar imported in each HS-10 product code (in logs). Each point in the graph is an HS-10 product code. The shaded area indicates 95% confidence intervals for the best-fitted linear relationship. Macro-differentiation for HS-10 code $h$ is measured as $\frac{1}{\sigma_h}$, and micro-differentiation is measured as $\frac{1}{\sigma_h}$.

**Low-wage import penetration**  The theory of the paper implies that the US imports relatively less from low-wage countries in differentiated product categories (or industries). To examine this, I look at import penetration by low wage countries and its relation to the level of differentiation in a product category. Low-wage import penetration is the percentage (value) share of imports from low-wage countries. As figure 12 displays, low-wage countries comprise a higher share of the US import basket in less-differentiated industries—I only see import penetration at the industry level. The result is in line with my theory regarding the competitive advantage of low-wage countries in less-differentiated products.

The above result serves importance because As Khandelwal [2010] puts it, “fear of globalization is often rooted in the vulnerability or, to use Edward Leamer’s terminology, the contestability of jobs. According to Leamer, the contestable jobs are those where wages in Los Angeles are set in Shanghai.” Khandelwal [2010] shows that in industries with a long quality ladder, labor markets in developed countries will be insulated from wage movements in low-wage countries. My analog argument is that labor markets in developed countries will be insulated in differentiated industries, which are also more likely to have a long quality ladder because a wider range of countries self-select into those industries.

To examine my claim I first run the following regression with NAICS industry fixed effects

quality to vary across HS-10 products and find that product quality and product differentiation co-move in the trade data at the HS-10 product level, i.e. demand elasticity is significantly lower in high-quality HS-10 product codes.

64 The list of low-wage countries is reported in appendix D.

65 An alternative strategy would be to look at the differentiation ladder, and examine the effect of low-wage import penetration on industries with a long differentiation ladder versus industries with a short differentiation ladder.

66 NAICS stands for North American Industry Classification System. The reason I use the NAICS classification is that employment is reported according to the NAICS rather than the SITC classification.
Figure 12: Scatter plot of import penetration from low-wage countries (% value of total imports in logs) against the average level of differentiation for various SIC-4 industries (in logs). The average level of differentiation is the inverse of the average estimated elasticity ($\sigma_h$) within the SIC-4 industry.

$$\ln \text{employment}_{S,t} = -0.0513 \ln \text{LWP}_{S,t} + 0.046 \ln \text{LWP}_{S,t} \ast \ln \frac{1}{\sigma_s} + 2.78$$

where \text{employment}_{S,t} is U.S. employment in industry $S$ in year $t$. \text{LWP}_{S,t} is low-wage import penetration index calculate by Bernard et al. [2006a] for industry $S$ in year $t$, and $\ln \frac{1}{\sigma_s}$ is the average level of differentiation in industry $S$—based on the estimated elasticities. All the coefficients are significant at the 99% confidence level and the $R^2$ is 0.120 for 240 NAICS industries—the robust standard errors are given in the parenthesis. The above regression indicates that the effect of low-wage import penetration on US (industry-level) employment diminishes significantly with the level of differentiation in the industry.

### 4.2 Step 2: Calibrating the Model to Aggregate Trade Flows

In the second stage of my empirical inquiry, I will map my model to global trade flows to explore the general equilibrium properties of my model. In this section, I calibrate the key parameters to the general equilibrium outcomes of the model using data for many countries. Specifically, I calibrate iceberg trade costs, country-specific qualities, fixed costs of exporting varieties, and market entry cost to data on bilateral
trade flows, and per capita GDP/wages. I solve for the endogenous (relative) wages, price indices, and mass of firms in every country. The results indicate that traditional assumptions in trade models can result in underestimating both trade costs and the gains from trade.

4.2.1 Data

I use data on bilateral merchandise trade flows in 2000 from the U.N. Comtrade database (Comtrade [2010]), and data on population and GDP from the World Bank database (World-Bank [2012]). I only consider the 50 largest economies (in terms of real GDP) that account for more than 80% of world trade in 2000. Each observation contains the total value of trade for an importer-exporter country pair. Data specific to country pairs—distance, common official language, and borders—are compiled by Mayer and Zignago [2011].

4.2.2 Calibration Strategy

Trade shares, \( \{ \lambda^j_i \}_{i,j \in O} \), are a function of the set of \( N \) countries, each with its population \( L_i \), wage \( w_i \), country-specific quality \( \mu_i \) and iceberg trade costs \( \tau_{ji} \); parameters \( \{ \gamma_h \}_{h \in H} \) (where \( \{ \gamma_h \}_{h \in H} = \eta \{ \sigma_h \}_{h \in H} \)), \( \epsilon \), and \( \{ \sigma_h \}_{h \in H} \) that control the elasticity of substitution across varieties; per-market entry cost parameter \( f^e \) that govern entry decision of firms into different markets, and per-product (and market) fixed exporting cost \( f \) that governs the decision of firms regarding exporting individual HS-10 product codes (post entry); parameter \( \alpha \) which determines the expenditure share on manufactured products.\(^{67}\) I take the set of countries, their population \( L_i \), and wages \( w_i \) from the data, and I calibrate \( \{ \tau_{ji} \}_{j,i=1}^N \), \( \{ \mu_i \}_{i=1}^N \), \( f^e \), \( f \), \( \{ \sigma_h \}_{h \in H} \), \( \alpha \), \( \epsilon \), and \( \eta \) to match trade flow and wage data.\(^{68}\)

**Parameters set without solving the model** Parameters \( \alpha \), \( \epsilon \), \( \eta \), and \( \{ \sigma_h \}_{h \in H} \) are set from the estimation in step 1 or external sources. In the previous section I estimated demand elasticities for 5,847 HS-10 products. In the calibration I confine my analysis to an economy with five products (i.e. \( H = \{1, 2, 3, 4, 5\} \)). Each product is representative of a sector from the estimation in step 1. The five sectors are chosen to incorporate different levels of differentiation. In particular, food, leather and apparel sectors are chosen to represent the less differentiated sectors, while electronics and industrial machinery are chosen to represent differentiated sectors. The description of each industry and the estimated average elasticity for the industries (from step

\(^{67}\)The equilibrium trade shares can be calculated using the two tier gravity represented by equations (8) and (9)

\[ \lambda^j_i = \sum_{h \in H} \lambda^j_{j|h} \lambda^h_i \]

where \( \lambda^j_{j|h} \) and \( \lambda^h_i \) are given by equations (8) and (9) respectively. Also, since in practice I have a discrete set of products instead of a continuum I sum up over all the products instead of integrating over the product space.

\(^{68}\)I already showed that the linear relationship between \( \sigma_h \) and \( \gamma_h \) is a very reasonable approximation based on my estimation results. Thus, in my calibration exercise I will allow for \( \gamma_h = \eta \sigma_h \forall h \).
<table>
<thead>
<tr>
<th>SIC code</th>
<th>Number of HS-10 industries in the data</th>
<th>Average estimated elasticity $\sigma_h$</th>
<th>Product index $h$ in the calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial machinery</td>
<td>35</td>
<td>1,632</td>
<td>2.3</td>
</tr>
<tr>
<td>Electronics</td>
<td>36</td>
<td>1,325</td>
<td>2.5</td>
</tr>
<tr>
<td>Apparel</td>
<td>23</td>
<td>2,560</td>
<td>2.8</td>
</tr>
<tr>
<td>Leather</td>
<td>30</td>
<td>403</td>
<td>3.3</td>
</tr>
<tr>
<td>Food</td>
<td>20</td>
<td>37</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Table 6: Representative industries in my calibration

1) is displayed in table 6. As table 6 suggest, I calibrate the elasticity within each sector to the average estimated elasticity for that sector from step 1. I calibrate $\eta$ to the median estimated value (i.e. $\eta = 2.15$), again from step 1. $\epsilon$ is calibrated to 1.2 from the cross HS-10 within-industry demand estimation, implemented in an earlier version of the paper.\(^{69}\) From Dekle, Eaton, and Kortum \citeyear{2007} I calibrate the share of spending on manufactured products, $\alpha$, to 0.188.

Next, I will describe my strategy for identifying iceberg trade costs $\{\tau_{ji}\}_{j,i=1}^N$, country-specific qualities $\{\mu_i\}_{i=1}^N$, and per-product fixed cost of exporting $f$. I normalize $f^e$ to one since the scale of $f^e$ only affects the scale of firm entry $\{M^i_j\}_{i,j\in C^e}$ but not the relative mass of firms in the market.

**Trade costs** I assume that iceberg trade costs take the following form

$$\tau_{ji} = \kappa_{\text{const}} (\text{dist}_{ji})^{\kappa_{\text{dist}}} (\kappa_{\text{border}})^{d_{\text{border}}} (\kappa_{\text{lang}})^{d_{\text{lang}}} (\kappa_{\text{agreement}})^{d_{\text{agreement}}}$$

Variable $\text{dist}_{ji}$ is the distance (in thousands of kilometers) between countries $j$ and $i$. $d_{\text{border}}$ is a border dummy and $(\kappa_{\text{border}})^{d_{\text{border}}}$ equals 1 if countries $j$ and $i$ do not share a border, and $\kappa_{\text{border}}$ otherwise. If $\kappa_{\text{border}}$ is, say, 0.8, sharing a border reduces trade costs by 20%; if $\kappa_{\text{border}} > 1$, sharing a border increases trade costs. Similarly, parameters $\kappa_{\text{lang}}$ and $\kappa_{\text{agreement}}$ refer, respectively, to whether countries $j$ and $i$ share a language, and whether they have a trade agreement. Henceforth, $\Upsilon = \{\kappa_{\text{const}}, \kappa_{\text{dist}}, \kappa_{\text{border}}, \kappa_{\text{lang}}, \kappa_{\text{agreement}}, f, f^e\}$ refers to the set of trade cost parameters and $\tilde{\Upsilon}$ refers to the set of data on countries pairwise geopolitical characteristics–distance, common border, language, and trade agreement.

**Country-specific qualities** I solve for the vector of country-specific qualities in an inner-loop with wage data, using the algorithm I will describe.\(^{70}\) Given parameters $\{\Upsilon, \eta, \{\sigma_h\}_{h\in H}, \epsilon, \alpha\}$, data on population $L = \{L_i\}_{i=1}^N$, and geopolitical characteristics $\tilde{\Upsilon}$, the product market clearing condition (PMC) pins down

\(^{69}\)Available at [http://www.personal.psu.edu/azl153](http://www.personal.psu.edu/azl153)

\(^{70}\)Fieler \citeyear{2011} uses the same strategy to pin down the technology parameters in a Ricardian model.
a relation between country-specific qualities \( \{ \mu_i \}_{i=1}^N \) and market clearing wages \( \{ w_i \}_{i=1}^N \). Therefore, fixing other parameters, I can use wages directly to back out the country-specific qualities \( \{ \mu_i \}_{i=1}^N \). I take per capita income from the data as a proxy for wages. Then, for each guess of the parameters, I simulate the whole economy, generating trade shares \( \lambda_j^i \) until I find a vector of country-specific qualities \( \{ \mu_i \}_{i=1}^N \), that satisfies equilibrium conditions.  

After substituting fixed and variable trade costs and the implicit solutions for country-specific qualities, \( \{ \mu_i \}_{i=1}^N \), the moment condition (minimized in the outer-loop) can be written as

\[
\min_T \left[ \lambda_j^i (\bar{T}; \bar{\bar{T}}, L, \eta, \{ \sigma_h \}_{h \in H}, \epsilon, \alpha) - \lambda_j^i \right]_{i \neq j = 1}^N
\]

where, \( \lambda_j^i \) is total share of spending on varieties from country \( j \) in country \( i \). Each element in the above \((N - 1) \times (N - 1)\) vector characterizes the distance between the respective model outcome (given the parameters) and the outcome in the data. The calibrations objective is to search for a set of parameters \( T = \{ \kappa_{\text{const}}, \kappa_{\text{dist}}, \kappa_{\text{border}}, \kappa_{\text{lang}}, \kappa_{\text{agreement}}, f, f^c \} \) that minimize the sum of the squared differences between the model outcomes and the data targets for these outcome. I normalize the wage and quality of the US varieties to 1 and 100 respectively.

The calibrated value of parameters and the goodness of fit are displayed in table 7 under three different specifications. Apart from the main specification the other two baseline specifications are (1) a model in which I shut down heterogeneity in demand elasticity across products—column two of table 7, and (2) a model in which I further force within-country and cross-country elasticities to be the same (i.e. \( \eta \rightarrow 1 \))—column three of table 7. As expected from the theory, the new specification outperforms the two baseline specifications in terms of fitting the trade flow data. Note that in all three calibrations, the degrees of freedom (i.e. number of calibrated parameters) are the same.

The calibrated value \( f = 0.05 \) could be interpreted as exporters will have to pay a 25% higher entry cost.

---

71 I solve for the trade shares along the following steps

i. Start with a guess of the vectors \( \{ M_{j}^{0} \}_{j \in C} \) and \( \{ P_{h}^{0} \}_{i \in C; h \in H} \);

ii. Calculate the vector of product-specific profits of firm \( \{ \pi_{j}^{i} \}_{i \in C; h \in H} \);

iii. Solve for the new vector of the mass of firms \( \{ M_{j}^{1} \}_{j \in C} \) using the free entry (FE) condition;

iv. Calculate the new vector of price indexes \( \{ P_{h}^{1} \}_{i \in C; h \in H} \) and

v. Start over from 1 and iterate until convergence is achieved up to a pre-assigned degree of accuracy .

After the convergence in the above loop I can calculate trade shares using the prices indices and mass of firms from equations (8) and (9).

72 To find the global minimum, I first perform a global search using the Genetic Algorithm. Then, I use the NelderMead algorithm to perform a local search. Chelouah and Siarry [2003] Show that this approach is more efficient in finding the global optimum than implementing either algorithm independently.

73 In the baseline calibration, I lower \( \eta \) to be as close to one as possible (i.e. \( \eta = 1.1 \)). When I let \( \eta \) to be exactly one the nested fixed-point algorithm does not converge, because the condition gives rise to knife edge equilibria.

---

45
relative to domestic firms to set up sales for all five products in a foreign location, i.e. 5% more for each product. Table 8 presents the calibrated country-specific qualities ($\mu_i$). The rank of countries in terms of their quality ($\mu_i$) is the same as their rank in technology ($T_i$) within the Eaton and Kortum [2002] model. This is quite intuitive given that the effect of technology ($T_i$) in this paper is captured by (1) the quality of a country’s products ($\mu_i$), and (2) the mass of varieties/firms that enter various markets form country $i$ ($M_{jh}$) which is endogenous and depends on quality $\mu_j$. The rank of countries in terms of their (calibrated) quality ($\mu_i$) is also similar to Hallak and Schott [2011]. This can be seen in figure 13 where I compare my calibrated qualities with the qualities estimated by Hallak and Schott [2011].

### Table 7: The calibrated trade cost parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Main model $\sigma = 4.2, \eta = 2.15$</th>
<th>Krugman–$\sigma = 4.2, \eta \rightarrow 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\kappa_{const}$</td>
<td>0.292</td>
<td>0.666</td>
</tr>
<tr>
<td>$\kappa_{dist}$</td>
<td>0.275</td>
<td>0.100</td>
</tr>
<tr>
<td>$\kappa_{lang}$</td>
<td>0.955</td>
<td>0.971</td>
</tr>
<tr>
<td>$\kappa_{border}$</td>
<td>0.939</td>
<td>0.966</td>
</tr>
<tr>
<td>$\kappa_{agreement}$</td>
<td>0.961</td>
<td>0.967</td>
</tr>
<tr>
<td>$f$</td>
<td>0.049</td>
<td>0.059</td>
</tr>
<tr>
<td>$f^r$</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Goodness of fit (R-squared)</td>
<td>0.39</td>
<td>0.33</td>
</tr>
</tbody>
</table>

4.2.3 Quantitative predictions

In this section I will illustrate the quantitative predictions of the calibrated model. In particular, I illustrate how quality translates into high wages (proposition 1) and determines the patterns of competitive advantage. Figure 14 plots the wage in each country against the calibrated quality of that country. A expected, high-wage countries are endowed with higher qualities.

Next, I look at how wage and quality determine the patterns of competitive advantage across countries. From equation (8) the market share of countries $i$ relative to $j$ in country $k$ for product $h$ is the following

---

<table>
<thead>
<tr>
<th>Country</th>
<th>$\hat{\mu}_i$</th>
<th>$w_i$</th>
<th>Country</th>
<th>$\hat{\mu}_i$</th>
<th>$w_i$</th>
<th>Country</th>
<th>$\hat{\mu}_i$</th>
<th>$w_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>100</td>
<td>100</td>
<td>Russia</td>
<td>1.52</td>
<td>5.13</td>
<td>Greece</td>
<td>10.15</td>
<td>30.34</td>
</tr>
<tr>
<td>Japan</td>
<td>94.14</td>
<td>105.92</td>
<td>Switzerland</td>
<td>37.28</td>
<td>98.99</td>
<td>Portugal</td>
<td>10.23</td>
<td>31.84</td>
</tr>
<tr>
<td>Germany</td>
<td>44.45</td>
<td>66.80</td>
<td>Sweden</td>
<td>37.28</td>
<td>78.86</td>
<td>Iran</td>
<td>1.10</td>
<td>4.60</td>
</tr>
<tr>
<td>UK</td>
<td>44.28</td>
<td>69.80</td>
<td>Belgium</td>
<td>20.49</td>
<td>65.38</td>
<td>Egypt</td>
<td>0.92</td>
<td>4.29</td>
</tr>
<tr>
<td>France</td>
<td>39.43</td>
<td>65.17</td>
<td>Turkey</td>
<td>2.77</td>
<td>8.54</td>
<td>Ireland</td>
<td>20.95</td>
<td>73.04</td>
</tr>
<tr>
<td>China</td>
<td>1.03</td>
<td>2.74</td>
<td>Austria</td>
<td>25.11</td>
<td>69.93</td>
<td>Singapore</td>
<td>22.80</td>
<td>66.70</td>
</tr>
<tr>
<td>Italy</td>
<td>34.22</td>
<td>55.69</td>
<td>S Arabia</td>
<td>11.12</td>
<td>26.36</td>
<td>Malaysia</td>
<td>3.50</td>
<td>11.35</td>
</tr>
<tr>
<td>Canada</td>
<td>32.49</td>
<td>67.109</td>
<td>Poland</td>
<td>4.07</td>
<td>12.88</td>
<td>Colombia</td>
<td>1.47</td>
<td>5.81</td>
</tr>
<tr>
<td>Brazil</td>
<td>5.84</td>
<td>10.71</td>
<td>Hong Kong</td>
<td>28.74</td>
<td>73.18</td>
<td>Philippines</td>
<td>0.52</td>
<td>2.89</td>
</tr>
<tr>
<td>Mexico</td>
<td>8.81</td>
<td>17.15</td>
<td>Norway</td>
<td>39.60</td>
<td>107.41</td>
<td>Chile</td>
<td>4.59</td>
<td>14.10</td>
</tr>
<tr>
<td>Spain</td>
<td>21.59</td>
<td>41.68</td>
<td>Indonesia</td>
<td>0.53</td>
<td>18.03</td>
<td>Pakistan</td>
<td>0.19</td>
<td>1.53</td>
</tr>
<tr>
<td>Korea Rep.</td>
<td>16.62</td>
<td>31.46</td>
<td>Denmark</td>
<td>29.80</td>
<td>2.31</td>
<td>UAE</td>
<td>20.11</td>
<td>62.83</td>
</tr>
<tr>
<td>India</td>
<td>0.26</td>
<td>1.31</td>
<td>South Africa</td>
<td>3.09</td>
<td>8.73</td>
<td>Czech Rep.</td>
<td>3.49</td>
<td>15.96</td>
</tr>
</tbody>
</table>

Table 8: The calibrated country-specific quality parameters. $\hat{\mu}_i$ is adjusted by the average elasticity of substitution, i.e. $\hat{\mu}_i = \mu_i^{1/(\sigma^{*s}_i-1)}$. 

47
Figure 13: Comparison of country-specific quality estimates by Hallak and Schott [2011] with the calibrated country-specific quality in this paper. I use the average value estimated by Hallak and Schott [2011] for years 1998 and 2003, and normalize the quality of Argentina to zero.
The above equation suggests that in more differentiated products, country-specific quality ($\mu_j$) plays a bigger role than effective wage ($\tau_{ik} w_i$) in determining a country's competitiveness. What defines a country's competitiveness in the global economy is wage per unit of quality or pure wage ($\frac{w_i}{\mu_i^{1/(\sigma_h-1)}}$). Figure 15 graphs pure wage against per capita income (i.e. nominal wage) for all countries in the sample, within the least differentiated sector (food, $\sigma_h = 4.2$). As seen, high-wage countries have a higher pure wage and are have a competitive disadvantage in producing the least differentiated product.

For the most differentiated product, the trend is quite the opposite. To see this, I graph per capita income against pure wage ($\frac{w_i}{\mu_i^{1/(\sigma_h-1)}}$) for the most differentiated product (industrial machinery, $\sigma_h = 2.3$) in figure 16. The resulting figure confirms that rich countries have a clear competitive advantage over poor countries in producing and selling the differentiated product in global markets.

To put it in words I will use the example of China versus the US. In the least differentiated product category China has a pure wage, i.e. marginal cost per unit of quality, that is less than half of the US. In the most differentiated category the pure wage in China is 33.8 times higher than the US. Clearly, US has a noticeable competitive advantage over China in differentiated product categories, which more importantly is quite immune to wage movements in China.

Out of Sample Fit To further assess the quantitative performance of the model, I turn attention to how good the model matches data on unit values. To this end, I look at the correlation between the price of traded goods generated by my calibrated model and the unit value of traded goods reported in the data. I calculate the same correlation for the two baseline specifications: (1) $\sigma = 4.2$ for all products, and (2) $\sigma = 4.2$ for all products plus $\eta \to 1$. Note that when calibrating my model I only targeted trade volumes, so this is an out of sample evaluation. The results are summarized in table 9, and show that my model fits the price data significantly better than the baseline models. The main model captures two effects extra to the baseline Krugman-Armington model, which explains its improved explanatory power: (i) the effect of trade costs on prices (i.e. shipping the good apples out), and (ii) the higher price of exports from high-wage countries.

75Since the U.N. Comtrade data base does not report quantity of trade, so I use the data compiled by Feenstra, Lipsey, Deng, Ma, and Mo [2005] to calculate unit values in the benchmark year, 2000.
Figure 14: Scatter plot of the calibrated country-specific quality $\ln \mu_i$ against nominal country wage $\ln w_i$ in 2000.

Figure 15: Competitive advantage of low-wage countries in the least-differentiated product in the the calibrated global market: Estimated pure (i.e. quality-adjusted) wage $\ln \frac{w_i}{\mu_i^{1/\theta}}$ against nominal wage $\ln w_i$ in 2000.
Figure 16: Competitive advantage of high-wage countries in the most-differentiated product in the calibrated global market: Estimated pure (i.e. quality-adjusted) wage $\ln \frac{w_i}{\mu_i} \alpha (m_i - 1)$ against nominal wage $\ln w_i$ in 2000.

Correlation of simulated prices with unit values observed in data

<table>
<thead>
<tr>
<th>Model</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>My model</td>
<td>0.473</td>
</tr>
<tr>
<td>$\eta = 2.15, \sigma = 4.2$</td>
<td>0.212</td>
</tr>
<tr>
<td>$\eta \to 1, \sigma = 4.2$ (Krugman)</td>
<td>0.206</td>
</tr>
</tbody>
</table>

Table 9: Comparing the fit of my model to observed unit values of trade in data, to the baseline model.
4.3 The Sizable Gains From Trade

In the framework of the model developed in this paper, differentiated products are traded more intensively due to higher markups, which make them more profitable to export. Hence, after opening to trade imports will be more concentrated in the differentiated products—more so in poor countries. Therefore, the gains from variety would be sizable if one accounts for the fact that the imported varieties are highly differentiated and not substitutable. To demonstrate this quantitatively, I perform a counterfactual analysis. I analyze the effect on welfare (i.e. real wage) of opening up to trade from autarky (i.e. \( \tau_{ij} \to \infty \ \forall i \neq j \)). In the counterfactual experiment the general equilibrium is resolved for the new trade values, and the new measure of real wage (i.e. \( \frac{w_i}{p_i} \)) is calculated using the counterfactual wage and price index.

To compare the gains from trade in the new model to the gains in the baseline model, I run the same counterfactual experiment first on a restricted model where elasticity is the same and equal to 4.2 across all products, and then on the baseline Krugman-Armington model where elasticity is 4.2 for all products and moreover \( \eta \to 1 \). The results are displayed in table 10 and suggest that the increase in welfare from trade is noticeably higher in the new model. The losses from going to autarky in the new model are on average -15.2% while losses are -4.9% and -1% in the two baseline specifications—as predicted by proposition 2. The larger gains from opening to trade (or the larger losses from going to autarky) in the new model happen even though the calibrated iceberg trade costs are higher relative to the baseline models (discussed in the next subsection).\textsuperscript{76} For comparison I also include the losses from going to autarky as reported by Eaton and Kortum [2002] in table 10.

The results point out to a noticeable aggregation bias from restricting elasticities to be the same across all products. I discussed the bias in detail in section 3.7 and will briefly review it again. When \( \sigma_h \) is forced to be the same for all products, trade is spread out across all sectors/products. Suppose this restriction is relaxed and \( \sigma_h \) varies by product; firms still pay the same per-product fixed cost for each product, but now they direct their sales towards highly differentiated products which provide them with the most profits. This, in turn, benefits consumers because they love variety more so when products are differentiated.

As \( \eta \) approaches one foreign firms bring nothing extra to the table compared to domestic firms, because the elasticity of substitution is the same across all firm varieties. When a country opens up to trade the number of domestic varieties drop. They are replaced by (most likely) more expensive foreign varieties that, horizontally, are not all that different. Hence, when \( \eta \to 1 \) consumers gain much less from the abundance of foreign varieties after trade. To better visualize these effects, figure 17 displays a bar chart comparing the gains from trade in the new model relative to the baseline.\textsuperscript{76}

\textsuperscript{76}This means that in the new model the trade equilibrium is closer to autarky than free trade when compared to the baseline models. Yet, opening the quasi-autarky trade equilibrium generates larger gains than the baseline models.
<table>
<thead>
<tr>
<th>Country</th>
<th>ISO code</th>
<th>$% \Delta V$ (New model)</th>
<th>$% \Delta V (\eta = 2.15, \sigma = 4.2)$</th>
<th>$% \Delta V (\eta \to 1, \sigma = 4.2)$</th>
<th>Eaton and Kortum [2002]</th>
</tr>
</thead>
<tbody>
<tr>
<td>UAE</td>
<td>ARE</td>
<td>-16.55</td>
<td>-5.83</td>
<td>-0.46</td>
<td>–</td>
</tr>
<tr>
<td>Argentina</td>
<td>ARG</td>
<td>-7.76</td>
<td>-2.65</td>
<td>-0.16</td>
<td>–</td>
</tr>
<tr>
<td>Australia</td>
<td>AUS</td>
<td>-5.66</td>
<td>-1.9</td>
<td>-0.01</td>
<td>-1.5</td>
</tr>
<tr>
<td>Austria</td>
<td>AUT</td>
<td>-19.13</td>
<td>-7.89</td>
<td>-3.21</td>
<td>-3.2</td>
</tr>
<tr>
<td>Belgium</td>
<td>BEL</td>
<td>-25.72</td>
<td>-11.22</td>
<td>-8.6</td>
<td>-10.3</td>
</tr>
<tr>
<td>Brazil</td>
<td>BRA</td>
<td>-6.56</td>
<td>-1.59</td>
<td>-0.04</td>
<td>–</td>
</tr>
<tr>
<td>Canada</td>
<td>CAN</td>
<td>-14.78</td>
<td>-5.84</td>
<td>-5.33</td>
<td>-6.5</td>
</tr>
<tr>
<td>Switzerland</td>
<td>CHE</td>
<td>-19.01</td>
<td>-7.08</td>
<td>-2.33</td>
<td>–</td>
</tr>
<tr>
<td>Chile</td>
<td>CHL</td>
<td>-13.5</td>
<td>-4.81</td>
<td>-0.29</td>
<td>–</td>
</tr>
<tr>
<td>China</td>
<td>CHN</td>
<td>-13.23</td>
<td>-1.52</td>
<td>-0.03</td>
<td>–</td>
</tr>
<tr>
<td>Colombia</td>
<td>COL</td>
<td>-17.89</td>
<td>-5.02</td>
<td>-0.22</td>
<td>–</td>
</tr>
<tr>
<td>Czech Rep.</td>
<td>CZE</td>
<td>-25.65</td>
<td>-9.29</td>
<td>-0.56</td>
<td>–</td>
</tr>
<tr>
<td>Germany</td>
<td>DEU</td>
<td>-8.45</td>
<td>-2.96</td>
<td>-1.18</td>
<td>-1.7</td>
</tr>
<tr>
<td>Denmark</td>
<td>DNK</td>
<td>-19.7</td>
<td>-7.38</td>
<td>-1.1</td>
<td>-5.3</td>
</tr>
<tr>
<td>Algeria</td>
<td>DZA</td>
<td>-26.74</td>
<td>-7.95</td>
<td>-0.11</td>
<td>–</td>
</tr>
<tr>
<td>Egypt</td>
<td>EGY</td>
<td>-21.28</td>
<td>-5.3</td>
<td>-0.17</td>
<td>–</td>
</tr>
<tr>
<td>Spain</td>
<td>ESP</td>
<td>-10.23</td>
<td>-3.56</td>
<td>-0.35</td>
<td>-1.4</td>
</tr>
<tr>
<td>Finland</td>
<td>FIN</td>
<td>-18.73</td>
<td>-7.32</td>
<td>-3.88</td>
<td>-2.4</td>
</tr>
<tr>
<td>France</td>
<td>FRA</td>
<td>-10.14</td>
<td>-3.56</td>
<td>-1.1</td>
<td>-2.5</td>
</tr>
<tr>
<td>UK</td>
<td>GBR</td>
<td>-8.69</td>
<td>-2.82</td>
<td>-0.28</td>
<td>-2.6</td>
</tr>
<tr>
<td>Greece</td>
<td>GRC</td>
<td>-17.2</td>
<td>-6.53</td>
<td>-0.22</td>
<td>-3.2</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>HKG</td>
<td>-14.05</td>
<td>-4.84</td>
<td>-0.2</td>
<td>–</td>
</tr>
<tr>
<td>Indonesia</td>
<td>IDN</td>
<td>-17.98</td>
<td>-3.22</td>
<td>-0.04</td>
<td>–</td>
</tr>
<tr>
<td>India</td>
<td>IND</td>
<td>-20.86</td>
<td>-2.62</td>
<td>-0.11</td>
<td>–</td>
</tr>
<tr>
<td>Ireland</td>
<td>IRL</td>
<td>-23.74</td>
<td>-10.21</td>
<td>-5.92</td>
<td>–</td>
</tr>
<tr>
<td>Iran</td>
<td>IRN</td>
<td>-19.11</td>
<td>-4.89</td>
<td>-0.03</td>
<td>–</td>
</tr>
<tr>
<td>Israel</td>
<td>ISR</td>
<td>-15.41</td>
<td>-5.56</td>
<td>-0.15</td>
<td>–</td>
</tr>
<tr>
<td>Italy</td>
<td>ITA</td>
<td>-7.81</td>
<td>-2.67</td>
<td>-0.22</td>
<td>-1.7</td>
</tr>
<tr>
<td>Japan</td>
<td>JPN</td>
<td>-2.15</td>
<td>-0.58</td>
<td>-0.01</td>
<td>-0.2</td>
</tr>
<tr>
<td>Korea Rep.</td>
<td>KOR</td>
<td>-8.71</td>
<td>-2.33</td>
<td>-0.02</td>
<td>–</td>
</tr>
<tr>
<td>Mexico</td>
<td>MEX</td>
<td>-8.56</td>
<td>-2.5</td>
<td>-0.08</td>
<td>–</td>
</tr>
<tr>
<td>Malaysia</td>
<td>MYS</td>
<td>-15.66</td>
<td>-5.75</td>
<td>-3</td>
<td>–</td>
</tr>
<tr>
<td>Netherlands</td>
<td>NLD</td>
<td>-18.99</td>
<td>-6.78</td>
<td>-3.88</td>
<td>-8.7</td>
</tr>
<tr>
<td>Norway</td>
<td>NOR</td>
<td>-16.64</td>
<td>-5.19</td>
<td>-0.15</td>
<td>-4.3</td>
</tr>
<tr>
<td>New Zealand</td>
<td>NZL</td>
<td>-12.86</td>
<td>-5.01</td>
<td>-0.02</td>
<td>-2.9</td>
</tr>
<tr>
<td>Pakistan</td>
<td>PAK</td>
<td>-28.26</td>
<td>-6.9</td>
<td>-0.86</td>
<td>–</td>
</tr>
<tr>
<td>Peru</td>
<td>PER</td>
<td>-18.15</td>
<td>-5.7</td>
<td>-0.12</td>
<td>–</td>
</tr>
<tr>
<td>Philippines</td>
<td>PHL</td>
<td>-23.12</td>
<td>-5.95</td>
<td>-0.08</td>
<td>–</td>
</tr>
<tr>
<td>Poland</td>
<td>POL</td>
<td>-17.76</td>
<td>-5.32</td>
<td>-0.14</td>
<td>–</td>
</tr>
<tr>
<td>Portugal</td>
<td>PRT</td>
<td>-18.21</td>
<td>-7.1</td>
<td>-1.28</td>
<td>–</td>
</tr>
<tr>
<td>Russia</td>
<td>RUS</td>
<td>-17.04</td>
<td>-3.62</td>
<td>-0.04</td>
<td>–</td>
</tr>
<tr>
<td>S Arabia</td>
<td>SAU</td>
<td>-10.78</td>
<td>-3.55</td>
<td>-0.15</td>
<td>–</td>
</tr>
<tr>
<td>Singapore</td>
<td>SGP</td>
<td>-16.12</td>
<td>-6.04</td>
<td>-2.21</td>
<td>–</td>
</tr>
<tr>
<td>Sweden</td>
<td>SWE</td>
<td>-15.12</td>
<td>-5.44</td>
<td>-0.96</td>
<td>-3.2</td>
</tr>
<tr>
<td>Thailand</td>
<td>THA</td>
<td>-15.44</td>
<td>-4.16</td>
<td>-0.05</td>
<td>–</td>
</tr>
<tr>
<td>Turkey</td>
<td>TUR</td>
<td>-15.88</td>
<td>-4.12</td>
<td>-0.07</td>
<td>–</td>
</tr>
<tr>
<td>Taiwan</td>
<td>TWN</td>
<td>-9.67</td>
<td>-2.96</td>
<td>-0.05</td>
<td>–</td>
</tr>
<tr>
<td>USA</td>
<td>USA</td>
<td>-1.69</td>
<td>-0.61</td>
<td>-0.09</td>
<td>-0.8</td>
</tr>
<tr>
<td>Venezuela</td>
<td>VEN</td>
<td>-13.64</td>
<td>-4.37</td>
<td>-0.13</td>
<td>–</td>
</tr>
<tr>
<td>South Africa</td>
<td>ZAF</td>
<td>-11.75</td>
<td>-3.53</td>
<td>-0.01</td>
<td>–</td>
</tr>
</tbody>
</table>

Table 10: The gains from opening to trade from autarky under different specifications. I am comparing changes in real wage when switching from the calibrated trade equilibrium to the counter-factual autarky equilibrium. Notice that $V = Q^1_N U^\infty_M$, and hence $d \ln V^i = \alpha d \ln U^\infty_M = \alpha d \ln \frac{w_i}{P_i}$. 

53
To illustrate the composition of the gains from trade, I break down the aggregate welfare gains into product-specific gains. Figure 18 displays the change in purchasing power (i.e. nominal wage relative to prices index of good \( h \)) after opening to trade for all five products used in the calibration. Every point displays the change in purchasing power (\( \frac{w_i}{P_i} \)) in one of the 50 countries after opening to the trade from autarky. Every (vertical) set of points refers to one of the five products (or industries) that constitute the product space in the calibrated model. The products are ordered in terms of the level of differentiation, which is shown on the x-axis. The gains in purchasing power are much larger and more dispersed for the more differentiated products. This explains the large aggregate gains from trade: The gains are mostly driven by high gains in the differentiated product categories.

For the least differentiated product, some countries experience a drop in their purchasing power after trade. In other words, their nominal wage drops relative to the price of the least differentiated product when trade is liberalized. To illustrate this effect thoroughly, I provide the exact welfare gains for all countries at all product levels in table 11. As the results suggest, it is mostly the low-wage countries that slightly loose their purchasing power in less-differentiated products after trade. However, poor countries also gain the most from trade overall.

The observation is due to fact that low-wage countries are not a profitable market for foreign firms

---

\(^{77}\) If the product space was continuous, as in the theoretical setting, high wage countries will also experience losses in purchasing power from some product categories with an infinitely large elasticity.
when it comes to selling less-differentiated products. The domestic firms produce less-differentiated products at a very low price, and will absorb all the market share. Hence, when compared to rich countries, imports in poor countries are even more concentrated in the highly differentiated products. Since the multi-product foreign firms crowd out a fraction of the domestic firms after trade, and yet only supply the most-differentiated of the products; trade can potentially lower the number of varieties in the less-differentiated categories.\textsuperscript{78}

Meanwhile, poor countries also gain access to high quality varieties from rich countries after trade. Pakistan, for example, is a major gainer (overall) according to my results. The reason is that after trade is liberalized, Pakistan gains access to electronics produced in Japan which are both highly different from electronics produced in Pakistan and also have a much lower pure price. Hence, after trade Pakistan might lose a few domestic suppliers of soccer balls, but it will benefit substantially from the availability of the high-tech electronics from high-wage countries.

\textsuperscript{78}In the CES framework consumers are identical and purchase all the varieties. The asymmetric gains in purchasing power, i.e. product-specific real wage, is of not of much interest in this setting. However the exact same aggregate demand and model could be generated with a nested logit demand structure, which is isomorphic to nested CES. If the underlying demand structure were nested logit, where everyone buys only one variety, the above result implies asymmetric gains from trade across consumers. Consumers of cheap less-differentiated product in low-wage countries lose from trade. Nevertheless, one average consumers in low-wage countries also gain the most from trade.
| Country        | ISO code | \( \% \Delta V_h | h=1 | \% \Delta V_h | h=2 | \% \Delta V_h | h=3 | \% \Delta V_h | h=4 | \% \Delta V_h | h=5 |
|---------------|----------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| UAE           | ARE      | -11.51           | -9.4             | -13.24           | -18.64           | -24.36           |
| Argentina     | ARG      | -0.55            | -1.3             | -5.19            | -10.51           | -16.65           |
| Australia     | AUS      | -2.59            | -1.71            | -3.68            | -6.66            | -10              |
| Austria       | AUT      | -10.53           | -12.49           | -16.99           | -22              | -26.96           |
| Belgium       | BEL      | -13.8            | -18.35           | -24.12           | -29.8            | -35.3            |
| Brazil        | BRA      | 1.19             | 0.85             | -3.43            | -9.82            | -17.49           |
| Canada        | CAN      | -5.24            | -8.22            | -12.86           | -17.56           | -22.05           |
| Switzerland   | CHE      | -12.72           | -13.84           | -17.14           | -20.84           | -24.52           |
| Chile         | CHL      | 0.42             | -2.95            | -10.58           | -20.04           | -29.93           |
| China         | CHN      | 2.07             | 1.59             | -8.4             | -22.67           | -37.63           |
| Colombia      | COL      | 2.03             | -2.82            | -14.99           | -29.37           | -43.7            |
| Germany       | DEU      | -4.18            | -4.82            | -7.11            | -9.63            | -12.23           |
| Denmark       | DNK      | -12.12           | -13.39           | -17.54           | -22.18           | -26.76           |
| Algeria       | DZA      | 1.8              | 9.29             | -26.48           | -43.93           | -60.53           |
| Egypt         | EGY      | 2.37             | -4.4             | -19.26           | -35.81           | -51.86           |
| Spain         | ESP      | -1.49            | -4.02            | -8.22            | -13.07           | -18.04           |
| Finland       | FIN      | -10.94           | -11.45           | -16.13           | -21.63           | -27.14           |
| France        | FRA      | -4.56            | -5.86            | -8.62            | -11.68           | -14.76           |
| UK            | GBR      | -4.36            | -4.81            | -7.16            | -9.91            | -12.69           |
| Greece        | GRC      | -4.6             | -7.68            | -14.55           | -22.42           | -30.29           |
| Hong Kong     | HKG      | -13.98           | -8.51            | -10.42           | -14.5            | -18.78           |
| Indonesia     | IDN      | 2.41             | -0.24            | -14.46           | -32.23           | -49.94           |
| India         | IND      | 2.6              | -0.39            | -17.74           | -38.66           | -59.04           |
| Ireland       | IRL      | -12.73           | -15.8            | -21.6            | -27.69           | -33.58           |
| Iran          | IRN      | 1.97             | 2.99             | -16.26           | -31.96           | -47.38           |
| Israel        | ISR      | -9.9             | -7.97            | -12.12           | -17.79           | -23.6            |
| Italy         | ITA      | -2.5             | -3.49            | -6.15            | -9.38            | -12.76           |
| Japan         | JPN      | -4.62            | -1.31            | -1.23            | -1.67            | -2.18            |
| Korea Rep.    | KOR      | -3.54            | -2.02            | -5.65            | -10.86           | -16.51           |
| Mexico        | MEX      | 1.24             | -1.3            | -5.46            | -12.5            | -20.08           |
| Malaysia      | MYS      | -1.83            | -3.7             | -12.16           | -22.93           | -33.91           |
| Norway        | NOR      | -12.32           | -11.42           | -14.29           | -18.01           | -21.76           |
| Pakistan      | PAK      | 0.43             | -7.42            | -27.71           | -50.3            | -72.16           |
| Peru          | PER      | 1.94             | -3.13            | -15.42           | -29.86           | -44.28           |
| Philippines   | PHL      | 2.2              | -4.48            | -21.3            | -40.25           | -58.54           |
| Poland        | POL      | 0.36             | -5.16            | -15.27           | -26.44           | -37.4            |
| Portugal      | PRT      | -3.4             | -8.55            | -16.08           | -24.12           | -32.04           |
| Russia        | RUS      | 2.21             | -1.71            | -13.75           | -28.1            | -42.3            |
| S Arabia      | SAU      | -1.85            | -2.74            | -7.79            | -14.48           | -21.57           |
| Singapore     | SGP      | -15.53           | -10.5            | -12.19           | -16.61           | -21.62           |
| Thailand      | THA      | 1.42             | -1.34            | -11.77           | -25.2            | -38.86           |
| Turkey        | TUR      | 1.53             | -2.55            | -12.85           | -24.9            | -36.92           |
| Taiwan        | TWN      | -5.9             | -3.37            | -6.6             | -11.35           | -16.36           |
| USA           | USA      | -1.82            | -1.07            | -1.25            | -1.64            | -2.1             |
| Venezuela     | VEN      | 0.58             | -2.45            | -10.48           | -20.38           | -30.53           |
| South Africa  | ZAF      | 1.66             | 0.15             | -8.05            | -18.83           | -30.17           |

Table 11: The gains from trade for different countries in various product categories. The table reports changes in purchasing power in each product category, i.e., \( \frac{\Delta w_i P_i}{U_i} \), when switching from the calibrated trade equilibrium to the counter-factual autarky equilibrium. Notice that \( V = Q_N^1 \alpha U_M^\alpha \), and hence \( d \ln V = \alpha d \ln U_M^\alpha = \alpha d \ln \frac{w_i P_i}{U_i} \).
4.4 A Gated Globe—the Large Scale of Iceberg Trade Costs

Finally, I show that forcing the within-country and cross-country elasticities to be equal leads to an aggregation bias when estimating the iceberg trade costs. Specifically, I argue that iceberg trade costs might even be larger than what traditional models estimate. The standard practice in the literature is to assume one elasticity for all products—usually equal to 5. Under this assumption one could then identify the unobserved iceberg trade costs. In this paper I took the alternative approach; I first identified and estimated the product-specific elasticities with micro-data that included observable freight and duty charges. Then, using the estimated elasticities I identified trade costs (in the calibration procedure) without imposing any further structure on elasticities.

Two effects cause the under-estimation of trade costs. The first one is forcing $\eta$ (the relative scale of the within-country to the cross-country elasticity) to one. The intuition is simple; suppose the elasticity of substitution between Home and Foreign varieties is not lower than the elasticity of substitution between different Home varieties. Then, if there are many domestic firms already operating in the local market, consumers will be indifferent between having an additional domestic variety versus an additional foreign variety (even though foreign varieties are scarce). Consequently, there will be less incentive for firms to enter foreign markets when they have a high export price—because their varieties can be substituted by cheap domestic varieties. Under these circumstances, to match the high volume of trade in the data, estimated trade costs should be sufficiently low so firms would have incentive to export. For instance, if iceberg costs are high enough so that the Home variety is always cheaper than the Foreign variety, there will be no trade at all under the assumption that $\eta = 1$.\footnote{It is important to note that the scale of $\eta$ matters less in the presence of firm-level heterogeneity.}

The second channel, which leads to understating trade costs, comes from over-estimating cross-country elasticities (due to not controlling for hidden varieties in the gravity estimation). With higher cross-country elasticity, to match trade flows one would have to estimate lower trade costs.

To quantify these biases, I compare the calibrated iceberg trade costs under three specifications in table 12. When $\sigma_h$ is forced to be the same and equal to 4.2 for all five product categories trade costs are underestimated by around 34% compared to the main model. When $\eta$ is also forced to be close to one (i.e. $\eta = 1.1$) trade costs are under-estimated by 53%. So what do these results imply? We are already benefiting substantially from trade, but there is room left for further gains. Trade barriers are quite large and the gains from eliminating them could be much greater than what traditional theories predict.
Average $\tau_{ij}$ | % difference compared to new model
---|---
New model | 3.28 | –
$\sigma = 4.2, \eta = 2.15$ | 2.17 | -33.84%
$\sigma = 4.2, \eta \to 1$ (Krugman) | 1.55 | -52.74%

Table 12: Comparison of calibrated iceberg trade costs under different specifications.

5 Conclusion

This paper lays out a theory that accounts for some well-established first order facts in bilateral trade data. In particular, it provides a unifying theory for why rich countries trade more intensively and specialize in high unit value products, or why exporters only ship the “goods apples” to the far corners of the world. In doing so, the paper builds upon Krugman [1980] and maintains the tractable properties of the Krugman model, i.e. homotheticity and symmetric iceberg trade costs. The takeaway message from the theory is that by allowing the elasticity of substitution to vary across products categories; (1) variations in export behavior across countries with different aggregate characteristics can be explained within one unified model, and (2) The gains from trade will be sizable. Moreover, the paper develops a tractable and easily quantifiable framework for analyzing North-South and North-North (South-South) trade simultaneously.

I fit the model to data in two steps. First, instead of imposing restrictive assumptions on demand elasticities to back out unobserved trade costs, I estimate the correct demand structure using disaggregated data, which includes observable trade costs. Then, using the data-driven demand structure I calibrate the model to aggregate trade flows to back out the aggregate trade costs and the gains from trade. My main empirical findings are the following: (1) the gap in competitiveness between wealthy and developing countries is strikingly large in highly differentiated sectors; (2) low wage import penetration in the US is significantly lower in more differentiated industries; (3) US employment in highly differentiated (i.e. low elasticity) industries is largely insulated from import penetration by low-wage countries; (4) the gains from opening to trade from autarky are bigger, by a large margin, in my model compared to the baseline Krugman model; and (5) the iceberg trade costs are understated by around 50% in the baseline model, which implies that further gains from reducing aggregate trade costs would be also bigger in my model relative to the baseline.

There are many aspects of the model that can be more thoroughly explored in future research. There is, however, one aspect that strikes me as the most significant: The uneven distribution of the gains from trade across consumers. Since the model matches a broader set of underlying patterns in the data, it also gener-
ates an extra layer of results regarding the gains from trade. For example, as a result of lowering iceberg trade costs, purchasing power in highly differentiated product categories rises dramatically at the cost of lower purchasing power in less differentiated products. The effect is starker in low-wage countries. If the underlying demand structure were nested logit which is isomorphic to the nested CES, this would imply an uneven distribution of the gains from trade: After trade liberalization, consumers of less-differentiated products lose while individuals who consume more-differentiated products gain substantially.

References


Daniel McFadden et al. Modelling the choice of residential location. Institute of Transportation Studies, University of California, 1978.


A Proofs and Additional Results

A.1 The Pro-variety Effects of Eliminating Trade Barriers

Suppose countries open up to trade from autarky. I can show that the total number of varieties in the market
post trade (i.e. $\sum_{j \in C_i} M_{ij}$) is larger in my model compared to the baseline Krugman-Armington model.
The intuition is the following: lowering trade costs, induces entry among foreign firms that specialize
in differentiated products. Availability of more variety in differentiated product categories encourages
consumers to reallocate their spending from less-differentiated products to highly differentiated products.
This results in the potential collectable revenue for firms net of marginal cost to be larger because firms can
charge a higher markup for the differentiated products. Mathematically, total revenues net of marginal cost
in country $i$ are

$$R_i = \left\{ \int_{h \in H} \frac{1}{\eta \sigma h} \lambda_h dh \right\} w_i L_i$$

The above equation implies that more spending on highly differentiated goods will increase potential
revenues, which translates into more firm entry. Moreover, in differentiated product categories spending is
more evenly distributed among varieties, making diversified firm entry possible. Both these pro-entry ef-
fects are absent in the baseline model. So given that firms pay the same per-product fixed cost for exporting
the highly differentiated products, my model predicts more profit gross of entry cost and therefore more
firm entry relative to the baseline model.

Proposition 3. Consider a baseline model in which cross-country elasticity is constant across all products and equal
to the average economy-wide elasticity (in autarky) $\sigma = \int_h \sigma h \lambda_h dh$, $\forall h \in H$

(i) There are more varieties within each country after trade liberalization in the new model relative to the baseline.

(ii) The new model predicts a larger increase in the number of varieties when trade costs are lowered.

Proof. The free entry condition for country $j$ in country $i$ can be re-written as

$$\left( \int_{h \in H} \frac{\lambda_{jh}^i \lambda_h^i}{\eta \sigma h} dh \right) L_i = M_j^i f^e + f \int_h M_{jh}^i dh$$

summing up (22) for all countries I will have

$$\left( \int_{h} \frac{1}{\eta \sigma h} \lambda_h dh \right) L_i = \sum_j M_j^i f^e + f \sum_{j \neq i} \int_h M_{jh}^i dh$$

See proof of proposition 3 for the derivation of the revenue equation.
\( \left\{ \int_{h \in H^i} \frac{1}{\sigma_h} \lambda_h^i dh \right\} \) is the total revenue that firms can collect in country \( i \). First, from Jensen’s inequality we have

\[
\int_{h \in H} \frac{1}{\eta \sigma_h} \lambda_h^i dh > \frac{1}{\eta \sigma} \]

Where \( \sigma = \int_h \sigma_h \lambda_h^i dh \). The above inequality implies that in every equilibrium there are more revenue for firms in the new model which prompts more entry. Second, a negative change in trade costs \(-d \tau\) will induce entry among foreign firms, hence redistribution spending form less-differentiated products to more differentiated products in the baseline model with \( \sigma_h = \sigma \) for all \( h \), the change in revenue will be zero because, it will a zero sum redistribution. In my model though I a small change \(-d \tau\) in trade costs will result in

\[
d \left( \int_{h \in H} \frac{1}{\eta \sigma_h} \lambda_h^i dh \right) = \left( \int_{h \in H} \frac{1}{\eta \sigma_h} d\lambda_h^i dh \right) > 0
\]

The above inequality follows from the fact that entry will be in less-differentiated products and spending will also move towards those products. Mathematically, if the product are ordered in terms of their differentiation, here exists a \( h^*_i \) such that

\[
\begin{align*}
\int_0^{h^*_i} d\lambda_h^i dh < 0 \\
\int_{h^*_i}^h d\lambda_h^i dh > 0 \\
\int_0^h d\lambda_h^i dh = 0
\end{align*}
\]

The above inequalities imply that \( d \left( \int_{h \in H} \frac{1}{\eta \sigma_h} \lambda_h^i dh \right) > 0 \). Therefore, lowering trade cost will increase total revenues net of marginal costs, more in the new model relative to the baseline. These two channels together imply that

\[
d \sum_j M_j^i > d \left( \sum_j M_j^i \right)^{baseline}
\]

This follows from the fact that as \( f \to \infty \) then just from the first channel of higher revenues \( d \sum_j M_j^i = \left( \sum_j M_j^i \right)^{baseline} = 0 \). Given \( -\frac{d}{df} \left\{ d \sum_j M_j^i - d \left( \sum_j M_j^i \right)^{baseline} \right\} > 0 \) then for every finite \( f \) we should have \( d \sum_j M_j^i > d \left( \sum_j M_j^i \right)^{baseline} \).

\[\Box\]

\[81\] In an asymmetric world where wages differ across countries the condition will be: \( d \sum_j w_j M_j^i > d \left( \sum_j w_j M_j^i \right)^{baseline} \)
A.2 Calculating Markups

The firm’s problem is the following

$$\max_{p_{\omega jh}} \left[ p_{\omega jh} - \tau_{ji}w_j \right] q_{\omega jh}(p_{\omega jh}) - f$$

The F.O.C will be

$$q_{\omega jh}^i(p) + (p - \tau_{ji}w_j) \frac{dq_{\omega jh}(p)}{dp} = 0$$

From the CES demand equation we have

$$q_{\omega jh}^i = \left( \frac{p_{\omega jh}^i}{P_{ji}^h} \right)^{(1-\gamma_h)} \left( \frac{P_{ij}^i}{P_{ij}^h} \right)^{1-\sigma_h} \left( \frac{P_{ih}^i}{P_{ih}^h} \right)^{1-\epsilon_h} \alpha w_j L_i \frac{1}{p_{\omega jh}^i}$$

Taking derivatives

$$q_{\omega jh}^i + p \frac{dq_{\omega jh}^i}{dp} = [1 - \gamma_h] q_{\omega jh}^i (1 - \frac{1}{M_{ji}^h})$$

Because every firm is measure zero $\frac{1}{M_{ji}^h} \approx 0$ then (in the above equation I have already omitted the terms with $\left( \frac{1}{M_{ji}^h} \right)^2$)

$$p - \tau_{ji}w_j = - \frac{q_{\omega jh}^i}{\frac{dq_{\omega jh}^i(p)}{dp}} = \frac{p}{1 - [1 - \gamma_h]}$$

Then

$$p_{\omega jh} = \frac{\gamma_h}{\gamma_h - 1} \tau_{ji}w_j, \quad \forall \omega \in \Omega_j$$

A.3 Proof of Proposition 1

Consider the labor market clearing condition

$$\alpha L^i = \left( M_i^i f^e + \int_{h \in H} q_{ih}^i M_i^i \nu_i^i(h)dh \right) + \left( \sum_{k \neq i} M_i^k f^e + \int_{h \in H} \left( \tau_{ik} q_{ih}^k + f \right) M_i^k \nu_i^k(h)dh \right) \text{(LMC)}$$

The assumption is that $\{\tau_{ik}\}_{k \in C} = \{\tau_{jk}\}_{k \in C}$, $L_i = L_j$, and $\mu_i > \mu_j$. I will prove the proposition by
contradiction; suppose \( w_i \leq w_j \) then

\[
\begin{align*}
\tau_{ik} q_j^k > \tau_{jk} q_j^k \\
M_i^k \nu_i^k(h) > M_j^k \nu_j^k(h) \quad \forall h \in H; \forall k \neq j, i \\
M_i^k > M_j^k
\end{align*}
\]

which implies that there is more demand for labor in country \( i \) while supply of labor in both countries is the same which is a contradiction. Therefore, \( w_i > w_j \). Moreover, there exists some \( \sigma^* \) such that for \( \sigma_h > \sigma^* \) then \( \mu_j w_j^{1-\sigma_h} > \mu_i w_i^{1-\sigma_h} \) - otherwise there the (LMC) will be contradicted because there would be more demand for labor in \( i \) while the supply of labor is the same in both countries.

An increase in \( w_i \) affects home sales more than exports because

(i) \( \nu_i^k(h) = 1 > \nu_j^k(h) \quad \forall k \neq i \) and

(ii) \( \frac{\partial q^k}{\partial h} \) is decreasing in \( h \) for all \( k \neq i \) because firms charge lower prices at home than in foreign markets. Hence, in equilibrium for demand to be equalized for labor between \( i \) and \( j \) we will have

\[
\begin{align*}
w_i &> w_j \\
M_i^f c + \int_{h \in H} q_i^k M_i^k dh < M_j^f c + \int_{h \in H} q_j^k M_j^k dh \\
\sum_{k \neq i} M_i^k f c + \int_{h \in H} (\tau_{ik} q_j^k + f) M_i^k \nu_i^k(h) dh > \sum_{k \neq i} M_j^k f c + \int_{h \in H} (\tau_{jk} q_j^k + f) M_j^k \nu_j^k(h) dh
\end{align*}
\]

Given that labor requirement for production is the same in both \( i \) and \( j \) (it is the same for all countries by assumption). The free entry (FE) condition and the second inequality above imply

\[
\int_{h \in H} \frac{\sigma_h}{\sigma_h - 1} M_j^f q_j^k dh > \int_{h \in H} \frac{\sigma_h}{\sigma_h - 1} M_i^f q_i^k dh
\]

Since \( L_i = L_j \), the above inequality can be written as

\[
\lambda_j^i = \frac{\int_{h \in H} \frac{\sigma_h}{\sigma_h - 1} w_j M_j^f q_j^k dh}{w_j L_j} > \frac{\int_{h \in H} \frac{\sigma_h}{\sigma_h - 1} w_i M_i^f q_i^k dh}{w_i L_i} = \lambda_i^j
\]

Form the balance of payments equation, the above conditions implies that country \( i \) exports a higher share of the value added in its country, relative to \( j \). The fact that country \( i \) exports more differentiated (and expensive) products follows from the argument in the text.
A.4 Proof of Proposition 2

Step 1 I first show that the change in the number of domestic varieties, and the share of exports in total spending are sufficient statistics to measure the gains from trade. As in Arkolakis et al. [2012] take the wage in country $i$ as the numeraire, then the change in welfare in country $i$ from a small change in trade costs is given by the change in the aggregate price index

$$ d \ln \frac{w_i}{P_i} = - \frac{1}{1-\epsilon} d \ln \left\{ \int_{h \in H} \left( \frac{P^i_h}{P^i_h} \right)^{1-\epsilon} dh \right\} \tag{19} $$

Given that $d \left( \frac{P^i_h}{P^i_h} \right)^{1-\epsilon} = (1-\epsilon) d \ln \frac{P^i_h}{P^i_h} \left( \frac{P^i_h}{P^i_h} \right)^{1-\epsilon}$, the above equation can be re-written as

$$ d \ln \frac{w_i}{P_i} = - \int_h d \ln \frac{P^i_h}{P^i_h} \left( \frac{P^i_h}{P^i_h} \right)^{1-\epsilon} \tag{20} $$

where

$$ d \ln P^i_h = \sum_j d \ln P^i_{jh} \left( \frac{P^i_{jh}}{P^i_h} \right)^{1-\sigma_h} \tag{21} $$

and

$$ P^i_{jh} = \tau_{ji} w_i \left( \mu_j M^i_{jh} \right)^{-\frac{1}{1+\sigma_h}} \tag{22} $$

Plugging (21) and (20) into equation (19) we will have

$$ d \ln \frac{w_i}{P_i} = \sum_j d \ln w_j \tau_{ji} \lambda^i_{jh} + \int_h \sum_j \frac{1}{1-\eta \sigma_h} d \ln M^i_{jh} \lambda^i_{jh} \tag{23} $$

where the above equation follows from the fact that $\lambda^i_{jh} = \lambda^i_{jh} \lambda^i_h = \left( \frac{P^i_{jh}}{P^i_h} \right)^{1-\sigma_h} \left( \frac{P^i_h}{P^i_h} \right)^{1-\epsilon}$. From the lower-tire gravity described by equation (8), we have

$$ d \ln \lambda^i_{jh} - d \ln \lambda^i_{ih} = (1-\sigma_h) [d \ln w_j + d \ln \tau_{ji}] + \frac{1-\sigma_h}{1-\eta \sigma_h} [\ln M^i_{jh} - M^i_{ih}] \tag{24} $$

Plugging (23) into equation (22) and we will have

$$ d \ln \frac{w_i}{P_i} = \left\{ \int_h \sum_j \frac{d \ln \lambda^i_{jh} - d \ln \lambda^i_{ih}}{1-\sigma_h} \lambda^i_{jh} \lambda^i_h + \int_h \frac{1}{1-\eta \sigma_h} d \ln M^i_{jh} \lambda^i_h dh \right\} = \int_h \frac{d \ln \lambda^i_{jh} \lambda^i_h}{1-\sigma_h} dh + \int_h \frac{1}{\eta \sigma_h - 1} d \ln M^i_{jh} \lambda^i_h dh \tag{25} $$
given that \( \sum_j \lambda_{j|h} = 1 \) the above equation simplifies to

\[
\frac{d \ln w_i}{P_i} = \int_h \frac{-d \ln \lambda_{i|h} \lambda_h^i}{\sigma_h - 1} dh + \left[ \int_h \frac{1}{\eta \sigma_h - 1} \lambda_h^i dh \right] d \ln M_i^i
\]  

(25)

and for every product \( h \) the change in purchasing power will be

\[
\frac{d \ln w_i}{P_h} = \frac{-d \ln \lambda_{i|h}^i \lambda_h^i}{\sigma_h - 1} + \frac{d \ln M_i^i}{\eta \sigma_h - 1}
\]

**Step 2** In this step I will first show that gains from trade in my model are larger than the baseline in a symmetric economy where wages are equalized. The fact that gains from trade are larger in my model follows from the same argument presented in the main text. Consider the change in welfare equation

\[
\frac{d \ln w_i}{P_i} = \int_h \frac{-d \ln \lambda_{i|h} \lambda_h^i}{\sigma_h - 1} dh + \left[ \int_h \frac{1}{\eta \sigma_h - 1} \lambda_h^i dh \right] d \ln M_i^i
\]

From the entry condition we have

\[
\left( \frac{1}{M_i^i} \int_{h \in H} \frac{\lambda_{i|h} \lambda_h^i}{\sigma_h - 1} dh \right) L_i = f^e
\]

Then

\[
d \ln M_i^i = d \ln \int_{h \in H} \frac{\lambda_{i|h}}{\sigma_h - 1} dh \implies d \ln M_i^i = \left\{ \int_{h \in H} \frac{d \lambda_{i|h}}{\sigma_h - 1} dh \right\}
\]

The above inequality follows from writing the FE condition as \( \frac{M_i^i f^e}{L_i} = \int_{h \in H} \frac{\lambda_{i|h}}{\sigma_h - 1} dh \), which in turn implies

\[
\frac{d \ln w_i}{P_i} = \int_h \frac{-d \ln \lambda_{i|h} \lambda_h^i}{\sigma_h - 1} dh - \left[ \int_h \frac{1}{\eta \sigma_h - 1} \lambda_h^i dh \right] d \ln \int_{h \in H} \frac{\lambda_{i|h}}{\sigma_h - 1} dh
\]

In autarky, and close to autarky a good approximation will be \( \lambda_{i|h} \approx 1 \) which allows me to write the above equation as

\[
\frac{d \ln w_i}{P_i} = \int_h \frac{-d \ln \lambda_{i|h} \lambda_h^i}{\sigma_h - 1} dh \left\{ 1 - \left[ \int_h \frac{1}{\eta \sigma_h - 1} \lambda_h^i dh \right] \right\}
\]

to prove the proposition I need to show that if parameters in the two models where somehow that import penetration was the same for both models (i.e. \( \int_h -d \ln \lambda_{i|h} \lambda_h^i dh = \left( \int_h -d \ln \lambda_{i|h} \lambda_h^i dh \right)_{\text{baseline}} \)), the new model would generates more gains. Note that in the symmetric equilibrium \( p_{ih}^i > p_{jh}^j \) \( \forall h \) and hence domestic firms have competitive advantage in the less-differentiated products. In the baseline model domestic firms do not have the same level of competitiveness in all products. Hence, it follows that (i)
\[
\frac{d \ln \lambda^i_{jh}}{\langle d \ln \lambda^i_{jh} \rangle_{\text{baseline}}} \text{ is increasing in } \frac{1}{\sigma_{n-1}}, \text{ and (ii) } \frac{\lambda^i_{jh}}{\langle \lambda^i_{jh} \rangle_{\text{baseline}}} \text{ is non-decreasing in } \frac{1}{\sigma_{n-1}}. \text{ (i) and (ii) together imply that } \int_h \frac{-d \ln \lambda^i_{jh} \lambda^i_{h}}{\sigma_{n-1}} dh > \left( \int_h \frac{-d \ln \lambda^i_{jh} \lambda^i_{h}}{\sigma_{n-1}} dh \right)_{\text{baseline}}. \text{ Moreover the term in the parenthesis on the RHS goes to zero as } \eta \to 1 \text{ which is another channel which pushes down the gains in the baseline model.} \]

\[\Box\]

### B  Market Size and the Price of a Country’s Consumption

A salient future of the upper tier gravity (equation (9)) is that love of variety is stronger in more differentiated product categories. Therefore, if the number of varieties in a country rises, spending will be redirected towards more differentiated products, so consumers can benefit from the extra variety. For example, in country \(i\) spending on product \(h\) relative to \(h'\) would be

\[
\frac{\lambda^i_{jh}}{\lambda^i_{jh'}} = \frac{\left[ \frac{\eta \sigma_{n-1}}{\eta \sigma_{n-1}} \right]^{(1-\epsilon)} \left\{ \sum_{k \in C} \mu_k \left( M^i_{kh} \right)^{\frac{\sigma_{n-1}}{\sigma_{n-1}-1}} \left( w_k T_{ki} \right)^{(1-\sigma_n)} \right\}^{\frac{\sigma_{n-1}}{\sigma_{n-1}-1}}}{\left[ \frac{\eta \sigma_{n-1}}{\eta \sigma_{n-1}} \right]^{(1-\epsilon)} \left\{ \sum_{k' \in C} \mu_{k'} \left( M^i_{k'h'} \right)^{\frac{\sigma_{n-1}}{\sigma_{n-1}-1}} \left( w_{k'} T_{k'1} \right)^{(1-\sigma_{n-1})} \right\}^{\frac{\sigma_{n-1}}{\sigma_{n-1}-1}}}.
\]

Suppose the total number of varieties in market \(i\) increase by a factor \(t > 1\) (i.e. \(\sum_{j \in C} M^i_{jh} = t \sum_{j \in C} M^i_{jh'} \forall h\)) then

\[
\left( \frac{\lambda^i_{jh}}{\lambda^i_{jh'}} \right)' = t^{\frac{\epsilon}{\eta}} \left( \frac{\sigma_{n-1}}{\sigma_{n-1}-1} \right) \left[ \frac{\sigma_{n-1}}{\sigma_{n-1}-1} \right] \frac{\lambda^i_{jh}}{\lambda^i_{jh'}}
\]

if \(\sigma_n < \sigma_{n-1}\) if follows that \(\left( \frac{\lambda^i_{jh}}{\lambda^i_{jh'}} \right)' > \frac{\lambda^i_{jh}}{\lambda^i_{jh'}}\). Putting it differently; if the number of supplied varieties in country \(i\) increases, then country \(i\) will spend relatively more on highly differentiated products.\(^{82}\)

### C  Isomorphism between CES and Nested logit

I will describe the nested logit demand first. Each consumer in country \(i\) buys only one variety of the differentiated good, and spends all of his income on that particular variety. If consumer \(n\) consumes variety \(fj\) of product \(h\) then he gets utility \(V_{\omega jh}\)

\[
V^n_{\omega jh} = \ln \left( \frac{u^n_i}{p^n_{\omega jh}} \right) + \ln \mu_j + \nu^n_{\omega jh},
\]

Where \(p^n_{\omega jh}\) is the price of variety \(\omega jh\) in country \(i\), and \(\frac{u^n_i}{p^n_{\omega jh}}\) is the amount of the variety \(\omega jh\), consumer

\(^{82}\)This factor in equilibrium prompts consumers in high-wage countries to spend relatively more on expensive differentiated products; a novel result that comes without the need to assume some type of non-homotheticity in demand. However, Unlike non-homothetic preferences, this channel does not disentangle the effect of population from wage on the patterns of spending.
$n$ in country $i$ with income $w_i$ can purchase. Every household is endowed with one unit of effective labor so that income is equal to wage $w_i$ in country $i$. $\mu_j$ is the common value all households attach to varieties produced in country $j$. Consumer $n$ also has a personal evaluation of each variety which I call “taste”, and is captured by the term $\nu^n_{\omega j h}$. I assume that every consumer independently and separately draws (a continuum of) taste shocks from the following general extreme value (GEV) distribution

$$H_n(\nu) = \frac{1}{e - 1} \exp \left[ \int_{h \in H} \left( \sum_{j \in C_h} \left( \sum_{\omega \in F_{jh}} (1 - \eta \sigma_h) \nu_{\omega j h} \right) \right)^{-\frac{1}{\eta \sigma_h - 1}} \sigma_h \right] dh$$

The consumer then ranks all the varieties, chooses only one (utility maximizing) variety, and allocates all her income to that variety. $\sigma_h$ is the correlation between taste of consumers for country-level composite varieties of product $h$. $\eta \sigma_h$ is the correlation of consumers’ tastes for firm-level varieties of product category $h$ produced in the same country. $\epsilon$ is the correlation between consumers’ taste for different product categories in $H$. As Anderson, De Palma, and Thisse [1992] show, the nested-logit demand structure (described above) is equivalent to a nested CES demand structure. The aggregate demand for variety $f_j h$ in country $i$ resembles that of a nested CES demand and is given by

$$q_{\omega j h}^i = \left( \frac{p_{f j h}^i}{P_{f j h}} \right)^{1-\eta \sigma_h} \left( \frac{P_{f j h}^i}{P_{f j h}} \right)^{-\sigma_h} \left( \frac{P_{h}^i}{P_{h}^i} \right)^{-\epsilon} w_i L_i \frac{1}{p_{\omega j h}}$$

where $q_{\omega j h}^i$ is the “quantity” demanded of variety $\omega j h$ in country $i$. The above demand equation is a simple reformulation of the demand equation derived by McFadden et al. [1978], and the (quality adjusted) price indexes are given by

$$P_{f j h}^i = \sum_{\omega' \in F_{jh}} \left( \frac{p_{\omega' j h}^i}{P_{\omega' j h}^i} \right)^{1-\eta \sigma_h}$$

$$P_{h}^i = \sum_{k \in C_h} \mu_k \left( P_{k h}^i \right)^{1-\sigma_h}$$

$$P^i = \left\{ \int_{h \in H} \left( P_{h}^i \right)^{1-\epsilon} dh \right\}^{\frac{1}{1-\epsilon}}$$

McFadden et al. [1978] show the expected utility of an average consumer
\[
\int_{\nu=-\infty}^{\infty} \left( \max_{w_{jh}} \left( \ln \frac{\mu_j w_j}{P_{w_j h}} + \nu^n_{w_j h} \right) \right) h(\nu) d\nu = \ln \left( \frac{w^n}{P^n} \right)
\]

However the realized welfare for consumers buying product \( h \) in country \( i \) will be \( \ln \left( \frac{w_i^n}{P^n_i} \right) \). This leads to asymmetric gains from trade across consumers in my model.

## D Additional Graphs and Tables

### D.1 Low-wage Countries

<table>
<thead>
<tr>
<th>Afghanistan</th>
<th>Chad</th>
<th>Haiti</th>
<th>Niger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albania</td>
<td>China</td>
<td>India</td>
<td>Pakistan</td>
</tr>
<tr>
<td>Angola</td>
<td>Congo</td>
<td>Kenya</td>
<td>Rwanda</td>
</tr>
<tr>
<td>Armenia</td>
<td>Equatorial Guinea</td>
<td>Lao PDR</td>
<td>Samoa</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>Ethiopia</td>
<td>Madagascar</td>
<td>Sierra Leone</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Gambia</td>
<td>Malawi</td>
<td>Sri Lanka</td>
</tr>
<tr>
<td>Benin</td>
<td>Georgia</td>
<td>Mali</td>
<td>Sudan</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>Ghana</td>
<td>Mauritania</td>
<td>Togo</td>
</tr>
<tr>
<td>Burundi</td>
<td>Guinea</td>
<td>Moldova</td>
<td>Uganda</td>
</tr>
<tr>
<td>Cambodia</td>
<td>Guinea-Bissau</td>
<td>Mozambique</td>
<td>Vietnam</td>
</tr>
<tr>
<td>Central African Republic</td>
<td>Guyana</td>
<td>Nepal</td>
<td>Yemen</td>
</tr>
</tbody>
</table>

Table 13: Notes: The table provides the list of low-wage countries used in the paper. Low-wage countries are defined as countries with less than 5% of US per capita GDP. (source: Bernard et al. [2006a])
D.2 Country-specific Quality vs. Differentiation

![Scatter plot of the average estimated quality in the HS-10 code against the level of differentiation in that HS-10 product code.](image)

Figure 19: Scatter plot of the average estimated quality in the HS-10 code against the level of differentiation in that HS-10 product code.

D.3 Data Layout

<table>
<thead>
<tr>
<th>HS</th>
<th>SITC (rev.3)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6302322060</td>
<td>58439</td>
<td>BED LINEN NESOI OF MANMADE FIBER</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>year</th>
<th>Country</th>
<th>Entry City</th>
<th>Unloading city</th>
<th>Unit 1</th>
<th>Unit 2</th>
<th>Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>CHINA M</td>
<td>CHICAGO</td>
<td>LOS ANG</td>
<td>NO</td>
<td>KG</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Value</th>
<th>Quantity 1</th>
<th>Quantity 2</th>
<th>Charge</th>
<th>Duty</th>
</tr>
</thead>
<tbody>
<tr>
<td>3634</td>
<td>920</td>
<td>417</td>
<td>198</td>
<td>472</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Air value</th>
<th>Vessel value</th>
<th>Air weight</th>
<th>Vessel weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3634</td>
<td>0</td>
<td>483</td>
</tr>
</tbody>
</table>

Table 14: Layout of the US import data compiled by Schott [2008]
D.4 Price Elasticity in BLP

![Figure 20: Price elasticity of demand for various car products in the U.S. (source: Berry et al. [1995]).](image)

D.5 Most vs. Least Differentiated HS-10 products

<table>
<thead>
<tr>
<th>The five most differentiated HS-10 codes</th>
<th>The five least differentiated HS-10 codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>9208900040 MUSICAL INST, NOT IN ANY OTHER</td>
<td>6404198030 FOOTWEAR RUBPLAS SOL NESOI OV$</td>
</tr>
<tr>
<td>9014106000 GYROSCOPIC COMPASSES, OTHER TH</td>
<td>8703230048 PASS MTR VEH, NESOI, SPARK IGN,</td>
</tr>
<tr>
<td>848510040 SHIPS’ PROPELLERS AND BLADES O</td>
<td>6402999060 OTH FTWR RUB/PLAS VALUED OVER</td>
</tr>
<tr>
<td>370510000 PHOTO PLATES &amp; FILM, EXPOS &amp; D</td>
<td>6404118060 FTWR UP TX ML SO R/P SPRT VA&gt;$</td>
</tr>
<tr>
<td>8529102050 TELEVISION ANTENNAS, NESOI</td>
<td>6404118090 FTWR U TXML S R/P SPT VA&gt;$6.50</td>
</tr>
</tbody>
</table>

Table 15: Description of the most and least differentiated HS-10 product codes.
Figure 21: The scatter plot of the country-specific quality $\mu_j$ against the average years of schooling in each country (in benchmark year 2000) as reported by Barro and Lee [2001] ($R^2 = 0.55$). The average years of schooling can be thought of as a proxy for skill of labor force in a country. This graph partially explains why a car produced by labor in the US is more valued by consumers than a car produced in India.