Essays on Price and Quality in International Trade

A Dissertation in Economics
by
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Abstract

Each of the three chapters in this dissertation is based on an empirical research paper. The collective goals of these, rather independent, papers is to present an alternative and unifying theory of international specialization. A theory suitable for analyzing international trade at various levels and between a broad set of countries.

The first chapter develops a new theory of international specialization that tractably combines all aspects of North-North and North-South trade into one model. The new theory also provides an alternative explanation for many other well-established facts, most notably the “Washington apples” effect. The theory builds upon, and retains the central elements of Krugman [1980]. In the new framework, North-North trade is governed by national product differentiation. North-South trade is governed by a new channel of across product specialization that has been overlooked in the literature. Specifically, there are many products and each product comes in different varieties. Products differ in how (horizontally) differentiated they are. Monopolistically competitive firms charge a higher markup for varieties of highly differentiated products. In equilibrium, rich countries specialize in highly differentiated–high markup products, while poor countries specialize in less differentiated–low markup products. To quantify the gains from trade, I estimate the structural parameters of the model using disaggregated data. Incorporating the new channel of across-product specialization into the Krugman model magnifies the gains from opening to trade by around 200%. Despite trading less, low-income countries experience the largest gains from trade liberalization.

The second chapters provides the first empirical confirmation of the iceberg trade cost assumption. The assumption is embodied in all major models of International trade. However, empirical evidence to support this rather conventional assumption is lacking. This paper provides such evidence by developing a simple model of international transportation. The model links shipping cost to the f.o.b. price of the shipment, and demonstrates that shipping cost per count is more iceberg-like than shipping cost per kilogram – existing studies have generally
looked at shipping cost per kilogram for goods that are measured primarily in counts (e.g. TVs, cars). To address this finding, I first calculate price and shipping cost on a per-count basis for goods that report count as the primary unit of measurement in US import data. Then, I estimate the dependence of shipping costs on f.o.b. price. Estimation results strongly support the iceberg specification. Specifically, for every 1% increase in f.o.b. price (per count), the shipping cost (per count) increases by 0.91%. The paper then estimates the “Washington apples” effect: the dependency of export f.o.b prices on shipping costs. The effect is estimated to be stronger in industries where shipping costs are more iceberg-like. This suggests that, contrary to common belief, per-unit trade costs cannot be the only driving force behind the “Washington apples” effect. The paper then proceeds to find strong empirical support for an alternative force.

The third chapter provides a simple framework to analyze the three main components of international trade flows: (i) the number of goods traded, (ii) the quantity of each good that is shipped, and (iii) the prices they are sold for. While gravity equations are massively successful in explaining the overall value of trade, they do not provide much insight about the decomposition of trade. In this paper I develop a novel framework that provides, consistent with data, predictions about not only the value of trade but the composition of trade values. I relax the conventional assumption that consumers are identical, and allow for demand heterogeneity across consumers. I also allow for quality heterogeneity across varieties. The model explains the effect of distance and per capita income on trade along the intensive margin, the extensive margin and the price margin—all of which are well-documented in the empirical literature. It also provides a novel theoretical foundation for the higher price of tradables in developed countries. To further assess the model, I evaluate two predictions, of the model, regarding the price of traded goods and one prediction regarding the extensive margin of trade. The exercise confirms that all three predictions are borne out in the data. The model provides a framework to investigate the (across-consumer) distributional effects of trade liberalization. I show that, despite the aggregate gains, the poorest consumers experience losses in face of trade liberalization.
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1. Markups, International Specialization, and the Gains from Trade

This paper develops a new theory of international specialization that tractably combines all aspects of North-North and North-South trade into one model. The new theory also provides an alternative explanation for many other well-established facts, most notably the “Washington apples” effect. The theory builds upon, and retains the central elements of Krugman [1980]. In the new framework, North-North trade is governed by national product differentiation. North-South trade is governed by a new channel of across product specialization that has been overlooked in the literature. Specifically, there are many products and each product comes in different varieties. Products differ in how (horizontally) differentiated they are. Monopolistically competitive firms charge a higher markup for varieties of highly differentiated products. In equilibrium, rich countries specialize in highly differentiated–high markup products, while poor countries specialize in less differentiated–low markup products. To quantify the gains from trade, I estimate the structural parameters of the model using disaggregated data. Incorporating the new channel of across-product specialization into the Krugman model magnifies the gains from opening to trade by around 200%. Despite trading less, low-income countries experience the largest gains from trade liberalization.

1.1. Introduction

The “Classical trade theories” were developed during the ‘first great age of globalization’ when trade was mainly North-South trade. They emphasized inter-industry specialization, and were specifically designed to explain North-South trade. Beginning in the 1970s, global trade underwent a major transition. In less than a decade, international trade became predominantly North-North trade: a two-way exchange of similar goods between similar (highly developed) countries. Following this change, the “new trade theories” were born—these the-
ories were specifically designed to explain North-North trade. Recently, international trade has undergone yet another transition. In the past decade North-South and North-North (and even South-South) trade have become equally important (Hanson [2012]; Krugman [2009]). To accommodate this trend, we should revise how we model international trade. More precisely, we need a model that combines North-South and North-North trade—a model that simultaneously incorporates the two-way exchange of autos between US and Canada and the high-volume export of apparels from China to the US.

The past decade also marked a data revolution in the study of international trade. Researchers documented two new features of North-South trade. First, using highly disaggregated data, many studies reported a robust pattern of intraindustry North-South trade. Specifically, North and South exchange goods that belong to the same industry, with north exporting higher price goods within each industry (Schott [2004]; Bernard, Jensen, and Schott [2006a]). Second, many studies documented that (conditional on total GDP) countries with higher per capita GDP, trade more intensely. In other words, export-to-GDP ratio is higher in North relative to South (Fieler [2011]; Waugh [2010]). Neither of these (recently documented) features is captured by “classical theories” of North-South trade.

The goal of this paper is to, first, bridge the gap between “classical trade theory” and the “new trade theory”. To this end, I propose an alternative theory of international specialization that tractably combines all aspects of North-South and North-North trade into one model. I take an alternative view from the “classical trade theories,” and abstract from non-homotheticity, which is computationally burdensome, but widely used in the contemporary North-South trade literature. Indeed, the alternative theory deviates minimally from the standard assumptions adopted by Krugman [1980], retains the tractability of the “new trade theories,” and is straightforward to estimate. Second, the theory developed in this paper is consistent with the recent empirical findings on North-South trade; the new theory simultaneously explains (1) why high-income countries trade more intensely, and (2) why they engage in intra-industry trade with low-income countries, but export high-price goods within each industry. In fact, this paper presents the first theory of international specialization that reconciles these two recently well-documented features of North-South trade.

The theory developed in this paper is more than just a theory of North-South (and North-North) trade. It is a comprehensive, multi-country, general equilibrium theory of international specialization; a theory of why (in the global economy) countries with different characteris-
tics specialize in different goods. For example, the new theory provides an alternative explanation for the “Washington apples” effect—a well-documented fact regarding intra-industry specialization.\(^1\) Due to its comprehensive nature, the new theory fits aggregate trade data significantly better than the baseline Krugman model. Moreover, the theory yields predictions (about intraindustry and interindustry trade) that are consistent with highly disaggregated US imports data.

The new theory provides a simple framework to quantify the gains from trade across low-income and high-income countries when all directions of trade are taken into account. Previous studies have generally quantified the gains from trade among high-income countries by focusing (exclusively) on North-North trade (Arkolakis, Costinot, and Rodriguez \([2012]\); Eaton and Kortum \([2002]\)). Quantifying the gains from trade in the new framework reveals two remarkable results: (1) when North-South specialization is embodied into a standard “new trade theory” framework, the gains from trade are magnified (for the average country) by around 200\%, and (2) low-income countries experience the largest gains from globalization, even though they trade less. In summary, the new theory introduces an alternative driving force behind (dissimilar) trade that exhibits generality, is highly consistent with disaggregated data, and generates distinct welfare implications. The new theory, therefore, complements the existing theories, and should be separately identified if we wish to attain consistent estimates for the gains from trade.

To model the global economy, I build upon the multi-country monopolistic competition model of trade with homogeneous firms, developed by Krugman \([1980]\). I modify the baseline Krugman model along two main directions. First, rather than one product, there are many products and each product comes in many different varieties. Varieties of a product are differentiated by country of origin (i.e. national product differentiation), and within every country varieties are differentiated at the firm level. National product differentiation is the driving force behind North-North trade.\(^2\)

Products are characterized by how (horizontally) differentiated they are. Specifically, preferences are nested CES, and each nest represents a product with a unique (product-specific)

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\(^1\)The “Washington apples” effect states that countries, which face higher trade costs specialize in higher price goods.

\(^2\)In the original Krugman model increasing returns to scale are the driving force behind North-North trade. Increasing returns to scale and national product differentiation are isomorphic in terms of generating North-North trade. However, Head and Ries \([2001]\) suggest that evidence sides with national product differentiation more than the other.
elasticity of substitution across varieties. Highly differentiated products have a low elasticity of substitution, while less differentiated products are subject to a high elasticity of substitution, e.g. designer handbags are highly differentiated while sandwich bags are less differentiated. In a monopolistically competitive setting, firms charge a higher markup for highly differentiated products. Therefore, within every industry, highly differentiated products on average exhibit a higher price due to higher markups.\(^3\)

The second direction in which I modify Krugman [1980] is allowing for countries to be asymmetric in labor skill. A Country that is populated with high-skill labor exhibits superior “national production quality,” and is endowed with a larger Armington demand shifter, i.e. varieties produced in high-skill countries are more attractive to consumers all over the world. High-skill labor improves the “quality of production” but not the “quantity of production.” For example, a worker in China produces the same quantity of cars as a German worker. However, the German car is more attractive to consumers because it is designed and assembled by high-skill labor. In equilibrium, there is more demand for high-skill labor. Therefore, equilibrium wages and income levels are higher in high-skill countries which exhibit superior “national production quality.”

In the trade equilibrium, two factors determine how much a country exports to global markets: (1) price, and (2) national production quality. For highly differentiated products, by definition, demand is less sensitive to price and “national production quality” is the main determinant of trade flows. For less differentiated products, on the other hand, demand is highly sensitive to price, and price is the main determinant of trade flows. As a result, high-wage countries, which have high-skill labor and production quality-advantage, are competitive in highly differentiated-high markup products. Low-wage countries, which have cheap labor and price-advantage, are competitive in less differentiated-low markup products—to put it in a more general context, high-wage countries are competitive in highly differentiated industries, and within each industry they enjoy competitive advantage in the most differentiated products.

Exports are subject to a per-product fixed cost. Exports of highly differentiated products that exhibit high markups, generate high enough profits to cover the (per-product) fixed cost. The least differentiated products that exhibit the lowest markups are not profitable to export.

\(^3\)A novel contribution of the new model is presenting an alternative view on (the product space and) prices in international trade. Existing models attribute across-product price differences to across-product quality differences. In the new model, however, a product is (on average) more expensive if it is more differentiated and is subject to a higher markup. I argue that price patterns in international trade can be largely explained with across-product differences in levels of differentiation and markups.
Less differentiated products are, however, profitable to sell domestically since there are no fixed costs associated with domestic sales. Hence, highly differentiated products are the main subject of international trade. Less differentiated products, on the other hand, are mostly purchased from domestic sources.

In summary, firms from low-wage countries have competitive advantage in products that exhibit low markups and are not profitable to export. Firms from low-wage countries, therefore, exploit their competitiveness in less differentiated–low markup products by selling predominantly in the domestic market (where they do not incur fixed costs). Firms from high-wage countries, meanwhile, profitably export a wide range of highly differentiated-high markup products. As a result, in the trade equilibrium, high-wage countries (1) trade more intensively, and (2) specialize in highly differentiated industries, and within each industry they specialize in highly differentiated–high markup products that exhibit higher prices.4

The “Washington apples” effect can be explained along the same lines. When firms face high trade costs they have a higher marginal cost and charge a higher price. Demand for highly differentiated products is less sensitive to the high price charged by these firms. Moreover, firms charge a higher markup for highly differentiated products, which allows them to collect profits despite low sales. These two channels encourage firms facing high trade costs to specialize in highly differentiated–high markup products, which exhibit higher unit values.

After developing a unifying model of international specialization, I conduct a two tier empirical analysis to discipline the parameters of the model. First, I fit the model to micro U.S. import data, which is disaggregated at the HS-10 product level.5 I use the traditional instrumental variable technique to estimate the structural demand parameters. The estimation quantifies national product differentiation and identifies the elasticity of substitution for more than five thousand product categories.6

Patterns of U.S. imports are highly consistent with the new theory. Within every SITC-5 industry, the HS-10 products that have a lower (estimated) elasticity and are more differentiated exhibit significantly higher prices.7 This suggest that the higher price of exports from rich

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4Specialization in the context of this paper is incomplete specialization; in equilibrium, high-wage countries are net exporters of highly differentiated–high markup products and net importers of less differentiated low-markup products.

5An HS-10 product in the data is a 10-digit product classification code belonging to the Harmonized System developed by the World Customs Organization (WCO).

6My estimation implies that varieties (of an HS-10 product) produced in the same country are 2.3 times closer substitutes relative to varieties produced in different countries.

7An industry is a set of products that are close substitutes. In the data an industry is characterized by a 5-digit
countries – within an SITC-5 industry – could be due to the fact that they are net exporters of (i.e. specialize in) highly differentiated–high markup HS-10 products. Patterns of inter-industry specialization are also consistent with the new theory. Low-wage countries penetrate the US market significantly more in less differentiated SITC-5 industries, i.e. low-wage countries are net exporters of (products that belong to) less differentiated industries.

In the second tier of my empirical analysis I take a subset of the elasticities, estimated in the first stage, and use them to calibrate the general equilibrium outcomes of my model to aggregate data on bilateral trade and country wages. The new model significantly improves upon the baseline Krugman model in terms of matching both trade flow data and (out of sample) data on the unit value of traded goods.

I use the calibrated model to revise our answer to two classic questions in the trade literature: (1) How large are the gains from trade, and (2) how big are the barriers to trade. The gains from trade are larger by a considerable margin in the new model compared to the baseline Krugman model. In the new model, opening to trade from autarky results in a 15% increase in real wage for the average country. In comparison, the baseline Krugman model estimates only (on average) a 5% increase in real wages after opening to trade.

To explain the substantially larger gains in the new model, note that the gains from trade depend on two factors: (1) the volume of trade (the more a country trades the more it gains from trade), and (2) the elasticity of substitution (the less substitutable the imported varieties the more one gains from importing them). In the new model after trade liberalization, highly differentiated products are imported more intensively. Since foreign varieties of highly differentiated products are less substitutable with their domestic counterparts, consumers gain considerably more from importing them—this is big step forward in generalizing the existing results about higher gains in the presence of sectoral heterogeneity.

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8 SITC (Standard International Trade Classification) code which comprises of multiple, closely related, HS-10 product categories.

9 In the literature the higher price of exports are attributed to the higher quality of exported goods. While I find a positive and significant relationship between price and degree of differentiation, the existing literature has struggled to find a positive and significant relationship between price and product quality at the same level of disaggregation. Khandelwal [2010], for example, finds a negative correlation between quality and f.o.b price at the HS-10 product level in the US import data.

10 By definition, a less differentiated SITC industry is comprised of less differentiated HS-10 products. Demand estimation suggests that the leather and food industries are less differentiated, while the electronics, instruments, and industrial machinery industries are highly differentiated—low-wage countries export relatively more apparel than industrial machinery to the US.

11 Ossa [2012] and Costinot and Rodriguez-Clare [2013] also show that sectoral heterogeneity (in demand elastic-
Contrary to what one might expect, low-wage countries gain more from trade even though they trade less. After opening to trade, consumers in low-wage countries gain access to the high-skill labor and the superior “national production quality” in high-wage countries. Low-wage countries are net importers of highly differentiated products, and for highly differentiated products “production quality” matters even more. Pakistan, for example, is one of the biggest gainers (from trade) in the new model. After opening to trade, Pakistani consumers gain access to laptops from Japan and cars from Germany, which are substantially better (per dollar) than their Pakistani counterparts.

In the new model, the iceberg trade costs are estimated to be 51% larger than the baseline Krugman model—a representative of traditional “new trade theory” models. The underlying reason is that the Krugman model, like most traditional models, is solely a model of North-North trade. The new theory introduces a new driving force behind (North-South) trade in the form of across-product specialization. Therefore, in the light of the new theory there is more incentive to trade—countries engage in trade to utilize from both national product differentiation and across-product specialization. With more incentive to trade in the new model, one can fit trade flow data with larger trade costs. Larger trade costs indicate that potential gains from eliminating them are also larger—in a nutshell, overlooking North-South trade undermines the gains from trade at various levels.

1.2. Related Literature

This paper complements a flourishing literature on North-South trade. The existing literature can be divided into two distinct blocks. The first block emphasizes inter-industry trade. This block includes the ‘Classical theories’ (e.g. Hecksier-Ohlin; Ricardian) that rely on factor specialization, and the contemporary models that incorporate non-homothetic demand to explain the higher intensity of trade in North (e.g. Flieler [2011]; Markusen [1986]).\footnote{Waugh [2010] accounts for the high intensity of trade in North using an alternative approach. He argues that the higher intensity of trade among rich countries is due to asymmetric trade costs. Specifically, rich countries face systematically lower trade costs than poor countries.} The second block of literature focuses on intra-industry North-South trade. These studies rely on quality differentiation (and usually non-homothetic demand) to explain the patterns of intra-
industry North-South specialization (e.g. Schott [2004]; Hallak [2006]; Fajgelbaum, Grossman, and Helpman [2011]). More precisely, they explain the higher price of exports from high-income countries within each industry.

The present paper contributes to the North-South trade literature along two directions. First, it develops a unifying framework that accounts for both inter-industry and intra-industry North-South trade in one model. The new framework tractably accounts for both the lower intensity of trade in South and the higher-price of exports from North within industries. Second, the present paper introduces a new channel of (across-product) specialization that has been overlooked in the literature. While previous theories have emphasized specialization in quality or specialization in factors, the new theory emphasizes a new channel of specialization. Countries specialize in products/industries that exhibit different degrees of differentiation (or alternatively different countries differentiated their products to various degrees). The new channel of specialization unveils a new channel for the gains from trade – a channel that magnifies the gains to a remarkable degree.

This paper builds heavily upon the “new trade theory” models. These models were originally designed to account for patterns of North-North trade in a tractable multi-country general equilibrium setting. Among the “new trade theories,” Krugman [1980] emphasizes increasing returns to scale, Armington-like models emphasize national product differentiation, and Eaton and Kortum [2002] rely on comparative advantage. Empirical studies have tested the relative importance of each channel, and have found strong support for national product differentiation among others (Head and Ries [2001]). The first contribution of this paper is incorporating North-South trade into a conventional multi-country “new trade theory” framework with national product differentiation. In doing so, the paper deviates minimally from conventional assumptions – e.g. homothetic CES preferences and symmetric iceberg trade costs. The proposed framework, therefore, retains the tractability of the “new trade theories” and is amenable to straightforward estimation. The second contribution is quantifying (the extent of) national product differentiation.

The new theory (developed in this paper) provides an alternative explanation for the “Washington apples effect.” The effect is one of the best-documented facts regarding intra-industry specialization, and states that higher trade costs induce countries to specialize in higher-price goods within each industry. The existing literature accounts for this effect with additive trade costs — generally referred to as the Alchian-Allen conjecture. Contrary to the Alchian-Allen
conjecture, the new theory explains the “Washington apples effect” in the context of conventional trade models, in which trade costs are iceberg. As demonstrated by Lashkaripour [2013], the new theory also captures aspects of the “Washington apples effect” that are inconsistent with the Alchian-Allen conjecture.

Finally, this paper contributes to an active area of ongoing research that measures the gains from trade. Recently, Arkolakis et al. [2012] argued that the gains from trade are relatively small in the context of mainstream trade models. In response, Costinot and Rodríguez-Clare [2013] and Ossa [2012] showed that introducing multiple sectors magnifies the gains. Both papers assume a Cobb-Douglas utility aggregator across sectors. Therefore, an endogenously fixed fraction of the consumers’ spending will be on sectors/products which exhibit a low elasticity of substitution. This automatically generates sizable gains from trade. This paper takes a big step forward in extending and generalizing their result; it relaxes the exogenous allocation of spending across sectors/products, and introduces a new channel of across-sector specialization that endogenously generates the sizable gains from trade.

1.3. Theory

In this section I will introduce the main ingredients of my general equilibrium model. The global economy consists of $N$ asymmetric countries denoted by $C = \{1, 2, ..., N\}$. 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. Countries differ in terms of their population and their production techniques. Varieties produced in countries with superior production technique are more appealing and carry more weight in the consumers’ utility function. 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 differentiated products and each product comes in different 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.
1.3.1. Product Space

There are two types of goods: (i) manufactured goods that are differentiated and tradable, and (ii) non-manufactured goods that are homogenous and non-tradable. The manufactured good comes in different 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. Mathematically, the commodity space can be expressed as

$$\Xi = \overset{\text{Product}}{\overset{\text{Country}}{\overset{\text{Firm}}{\mathcal{H}}}} \times \overset{\text{Country}}{\mathcal{C}} \times \overset{\text{Firm}}{\Omega}$$

where \(H = [0, \bar{H}]\) denotes the (continuous) set of products, \(C = \{1, 2, ..., N\}\) is the set of countries, and \(\Omega_j\) is the continuum of firms in country \(j \in C\). Variety \(\omega jh\) denotes a manufactured good that belongs to product category \(h \in H\), is manufactured in country \(j \in C\), by firm \(\omega \in \Omega_j\) (e.g. a 40” Samsung TV is a variety that belongs to the 40” TV product category, is manufactured by Samsung, in Korea. ) A simple illustration of the commodity space is provided in figure 1.3.1.\(^{13}\)

![Figure 1.3.1: The commodity space. There is a continuum of differentiated products. Each differentiated product comes in different varieties. Varieties of a product are differentiated by country of origin (i.e. national product differentiation). Within a country, varieties are differentiated at the firm level.](#)

In the background, product space \(H\) can be broken down into industries. Precisely, \(H = \bigcup_{s \in S} H_s\) where \(S\) is the set of industries and \(H_s \subset H\) is a subset of products that belong to industry \(s \in S\) — an industry comprises of products that are comparable. In this paper, when-

\(^{13}\)A product category in the data is defined as a 10-digit HS-10 code belonging to the Harmonized System developed by the World Customs Organization (WCO). A group of closely substitutable products constitute an industry. In trade data, an industry is classified by a 5-digit SITC-5 (Standard International Trade Classification) code. Figure A.5.1 (in appendix D) displays an example of an SITC-5 industry in the US import data (compiled by Feenstra et al. [2002])—the industry displayed in figure A.5.1 is classified as (the 5-digit number) 71620 and comprises of various categories of DC generators and motors.
ever I compare unit values across products I confine my comparison to products within an industry. In other words, I am comparing the price of apples to apples (e.g. the price of luxury cars to economy cars).

1.3.2. Demand

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

\[
V = U_M^\alpha Q_N^{1-\alpha}
\]

where \( Q_N \) is the quantity consumed of the non-manufactured good. A share \( 1 - \alpha \) of expenditure is, therefore, allocated to the non-manufactured good and the remaining share \( (\alpha) \) is spent on manufactured products. \( U_M \), the utility consumers derive from manufactured products, is characterized by a nested CES function

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

where \( C_h \) is the sub-utility derived from the consumption of manufactured product \( h \in H \), and \( \epsilon \) is the elasticity of substitution between any two composite products in set \( H \). \(^{14}\) Sub-utility \( C_h \) is characterized by the following (lower-tier) CES aggregator

\[
C_h = \left[ \sum_{j \in C} \frac{1}{Q_{jh}^{\epsilon \frac{\sigma_{jh} - 1}{\sigma_{jh}}}^{\frac{\sigma_{jh}}{\sigma_{jh} - 1}}} \right]^{\frac{1}{\epsilon - 1}}
\]

\(^{14}\)In the background, products are implicitly nested within various industries with the assumption that \( \epsilon_s = \epsilon \) for all \( s \in S \) where \( S \) is the set of industries (i.e. the across-product elasticity of substitution is the same for all industries). Specifically, 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 utility can be written as

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

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

\[
U_M = \left[ \sum_{s \in S} \left\{ \int_{h \in H_s} C_h^{\frac{\epsilon - 1}{\epsilon}} dh \right\}^{\frac{\epsilon - 1}{\epsilon - 1}} \right]^{\frac{1}{\epsilon - 1}} = \left[ \int_{h \in H} C_h^{\frac{\epsilon - 1}{\epsilon}} dh \right]^{\frac{1}{\epsilon - 1}}
\]
where $\mu_j$ is a country-specific Armington demand shifter (or taste parameter). I will refer to $\mu_j$ as production technique in country $j$—countries with superior production techniques produce varieties that are universally more appealing. Essentially, $\mu_j$ is a function of some underlying characteristic like labor-quality (or human capital) in country $j$. In other words, countries that are endowed with high-quality labor exhibit superior production techniques, and produce more appealing varieties of each product.\textsuperscript{15}

$\sigma_h > 1$ is the elasticity of substitution between composite country-level varieties of product $h$. I will refer to $\sigma_h$ as the across-country elasticity for product $h$. $\sigma_h$ determines how (horizontally) differentiated product $h$ is to the consumers. Precisely, if $\sigma_h$ is low consumers perceive a German variety of product $h$ to be very different from the French variety. The composite variety $Q_{jh}$ is itself characterized by

$$Q_{jh} = \left[ \int_{\omega \in \Omega} q_{\omega jh}^{\gamma_h-1} d\omega \right]^{\frac{\gamma_h}{\gamma_h-1}}$$

where $q_{\omega jh}$ is the quantity of variety $\omega jh$ directly consumed by the individual. $\gamma_h > 1$ is the elasticity of substitution across firm-level varieties of product $h$ that are manufactured in country $j$. I will refer to $\gamma_h$ as the within-country elasticity. Figure 1.3.2 displays patterns of substitution across varieties.

Krugman [1980] assumes $\epsilon = \sigma_h = \gamma_h$ for all $h \in H$. This assumption implies that all products are identical to the consumer and there is no national product differentiation. I partially relax the restrictions imposed by Krugman. I allow for different products that exhibit different degrees of differentiation, and I also allow for national product differentiation. To introduce national product differentiation, I restrict the within-country elasticity of substitution to be greater than the across-country elasticity: $\gamma_h > \sigma_h$ for all $h \in H$. Putting it differently, varieties

\textsuperscript{15}Generally speaking, sub-utility $C_h$ has the following form

$$C_h = \left[ \sum_{j \in J} \frac{1}{\mu_{j h} Q_{j h}^{\sigma_h}} \right]^{\frac{\sigma_h}{\sigma_h-1}}, \quad h \in H_s$$

Where $s \in S$ is an industry consisting of narrowly defined products that are comparable (the above formulation is similar to Hallak and Schott [2011] with the exception that they assume a common elasticity for all products belonging to same 2-digit sector). In this paper, I will introduce a new channel of international specialization that does not depend on North having better technology when producing certain goods – this channel is already well-explored in the literature. Most existing models of North-South trade assume that $\mu_{j h}$ depends on the quality assigned to product $h$ ($\alpha_h$) and human capital in country $j$ ($H_j$). If $\mu_{j h} = \mu(\alpha_h, H_j)$ is super-modular, then the technological gap between countries with low human capital and countries with high human capital is more prominent for products that are perceived as high-quality. In this paper I shut down this, already well-explored, channel by assuming $\mu_{j h} = \mu_j$ for all $h \in H_s$. This assumption assures that the technological gap between North and South is product-independent.
produced in the same country are closer substitutes. National product differentiation will induce similar countries to trade with each other – similar to any Armington-type model. In Krugman [1980], similar countries trade due to economies of scale.

I also allow for different products (in $H$) to be subject to different elasticities of substitution: $\sigma_h \neq \sigma_{h'}$, and $\gamma_h \neq \gamma_{h'}$ for every $h, h' \in H$. However, the within-country elasticity ($\gamma_h$) is restricted to have the same ordering as the cross-country elasticity ($\sigma_h$): $\sigma_h > \sigma_{h'} \implies \gamma_h > \gamma_{h'}$ for every $h, h' \in H$. This restriction rules out the (counter-intuitive) possibility that consumers are highly sensitive to which country a variety is produced in, but are indifferent to which firm produces that variety in a given country.

To tractably incorporate both restrictions, I parametrically assume that $\{\gamma_h\}_{h \in H}$ is a linear transformation of $\{\sigma_h\}_{h \in H}$:

**Parametric assumption 1.** $\{\gamma_h\}_{h \in H} = \{\eta \sigma_h\}_{h \in H}$, with $\eta > 1$

Later, I will estimate the elasticities non-parametrically and show that this parametric assumption is highly consistent with data.

I will refer to $\frac{1}{\sigma_h}$ as the degree of differentiation in product category $h$ — the higher $\frac{1}{\sigma_h}$, the more differentiated (the varieties of) product $h$. Each product in $H$ exhibits a unique degree of differentiation. Specifically, there is a one-to-one mapping from the product space to the

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16 If $\gamma_h \leq \sigma_h$ the model will generate trade equilibria with only one country supplying to each market – firms from the lowest price country will absorb all the revenues in any given market.

17 Head and Ries [2001] find support for both economies of scale and national product differentiation. However, the preponderance of the evidence supports national product differentiation.
degree of differentiation
\[ 1 \sigma_h : [0, \bar{h}] \to [0, \frac{1}{\sigma}] \]

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 \( p^i_{\omega jh} \) is

\[ q^i_{\omega jh} = \mu_j \left( \frac{p^i_{\omega jh}}{P^i_{\omega jh}} \right)^{1-\eta \sigma_h} \left( \frac{P^i_{\omega jh}}{P^i_h} \right)^{1-\sigma_h} \left( \frac{P^i_h}{P^i} \right)^{1-\epsilon} \alpha \omega^1 L^i \]

(1.3.1)

where \( P^i \) is the aggregate price index, \( P^i_h \) is the price index associated with product \( h \), and \( P^i_{\omega jh} \) is the price index associated with country \( j \) varieties of product \( h \), all in country \( i \)'s market. The price indices are given by

\[ P^i_{\omega jh} = \left\{ \int_{\omega' \in \Omega^i_{\omega jh}} \left( \frac{P^i_{\omega jh}}{P^i_{\omega' jh}} \right)^{1-\eta \sigma_h} d\omega' \right\}^{\frac{1}{1-\eta \sigma_h}} \]

(1.3.2)

\[ P^i_h = \left\{ \sum_{k \in C} \mu_k \left( \frac{P^i_{kh}}{P^i_h} \right)^{1-\sigma_h} \right\}^{\frac{1}{1-\sigma_h}} \]

(1.3.3)

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

(1.3.4)

where \( \Omega^i_{\omega jh} \) is the set of firms exporting product \( h \) from country \( j \) to country \( i \). As a general rule, the superscripts refer to the country that is importing the variety while the subscripts index 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.

### 1.3.3. Supply

Every country is populated with a large pool of homogenous multi-product firms.\(^{18}\) Each firm can potentially enter various markets, and sell its own variety of every product in \( H \). Entry

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\(^{18}\) 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, the “Washington apples” effect, is documented as a within-firm effect, and one goal of the model is to account for this within-firm regularity. Second, multi-production 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. From the perspective of my model, economies of scope could be one channel, among others, that magnifies the dissimilarity between North and South in the international trade scene.
and exports are, however, subject to the following fixed costs:

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 both the domestic market and one 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 $h$ to that market. The per-product fixed cost is only for exports; domestic sales are not subject to the per-product fixed cost.$^{19}$

Both fixed and entry costs are paid in terms of labor in the country of origin.$^{20}$ Also note that, the fixed and entry costs are not product or country-specific — in terms of magnitude, they are the same for all markets and all products. Paying the entry cost per market rules out economies of scale. Unlike the Krugman model (which relies on economies of scale), in the present framework North-North trade is driven by national product differentiation. When I fit the model to data in section 4, I find strong empirical support for national product differentiation.

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

$$c_{\omega jh}(q) = c_j^i(q) = \tau_{ji} w_j q + w_j f, \quad \forall \omega \in \Omega_j, \forall h \in H$$

$\tau_{ji} w_j$ is the marginal cost of production, which is the same for all products in $H$—the marginal labor requirement of production is one regardless of the product. $\tau_{ji}$ is the iceberg transportation cost from country $j$ to $i$; and $\tau_{ii} = 1$. The marginal labor requirement (for producing one unit of a differentiated product) is also the same for all countries. However, one unit of labor in certain countries is more productive in terms producing utils—a standard assumption in Armington models.

For domestic firms in country $i$ the cost of producing $q$ units and selling them domestically is

$$c_{\omega ih}(q) = w_i q, \quad \forall \omega \in \Omega_i, \forall h \in H$$

$^{19}$Paying the entry cost per market rather than once (for all markets) is not critical for the results of the paper. The per-market entry cost is a conservative assumption in terms of the gains from trade (shown later) – it results in less entry into foreign markets.

$^{20}$Eaton, Kortum, and Kramarz [2011] make a similar assumption regarding entry costs. 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.
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

\[
\pi_{iwh} = \max_{p_{iwh}} \left[ p_{iwh}^j - \tau_{ji}w_j \right] q_{iwh}^j - w_j f
\]

where \( p_{iwh}^j \) 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

\[
p_{iwh}^j = p_{iwh}^j = \frac{\eta \sigma_h}{\eta \sigma_h - 1} \tau_{ji} w_j, \quad \omega \in \Omega_{jwh}^i, \ j \in C, \ h \in H
\]

(1.3.5)

The markup \( \left( \frac{\eta \sigma_h}{\eta \sigma_h - 1} \right) \) is increasing in \( \frac{1}{\sigma_h} \) – firms charge a higher markup for products that exhibit a higher degree of differentiation. More differentiated products, therefore, exhibit higher prices on average. This is a purely 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 degree of (horizontal) differentiation. I argue that documented patterns regarding the price of tradables could be largely explained considering across-product differences in markups (within a narrowly defined set of product).

Firms from country \( j \) all charge the same price and make the same product-specific profit conditional on selling the product, i.e. \( \pi_{iwh} = \pi_{iwh'} = \pi_{iwh}^j \forall \omega, \omega' \in \Omega_{jwh}^i \) where \( \Omega_{jwh}^i \) 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 \( \int_{h \in H_{iwh}^j} \pi_{iwh}^j dh \), where \( H_{iwh}^j \) is the set of products firm \( \omega \) supplies after entering market \( i \) — in the next subsection I will characterize the set \( H_{iwh}^j \) and the free entry condition in detail.21

Finally, The market for the non-manufactured good is assumed to be perfectly competitive. The marginal labor requirement for producing one unit of the non-manufactured good is one. Hence, the price of the (non-traded) non-manufactured good in country \( i \) is \( w_i \). In

---

21 What determines the market share of a variety is pure price—rather than price. The pure price – as Hallak and Schott [2011] put it – of variety \( \omega jh \) is defined as \( \frac{v_{iwh}^j}{\rho_{iwh}^{\sigma_h-1}} \). Pure price is price per unit of utils rather than price per unit of quantity. The pure price is what matters consumers and determines demand for every variety. Similarly, \( \frac{v_{iwh}^j}{\rho_{iwh}^{\sigma_h-1}} \) is the effective pure wage of country \( j \) in the production of \( h \). The product-specific effective pure wage determines a country’s competitiveness in the global markets in each product category.
equilibrium, \((1 - \alpha)\) share of the labor in country \(i\) will be allocated to the production of the non-manufactured good.

### 1.3.4. Equilibrium

**Free Entry.** 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

\[
\pi^i_{jh} = \frac{1}{\eta \sigma_h} \left( M^i_{jh} \right)^{\frac{\sigma_h - 1}{\eta \sigma_h - 1}} \left( \frac{p^i_{jh}}{P^i_h} \right)^{1 - \sigma_h} \left( \frac{P^i_h}{P^j_h} \right)^{1 - \epsilon} \alpha w_i L_i - w_j f
\]

where \(p^i_{jh}\) 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

\[
M^i_{jh} = \min \left\{ \left[ \frac{\mu_j \left( \frac{p^i_{jh}}{P^i_h} \right)^{1 - \sigma_h} \left( \frac{P^i_h}{P^j_h} \right)^{1 - \epsilon} \alpha w_i L_i}{\eta \sigma_h w_j f} \right]^{\frac{\eta \sigma_h - 1}{\eta \sigma_h (\eta - 1)}} \right\}
\]

the above equation 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

\[
\int_{h \in H} \pi^i_{jh} v^j_h dh = w_j f^c \quad (FE)
\]
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 $h$. 

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

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.

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

$$\alpha L^i = \left( M^i_j f^e + \int_{h \in H} q^i_{ih} M^i_j \nu^i_j(h) dh \right) + \left( \sum_{k \neq i} M^k_i f^e + \int_{h \in H} \left( \tau_k q^k_{ih} + f^e \right) M^k_i \nu^k_j(h) dh \right) \quad \text{(LMC)}$$

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

$$\sum_{k \in C} \int_{h \in H^i_k} p^i_{kh} q^i_{kh} M^i_k \nu^i_k(h) dh = \alpha w^i L^i \quad \text{(PMC)}$$

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 $P^i_h$, $P^i_j$, prices $p^i_{jh}$, and consumer allocations $q^i_{ih}$, profits $\pi^i_{jh}$ and scope of production $H^i_j$ such that

---

22 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.

23 The free entry condition can be rewritten as

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

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.
(i) Equation (1) is the solution of the consumer’s optimization problem.

(ii) $p_{jh}^i$ solves the firms’ profit maximization problem—equation (5).

(iii) $v_j^i(h) = \frac{M_{jh}^i}{M_j}$ where the mass of sellers $M_{jh}^i$ 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.

1.3.5. Gravity

In equilibrium, bilateral trade is governed by a two-tier gravity equation. Let $X_{jh}^i$ denote total spending in country $i$ on varieties of product category $h$ that are manufactured in country $j$ – $X_{jh}^i = p_{jh}^i q_{jh}^i M_{jh}^i$. The lower tier gravity equation, describing bilateral trade of product $h$, is the following

$$
\lambda_{jh}^i = \frac{X_{jh}^i}{\sum_{k \in C} X_{kh}^i} = \frac{\mu_j \left( M_{jh}^i \right)^{\frac{\sigma_h-1}{\sigma_h-1}} \left[ w_j \tau_{ji} \right]^{(1-\sigma_h)}}{\sum_{k \in C} \mu_k \left( M_{kh}^i \right)^{\frac{\sigma_h-1}{\sigma_h-1}} \left[ w_k \tau_{ki} \right]^{(1-\sigma_h)}}, \quad i, j \in C \quad (1.3.8)
$$

$\lambda_{jh}^i$ is the share of total expenditure in country $i$ allocated to varieties of product $h$ that are manufactured in country $j$. In the equation above, trade elasticity (specifically, elasticity of trade volumes with respect to iceberg trade costs) is lower for products that exhibit higher degrees of differentiation.

The upper-tier gravity equation characterizes relative spending on each product $h \in H$. Let $X_h^i$ denote total spending in country $i$ on product $h$ ($X_h^i = \sum_{k \in C} X_{kh}^i$), and let $X^i$ be total spending in country $i$ on manufactured products (i.e. $X^i = \int_{h \in H} X_h^i \, dh = \alpha \omega^i L^i$). The share of total expenditure spent on product $h$ in country $i$ is

$$
\lambda_h^i = \frac{X_h^i}{X^i} = \frac{\left( \frac{\sigma_h}{\eta \sigma_h-1} \right)^{(1-\epsilon)} \left\{ \sum_{k \in C} \mu_k \left( M_{kh}^i \right)^{\frac{\sigma_h-1}{\sigma_h-1}} \left( w_k \tau_{ki} \right)^{(1-\sigma_h)} \right\}^{\frac{\epsilon-1}{\sigma_h-1}} \int_{h' \in H} \left( \frac{\sigma_{h'}}{\eta \sigma_{h'}-1} \right)^{(1-\epsilon)} \left\{ \sum_{k' \in C} \mu_{k'} \left( M_{k'\ell}^i \right)^{\frac{\sigma_{h'}-1}{\sigma_{h'}-1}} \left( w_{k'} \tau_{k'i} \right)^{(1-\sigma_{h'})} \right\}^{\frac{\epsilon-1}{\sigma_{h'}-1}} \, dh'}{\sum_{k \in C} \mu_k \left( M_{kh}^i \right)^{\frac{\sigma_h-1}{\sigma_h-1}} \left( w_k \tau_{ki} \right)^{(1-\sigma_h)}}, \quad h \in H \quad (1.3.9)
$$

A novel future of equation (9) is that love of variety is stronger the more differentiated the product. Therefore, as the number of available varieties in a market rise, to benefit from the extra variety, consumers redirect spending from less-differentiated products to highly differentiated
products. This result, explained thoroughly in appendix B, induces wealthy countries with big markets and many incumbent varieties to spend relatively more on highly differentiated (and high-price) products.

1.3.6. Patterns of International Specialization

1.3.6.1. North-South Trade (the Big Divide)

Two well-established facts characterize North-South trade:

i. Within a narrowly defined set of goods, the richer countries (in North) sell goods that exhibit higher unit values compared to the goods sold by poor countries (Schott [2004]; Hallak and Schott [2011]; Hummels and Klenow [2005]).

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

Here, I explain how the new model reconciles both of these patterns – existing models usually explain one fact at the expense of the other. To this end, consider two countries $n$ (North) and $s$ (South) that share the same geography. North, however, is endowed with higher-quality labor: $\mu_n > \mu_s$ and South is more populated $L_s > L_n$. In equilibrium, there would be more demand for high-quality labor (in North), which results in higher equilibrium wages in North relative to South, i.e. $\mu_n > \mu_s \implies w_n > w_s$. However, suppose parameters of the model are such that total income (GDP) is the same in North and South

\[
\begin{align*}
  w_n &> w_s \\
  w_nL_n &= w_sL_s
\end{align*}
\]

For any product $h \in H$, spending (in country $i$) on varieties manufactured in North relative to varieties manufactured in South is

---

24Hallak [2006], Hallak and Schott [2011] look at variations within 2 and 3-digit SIC sectors. Hummels and Klenow [2005] looks at within HS-6 product variations in export prices across exporters. Each SIC sector, SITC industry, and HS-6 product consists of many narrowly defined HS-10 products. This suggests that part of the across-exporter variation in export prices could be due to some exporters exporting more expensive HS-10 codes (rather than more expensive varieties of the same HS-10 product). Khandelwal [2010] and Schott [2004] analyze within HS-10 variations in unit values. Khandelwal [2010], however, finds that the estimated quality and f.o.b unit values move in significantly opposite directions. My view is that within a class of products, say an SITC-5 industry, exporters from high-income countries are selectively exporting more differentiated and expensive HS-10 products, rather than higher quality products.
Two factors control the competitiveness of North relative to South: relative wage \( \frac{w_n}{w_s} \), and relative production technique \( \frac{\mu_n}{\mu_s} \)—North has technical advantage over South while South has price advantage over North. The degree of differentiation \( \frac{1}{\sigma_h} \) controls the relative importance of these two factors. For highly differentiated product, wage is relatively less important and production technique is the main determinant of trade flows. Hence, North has competitive advantage (over South) in highly differentiated–high markup products. South, on the other hand, is competitive advantage in less differentiated–low markup products. Therefore, firms from North specialize in highly differentiated products and, within a narrowly defined set of products, they export relatively more of the high-price (high-markup) products. In data terms, within each SITC-5 industry, rich countries export HS-10 products that (on average) exhibit higher markups and higher prices.

The pattern I discussed above is illustrated in figure 1.3.3. Figure 1.3.3 compares the product-specific pure wage \( \left( \frac{w_i}{\mu_i} \right)^{\sigma_h^{-1} \sigma_{h^{-1}}} \) in North and South. The product-specific pure wage, as noted before, represents the competitiveness of a country for a given product. Specifically, the lower the product-specific pure wage the more competitive the country is when it comes to selling and exporting that product. In the baseline Krugman-like model (where \( \sigma_h = \sigma \) for all \( h \in H \)), pure wage is the same for all products. Moreover, in the baseline, pure wage equalizes across countries conditional on geography. A product-specific pure wage that varies across countries is the main driving force behind international specialization and dissimilar trade—an absent element in the original Krugman model.

The demonstrated patterns of North-South specialization automatically lead to higher intensity of trade in rich countries. This all follows from the fact that less-differentiated products are traded less intensively. Firms charge lower markups for less-differentiated products, while they have to pay the same (per-product) fixed cost to export them. Consequently the less-differentiated products are also less profitable to export. Poor countries, therefore, enjoy

\[
\frac{\lambda_i^{n|h}}{\lambda_s^{n|h}} = \frac{\mu_n}{\mu_s} \left( \frac{M^{n|h}_{h}}{M^{s|h}_{h}} \right)^{\frac{\sigma_h^{-1}}{\eta_{h^{-1}}}} \left[ \frac{w_s}{w_n} \right]^{(\sigma_h-1)}, \quad h \in H, \; i \neq n, s
\]  

25 This pattern is mirrored by the mass of entrants. Precisely, there are relatively more firms from North exporting highly differentiated products to country \( i \), i.e. \( M^{n|h}_{i} \) is non-decreasing in \( \frac{1}{\sigma_h} \).

26 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]). However, in that literature there is no direct link between price and degree of differentiation.

27 Mathematically, I can show that for every pair of countries \( i \) and \( j \) where \( \mu_i > \mu_j \), there exists a cutoff \( \frac{1}{\sigma_h} \) such that country \( i \) has competitive advantage over to \( j \) in products with a degree of differentiation above the cut-off.
competitive superiority over rich countries for products that are not profitable to export. Figure 1.3.3 demonstrates this result – the scope of competitive advantage for South (low-wage countries) is very narrow when considering the set of products that are traded intensively. In fact, the majority of sales by firms located in low-wage countries would be domestic sales, since firms do not incur fixed costs when selling domestically – upon entry every product is profitable to sell domestically. Proposition 1 summarizes the above results.

**Proposition.** Consider two countries $n$ (North) and $s$ (South); all else being equal, if $\mu_n > \mu_s$ (North has better production technique relative to South) then

(i) $w_n > w_s$ : wages in North are higher than South.

Another important implication of the model is how trade openness affects employment in the North. 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 et al. [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 competitive advantage in my model suggest that industries with a high degree 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.
(ii) North exports a larger share of its GDP relative to South

(iii) North is a net exporter of highly differentiated-high markup products to South, and South is a net exporter of less differentiated-low markup products to North — within every industry North exports product that exhibit higher prices.

Proof. see Appendix A.3

\[
\text{Pure wage } (\frac{w_j}{\mu_j})
\]

\[
\text{Degree of differentiation } (\frac{1}{\mu_j})
\]

\[
\text{Scope of specialization in South}
\]

\[
\text{Scope of specialization in North}
\]

Figure 1.3.4: The narrow scope of competitive advantage for South (s). Note that \( \mu_n > \mu_s \) and \( w_n > w_s \).

1.3.6.2. The “Washington Apples” Effect.

The “Washington Apples” effect is a well-documented regularity in the empirical literature. The effect states that within a narrowly defined set of goods, the (free on board) unit value of exported goods are higher from countries that face higher trade costs – that is to say, in response to high trade costs exporters selectively export goods that posses higher unit values. Surprisingly, even though the effect is highly documented, conventional gravity models do not account for it.\(^{29}\) The standard explanation in the literature is due to Alchian and Allen [1983], and relies on trade costs being per-unit rather than iceberg.\(^{30}\)

\(^{29}\)Baldwin and Harrigan [2011] survey the mainstream trade literature and show that all leading models generate results that are inconsistent with this empirical regularity.

\(^{30}\)Lashkaripour [2013] analyzes highly disaggregated US import data and argues that additive trade costs alone
The present model provides a novel explanation for the “Washington apples” that does not require any restriction on trade costs. Specifically, consider two countries $i$ and $j$ that are endowed with similar qualities ($\mu_i = \mu_j$) and, hence, pay the same wage in equilibrium ($w_i = w_j$).\textsuperscript{31} Suppose, however, that firms in country $j$ incur larger trade costs (relative to firms in $i$) when exporting to (a third) country $k$: $\tau_{ik} < \tau_{jk}$. From equation (8), the value of imports from $i$ relative to $j$ of product $h$ is

$$\frac{\lambda_{ih}^k}{\lambda_{jh}^k} = \left( \frac{M_{ih}^k}{M_{jh}^k} \right)^{\frac{\sigma_h-1}{\sigma_h}} \left[ \frac{\tau_{jk}}{\tau_{ik}} \right]^{1/(\sigma_h-1)}, \quad h \in H, \ k \neq i, j$$

In the above equation, two factors determine trade shares: the mass of exporters (that engage in exporting product $h$ to country $k$) and the iceberg trade costs. Due to higher trade costs, relatively less firms from country $j$ would export to country $k$: $M_{jh}^k \leq M_{ih}^k$ for each $h \in H$. Hence, country $j$ is at a disadvantage both due to higher trade costs and due to a lower number of firms exporting. However, for products that exhibit higher degrees of differentiation (have a lower $\sigma_h$), the disadvantage diminishes – both $\left( \frac{M_{ih}^k}{M_{jh}^k} \right)^{\frac{\sigma_h-1}{\sigma_h}}$ and $\left[ \frac{\tau_{jk}}{\tau_{ik}} \right]^{1/(\sigma_h-1)}$ fall as $\frac{1}{\sigma_h}$ increases.\textsuperscript{32}

The intuition is the following. Since firms from country $j$ face higher trade costs they incur a higher marginal cost and charge a higher price. Demand for highly differentiated products is less sensitive to the high price charged by country $j$ firms. Moreover, country $j$ firms charge a higher markup for highly differentiated products, which allows them to collect profits despite low sales. These two channels encourage firms exporting from country $j$ to specialize in highly differentiated-high markup products, which exhibit higher f.o.b unit values.

\textbf{1.3.6.3. Discussion}

\textbf{Across versus within product specialization.} The theory developed in this paper generates predictions regarding within-industry and across-industry patterns of specialization. High-income countries specialize in highly differentiated industries, and within each industry they specialize in highly differentiated products. This is incomplete specialization, rather than complete specialization as in a Ricardian model of trade. Moreover, unlike classical mod-

\textsuperscript{31}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.

\textsuperscript{32}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.
els of incomplete specialization (e.g. Hecksier-Ohlin), high-income countries are not the sole exporters of highly differentiated products. Both high-income and low-income countries export highly differentiated products. Even though high-income countries are strictly better at highly differentiated products, they would still import these products from other countries (including low-income countries) to benefit from national product differentiation combined with cheap labor in low-income countries. High-income countries are, however, net exporters of highly differentiated products and net importers of less differentiated products. This pattern of specialization is consistent with the findings of Schott [2004].

The new theory can also be extended to incorporate within-product specialization. Suppose every product consists of sub-products that exhibit different degrees of differentiation—a product $h$ can be costlessly differentiated to various degrees. High-income countries would specialize in the highly differentiated sub-products and charge a higher markup, while low-wage countries specialize in less differentiated—low markup sub-products. This could (alternatively) explain within product variations in f.o.b. export prices across different exporters (which until now, has been mostly attributed to quality differentiation).

**Comparison to the existing theories.** The theory presented in this paper is both a theory of why nations trade and a theory of what they trade. The theory introduces a new driving force behind North-South trade and provides an alternative explanation for the “Washington apples” effect. It relies on across-product differences in degree of differentiation and monopolistic competition. The are many competing theories in the trade literature—e.g. non-homothetic demand and factor specialization explain certain aspects of North-South trade; additive trade costs explain the “Washington apples” effect. The theory developed in this paper stands out among competing theories for several reasons. First, it exhibits generality. The theory tractably combines two basic features of North-South trade that were previously explained only in isolation. At the same time, the theory also accounts for patterns of North-North and South-South trade. Second, the theory achieves generality with minimal deviation from conventional modeling assumptions. As a result the theory retains the analytical tractability of standard gravity models and is amenable to straightforward estimation. Competing theories, in contrast, impose computational and analytical burden in a general equilibrium multi-country setting.

Most importantly, the new theory raises questions about how big of a role the competing

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33The goal of this paper is to match these first order facts simultaneously with minimal deviation from the as-
mechanisms play. To identify the effect of say additive trade costs or non-homothetic preferences, researchers have shut down across-product heterogeneity in (degree of) differentiation. If one allows for products to exhibit different degrees of differentiation, estimation would imply a weaker role for the competing theories. Precisely, estimations would imply preferences that are less non-homothetic and trade costs that are less additive. If that is the case, and as I will demonstrate in the empirical section, the welfare gains from trade would be sizable. If countries trade according to the theory presented in this paper – and disaggregated data suggest that they do – the gains from trade would be considerably larger than traditional estimates.

1.4. 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 counter-factual welfare analysis to quantify the gains from trade.

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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. The “Washington apples” effect 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 result, however, does not depend on how the country-specific quality (demand shifter \( \mu_j \)) enters the utility function.

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.
1.4.1. Step 1: Estimating Demand Parameters

1.4.1.1. Data description and preliminary evidence

This paper uses the publicly available US import data, which is compiled by Schott [2008]. The data documents the value and quantity of imported goods from various 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. This paper uses data 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. 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].

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. I use the total number of export cards from country $j$ in HS-10 code $h$ as a proxy

---

34 The layout of the data is illustrated in table A.3 in appendix D.
35 In the words of Hummels and Schar [2012]: “When a firm exports into the US they electronically file a Shipper’s 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.”
for $M_{jh}$ (the number of firms exporting to the U.S. from country $j$ in that HS-10 code). Since higher number of export cards can be due to more quantity sold, I rerun the estimation with the number of export cards (of product $h$) per quantity exported (from country $j$) as a proxy for $M_{jh}$.

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. One way of assessing the proxy is merging import data with firm-level export data. In Figure A.5.4 (in the appendix) I do so by plotting the number of cards reported in the public US import data against 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 – the correlation is high but not perfect, partly due to imperfect concordance between HS codes in the two data sets.

Even though approximating the number of firms with the number of export invoices is not a perfect step forward, but it is a big step forward compared to the existing literature. Khan-delwal [2010] uses population of the exporting country to control for the number of firms/varieties. Other studies that estimate gravity at the product-level (e.g. Broda and Weinstein [2006]) usually do not account for the extensive margin of trade altogether. These studies basically assume a representative firm/variety in each country, i.e. $M_{jh} = 1 \ \forall j, h$.

1.4.1.2. Estimating $\sigma_h$ and $\gamma_h$

In this section I will identify and estimate demand elasticities $\sigma_h$ and $\gamma_h$, where $h$ denotes an HS-10 product code. In the theory section, I parametrically assumed that $\gamma_h = \eta \sigma_h$ for all $h \in H$, to achieve tractability. Here, I will identify and estimate $\gamma_h$ and $\sigma_h$ non-parametrically for each HS-10 product $h$. This, in turn, will enable me to evaluate the parametric assumption in imposed in theory. After estimating the elasticities, I can get a sense of which products are highly differentiated. I can also investigate how degree of differentiation and f.o.b price are

---

36 The results of the estimation of very robust to both specifications.
37 Helpman, Melitz, and Rubinstein [2008] use aggregate bilateral trade data and 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.
38 $\epsilon$ can be estimated looking at cross-HS10 variations; I perform this estimation in the appendix.
correlated across HS-10 product codes.

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

$$X_{jh} = \mu_j M_{jh}^{\sigma_h - 1} \left( \frac{p_{jh}}{P_h} \right)^{1-\sigma_h} \left( \frac{P_h}{P_t} \right)^{1-\epsilon} \alpha w_{US} L_{US} \quad (1.4.1)$$

where $M_{jh}$ is the number of firms from country $j$ exporting product $h$ to the U.S. market. $p_{jh}$ 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

$$\ln X_{jht} = \frac{\sigma_h - 1}{\gamma_h - 1} \ln M_{jht} - (\sigma_h - 1) \ln p_{jht} + \ln \frac{1}{P_{ht}^{1-\gamma_h}} \left( \frac{P_{ht}}{P_t} \right)^{1-\epsilon} \alpha w_{US,t} L_{US,t} + \ln \mu_{jht} \quad (1.4.2)$$

where $t$ refers to a year from 1989 to 2011. $\psi_{h,t}$ is a year-product fixed effect. $\ln \mu_{jht}$ is the Armington demand shifter attached to varieties of product $h$ produced in country $j$ in year $t$—the demand shifters reflect differences in production technique across countries. In theory, I assumed that production technique (or the demand shifter) is country-specific, but not product-specific: $\mu_{jht} = \mu_{jt}$, $\forall h$, i.e. $\text{Corr}[\mu_{jht}, \mu_{jht'}] = 1$. The theory, however, requires that either (1) $\mu_{jht}$’s for each country $j$ to be sufficiently correlated across different HS-10 products, or (2) the gap in production technique ($\mu_{jht}$) between rich and poor countries to widen as products become more differentiated. After estimating the demand parameters, data confirms the latter scenario. I allow for Heteroskedasticity in $\mu_{jht}$ across countries, and I also allow for $\mu_{jht}$’s to be correlated within a (exporter) country across time, i.e. $\text{Cov}[\mu_{jht}, \mu_{jht'}] > 0$ for all $t$ and $t'$ in the sample.39

For every HS-10 product I have a separate equation to estimate, but since the production technique $\ln \mu_{jht}$ is (likely) correlated across products I 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).40 I also would not be able to identify $\epsilon$ (i.e. the elasticity

39Broda and Weinstein [2006] do not allow for the country-specific qualities $\mu_{jht}$’s to be clustered by country across time.

40Estimating each equation separately regardless of whether or not the explanatory variable are the same across
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 $\epsilon$.

### 1.4.1.3. 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 uncor-
related with the country-specific demand shifter $\ln \mu_{jht}$. In theory, I imposed the parametric
assumption that $\gamma_h = \eta \sigma_h$ with $\eta > 1$. Here, I non-parametrically estimate $\gamma_h$ (for every HS-10
product $h$), which enables me to evaluate the validity of the parametric restriction I imposed
in theory – as we will see later, the non-parametric estimates confirm the validity of imposed
restriction.

Let $\Theta_h = (\gamma_h, \sigma_h)$ denote the vector of parameters to be estimated, and $Y_h$ denote data on
$X_{jht}$, $M_{jht}$, and $p_{jht}$. The moment condition will, then, be the following

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

where $z$ denotes the vector of instruments and

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

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

$$ \hat{\Theta}_h = \arg \min_{\Theta} \hat{G}(\Theta_h; Y_h)'z' \hat{W}_2z \hat{G}(\Theta_h; Y_h) $$

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.

30 Prices (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 ($\tau_{ij}$) 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.
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.\textsuperscript{42}

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, \textit{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.\textsuperscript{43} Therefore, within an HS-10 category tariff rate is not correlated with the demand shifter $\mu_{jht}$. 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 $t$.\textsuperscript{44} I also use the total number of export cards documented in year $t$ in product $h$ from all sources, and the number of exporting countries of product $h$ in year $t$ as additional instruments.\textsuperscript{45}

Table 1.1 summarizes the estimation result. 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 is in-line with assumption 1 in the theory section – I the following section I will verify assumption 1 more closely. As demonstrated in table 1.2, there is sizable heterogeneity in the estimated (within and across-country) elasticity across HS-10 products.

Figure 1.4.1 displays the relative ranking of various SIC-2 sectors in terms of the estimated elasticity. A low elasticity indicates that either consumers allocate their spending more evenly across different varieties of a product, or that imports are less sensitive to price and more

\textsuperscript{42}Broda and Weinstein [2006] perform a restricted grid search to estimate $\sigma_h$’s. In particular, they evaluate the GMM objective function for values of $\sigma_h \in [1.05, 131.5]$ at intervals that are 5 percent apart.

\textsuperscript{43}Higher tariff would result in firms selecting into highly differentiated HS-10 codes, regardless of the demand shifter $\mu_{jht}$ they face.

\textsuperscript{44}In 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.

\textsuperscript{45}Khandelwal [2010] uses the number of exporting countries of product $h$ as an instrument (for conditional nest share) which proxies competition in code $h$. 

31
<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>( \gamma_h )</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>
<tr>
<td>Observations per estimation</td>
<td>336</td>
<td>262</td>
<td>167</td>
<td>421</td>
</tr>
<tr>
<td>Estimation with stat. sig. ( \sigma_h &gt; 1 )</td>
<td>.72</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations with stat. sig. ( \sigma_h &gt; 1 )</td>
<td>.78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations with stat. sig. ( \gamma_h &gt; 1 )</td>
<td>.91</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total estimations</td>
<td>5,847</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total observations across all estimations</td>
<td>1,980,018</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1.1.: Summary of statistics from estimating equation (15) for 5,847 manufacturing HS-10 products.

<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>Across-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>
</tbody>
</table>

Table 1.2.: The variation of elasticities across HS-10 product codes.

sensitive to the country-specific demand shifters. A high elasticity, in contrast, implies that consumers spend mostly on the cheapest variety and are highly sensitive to price. The ranking of sectors (in terms of the within-country and cross-country elasticity) are subjectively sensible. However, the ranking based on my estimation is different from the one in Broda and Weinstein [2006] (left panel in figure ??). For example, my estimation suggests that food and paper are relatively less differentiated than machinery and electronics. In Broda and Weinstein [2006], paper is more differentiated than industrial machinery, and food is more differentiated than electronics.

**Evaluating the Theoretical Assumptions**

The theory developed in this paper relies on two conditions:

i. \( \gamma_h > \sigma_h \) for all \( h \in H \).
ii. $\sigma_h > \sigma_{h'} \implies \gamma_h > \gamma_{h'}$ for any $h, h' \in H$ (i.e. $\{\sigma_h\}_{h \in H}$ and $\{\gamma_h\}_{h \in H}$ have the same order type).

In table 1.1, I already demonstrated that condition 1 holds for 91% of the HS-10 manufacturing products. To check condition 2, I rank HS-10 products both in terms of the magnitude of $\hat{\sigma}_h$ and in terms of the magnitude of $\hat{\gamma}_h$. Then, I plot these two ranks against one another for all HS-10 products. Figure 1.4.2 displays the outcome. 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. That is to say, if an HS-10 product exhibits a relatively high cross-country elasticity of substitution it also subject to a relatively high within-country elasticity.

In theory, to tractably incorporate conditions 1 and 2, I parametrically restricted $\{\gamma_h\}_{h \in H}$ to be a linear transformation of $\{\sigma_h\}_{h \in H}$, i.e. $\gamma_h = \eta \sigma_h$ for all $h$. In this section, however, I non-parametrically estimated $\gamma_h$ and $\sigma_h$ for various HS-10 products. This, allows me to verify the parametric restriction I imposed in theory. To compare the ordering of $\{\gamma_h\}_{h \in H}$ to $\{\sigma_h\}_{h \in H}$, I plot the estimated $\gamma_h$ against the estimated $\sigma_h$ for each HS-10 product in my sample. The resulting scatter plot is displayed in figure 1.4.3, and implies a tight linear relationship between $\gamma_h$ and $\sigma_h$.

Now I turn my attention to the assumption that production technique is not product-specific. In particular, I assumed the production technique to be country-specific, but common across
Figure 1.4.2: 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.

Figure 1.4.3: The scatter plot of the estimated $\gamma_h$ against the estimated $\sigma_h$. The right graph contains only a subset of HS-10 codes for which the estimated $\sigma_h$ is less than 5. The slope of the best-fitted line (i.e. $\eta$) is 2.15 with $R^2 = 0.9$. 
all products

\[ \mu_{jht} = \mu_{jh't} = \mu_{jt} \quad \forall h, h' \in H \]

In the context of the new theory, countries with superior production techniques are more competitive in highly-differentiated. Suppose now that production technique is both country and product-specific. Specifically, suppose production technique depends on both human capital in country \( j \) (denoted by \( H_j \)) and degree of differentiation of product \( h \): \( \mu_{jh} = \mu(H_j, \frac{1}{\sigma_h}) \). If \( \mu(H_j, \frac{1}{\sigma_h}) \) is log super-modular – \( \frac{\partial^2 \mu(H, \frac{1}{\sigma_h})}{\partial \sigma_h \partial H} > 0 \) – then the channel of across-product specialization introduced in this paper will be amplified. That is to say, the gap in competitiveness between North and South will be even larger for highly differentiated products (relative to the main model).

It is straightforward to verify that \( \mu_{jh} \) is indeed log super-modular. To demonstrate this, I regress \( \ln \hat{\mu}_{jht} \) (the estimated demand shifter for country \( j \) in product \( h \)) on per capita GDP \((w_{jt})\) – as a proxy for human capital – and the degree of differentiation in product category \( h \) \((\ln \frac{1}{\sigma_h})\). I also include the interaction of these two variables as an additional regressor:

\[
\ln \hat{\mu}_{jht} = 0.157 \ln w_{jt} + 0.8600 \ln \frac{1}{\sigma_h} + 0.0576 \ln w_{jt} \times \ln \frac{1}{\sigma_h}
\]

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). \( \mu_{jh} \) is log super-modular because the coefficient on the interaction term \((\ln w_{jt} \times \ln \frac{1}{\sigma_h})\) is positive. In other words, the technical gap between rich and poor countries widens as products become more differentiated. Hence, enforcing \( \mu_{jh} = \mu_j \) (for all \( h \)) is a rather conservative restriction in terms of generating the patterns of North-South trade that I am interested in. All the theoretical results not only would go through, but would be magnified if \( \mu_{jh} \) was assumed to be log super-modular, as suggested by data.

### 1.4.1.4. Product Differentiation and the Patterns of US Imports

Before I take the model to aggregate data and perform a cross-country welfare analysis, I will illustrate two micro-data patterns that confirm the theory. First, high price does indicate a high degree of differentiation (and not just high-quality as most studies suggest). Second, countries

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46\( \ln \hat{\mu}_{jht} \) is the residual from the micro-gravity estimation.
do specialize in particular products based on how differentiated they are.

**Pattern 1.** *Within an SITC-5 industry, HS-10 products that are more differentiated exhibit higher f.o.b unit-values*

The new theory suggests that across-product within-industry differences in unit values can be attributed to differences in markups that stem from differences in the degree of differentiation. Data reveals that this is well the case; higher unit values are significantly associated with lower demand elasticities (note that lower demand elasticity implies higher markup). To illustrate this association, I plot the estimated degree of differentiation (\( \frac{1}{\rho_h} \)) for each HS-10 product against the average f.o.b unit value of varieties of that HS-10 product (the unit values are normalized by the average of the SITC-5 industry to which the HS-10 product belongs to). The result is displayed in figure 1.4.4. HS-10 products that are more differentiated exhibit on average a higher f.o.b unit value.

As noted earlier, in the literature, across-product price differences are attributed to quality differences. However, a positive association between f.o.b unit value and quality at the same level of disaggregation (used in this paper) has yet to be established. Khandelwal [2010] (who, to my knowledge, is the only study that structurally estimates quality at the HS-10 level of disaggregation) finds a negative correlation between quality and f.o.b unit value. The theory proposed in this paper, therefore, has at least one advantage over the quality theory: it is consistent with highly disaggregated data.\(^{47}\)

**Pattern 2.** *Low-wage countries penetrate the US market significantly more in less differentiated industries*

The new theory claims that the US, imports relatively less of the highly differentiated product from low-wage countries – highly differentiated products are mostly imported from other advanced nations.\(^{48}\) To assess this claim I look at how import penetration from low-wage countries varies across different product categories. Low-wage import penetration is calculated as the total value share of imports (in percentage terms) from low-wage countries. Varieties from low-wage countries comprise a higher share of the US import basket in less-differentiated industries (figure 1.4.5) – I am using industry-level data because I observe import penetration

---

\(^{47}\)In an earlier version of the paper (available upon request) I estimate demand allowing for 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.

\(^{48}\)The list of low-wage countries is reported in appendix D.
only at the industry level. The pattern is consistent with the new theory of international specialization developed in this paper.

The pattern 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. In appendix D.2 I show that this argument is indeed consistent with data.

1.4.2. 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.

1.4.2.1. 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].

1.4.2.2. Calibration Strategy

Trade shares, \( \left\{ \lambda_{ij} \right\}_{i,j \in C} \), are a function of the set of \( N \) countries, each with its population \( L_i \), wage \( w_i \), country-specific demand shifter \( \mu_i \) and iceberg trade costs \( \tau_{ij} \); parameters \( \left\{ \gamma_h \right\}_{h \in H} \) (where \( \left\{ \gamma_h \right\}_{h \in H} = \left\{ \sigma_h \right\}_{h \in H} \cdot \epsilon \)) and \( \left\{ \sigma_h \right\}_{h \in H} \) 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.\(^{49}\) I take the set of countries, their population \( L_i \), and wages \( w_i \) from the data, and I calibrate \( \{ \tau_{ji} \}_{j,i=1}^N, \{ \mu_{i} \}_{i=1}^N, f, f^e, \{ \sigma_h \}_{h \in H}, \alpha, \epsilon, \) and \( \eta \) to match trade flow and wage data.\(^{50}\)

**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 represent different degrees 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 1) is displayed in table 1.3. As table 1.3 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.\(^{51}\) From Dekle, Eaton, and Kortum [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 demand shifters \( \{ \mu_{i} \}_{i=1}^N \), 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 \( \{ M^f_j \}_{i,j \in G} \), but not the relative mass of firms in the market.

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

\[ \lambda^i_j = \sum_{h \in H} \lambda^i_{ji} \lambda^h_i \]

where \( \lambda^i_{ji} \) 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.\(^{50}\)

\( I \) 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 \( \gamma_h = \eta \sigma_h \forall h \).

\( I \) The paper is available upon request

\(^{49}\) The equilibrium trade shares can be calculated using the two tier gravity represented by equations (8) and (9)

\(^{50}\) 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 \( \gamma_h = \eta \sigma_h \forall h \).

\(^{51}\) The paper is available upon request
<table>
<thead>
<tr>
<th>SIC code</th>
<th>No. of HS-10 industries</th>
<th>Average estimated elasticity $\eta_h$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial machinery</td>
<td>35</td>
<td>1,632</td>
</tr>
<tr>
<td>Electronics</td>
<td>36</td>
<td>1,325</td>
</tr>
<tr>
<td>Apparel</td>
<td>23</td>
<td>2,560</td>
</tr>
<tr>
<td>Leather</td>
<td>30</td>
<td>403</td>
</tr>
<tr>
<td>Food</td>
<td>20</td>
<td>37</td>
</tr>
</tbody>
</table>

Table 1.3: Representative industries in my calibration

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

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, $\Upsilon = \{\kappa_{\text{const}}, \kappa_{\text{dist}}, \kappa_{\text{border}}, \kappa_{\text{lang}}, \kappa_{\text{agreement}}, f, f^c\}$ refers to the set of trade cost parameters and $\bar{\Upsilon}$ refers to the set of data on countries’ pairwise geopolitical characteristics—distance, common border, language, and trade agreement.

**Country-specific demand shifters.** I solve for the vector of country-specific demand shifters (or Armington taste parameters) in an inner-loop by matching data on per capita GDP, using the following algorithm. Given parameters $\{\Upsilon, \eta, \{\sigma_h\}_{h \in H}, \epsilon, \alpha\}$, data on population $L = \{L^i\}_{i=1}^N$, and geopolitical characteristics $\bar{\Upsilon}$, the product market clearing condition (PMC) pins down a relation between country-specific demand shifters $\{\mu_i\}_{i=1}^N$ 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 $\lambda^i_j$ until I find a vector of country-specific demand shifters $\{\mu_i\}_{i=1}^N$ that satisfies equilibrium

---

52 Fieler [2011] uses the same strategy to pin down the technology parameters in a Ricardian model.
After substituting fixed and variable trade costs and the implicit solutions for country-specific qualities, the moment condition (minimized in the outer-loop) can be written as

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

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 calibration’s objective is to search for a set of parameters \(\mathbf{T} = \{\kappa_{\text{const}}, \kappa_{\text{dist}}, \kappa_{\text{border}}, \kappa_{\text{lang}}, \kappa_{\text{agreement}}, f, f^c\}\) that minimize the sum of the squared differences between the model outcomes and the data targets for these outcome.\(^{54}\) I normalize wage in the US and taste parameter for US varieties to 1 and 100 respectively.

The calibrated value of parameters and the goodness of fit are displayed in table 1.4. I also calibrate the model under two alternative baseline specifications. First, I shut down across product heterogeneity in degree of differentiation (reported in column two of table 1.4). By doing so, I partially shut down the incentive for high-wave and low-wage countries to trade. Second, I calibrate a model in which I also shut down national product differentiation (reported in column three of table 1.4).\(^{55}\) In the absence of national product differentiation there is no incentive for similar trade (e.g. North-North trade). Expectedly, in terms of fitting trade flow data, the main model outperforms both baseline models. The fit of the model improves dramatically when I incorporate North-South trade (by allowing for across-product heterogeneity in the degree of differentiation) – The model, therefore, dramatically improves upon

---

\(^{53}\) I solve for the trade shares along the following steps

i. Start with a guess of the vectors \(\{M^0_{ij}\}_{i,j\in C}\) and \(\{P^0_{ih}\}_{i,j\in C, h\in H'}\);

ii. Calculate the vector of product-specific profits of firm \(\{\pi^0_{ih}\}_{i,j\in C; h\in H'}\);

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

iv. Calculate the new vector of price indexes \(\{P^1_{ih}\}_{i,j\in C, h\in H'}\);

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).

\(^{54}\) To find the global minimum, I first perform a global search using the Genetic Algorithm. Then, I use the Nelder–Mead 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.

\(^{55}\) 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.
the Krugman or Armington model without any drastic assumption.

\( f = 0.05 \) implies that exporters have to pay a fixed cost per-product (inclusive of entry costs) that is 25% higher than that paid by domestic firms. Table A.6 (in the Appendix) reports the estimated country-specific demand shifters (\( \mu_i \)). As one would expect, the rank of countries in terms of production technique (\( \mu_i \)) is the same as their productivity (\( T_i \)) rank in Eaton and Kortum [2002]. This is quite intuitive given that, in the gravity equation, technology (\( T_i \)) is replaced with (1) a country-specific demand shifter (\( \mu_i \)), and (2) the mass of firms (\( M_{ik} \)) that actively export from country \( i \) (mass of firms that export is endogenously determined by \( \mu_j \) and other country-specific characteristics).

**Out of Sample Fit** To further demonstrate the explanatory power of the model, I turn attention to how the model performs in terms of matching data on the unit value trade. To this end, I look at the correlation between the unit value of traded goods in the calibrated model and the unit value of traded goods in data.\(^{57}\) I calculate the same correlation for the two baseline

---

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Main model</th>
<th>No across-product specialization (( \sigma_h = 4.2, \forall h; \eta = 2.15 ))</th>
<th>No national product differentiation (( \sigma_h = 4.2, \forall h; \eta \to 1 ))</th>
</tr>
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<td>0.666</td>
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<td>( \kappa_{dist} )</td>
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<td>( \kappa_{agreement} )</td>
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<td>0.051</td>
<td>0.059</td>
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<td>Goodness of fit (R-squared)</td>
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*Table 1.4.: The calibrated trade cost parameters*
Correlation between simulated prices and observed export prices

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<th>Model</th>
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<td>No national product differentiation and no across-product specialization (( \eta \to 1; \sigma_h = 4.2 ), ( \forall h ))</td>
<td>0.206</td>
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</table>

Table 1.5: Comparing the fit of my model to observed unit values of trade in data, to the baseline model.

specifications, described earlier. Note that when calibrating the model I only matched trade flow values, so by looking at unit values I am performing an out of sample evaluation. The results are summarized in table 1.5, and reveal that main model fits the price data significantly better than both baseline models. The main model captures two additional patterns compared to the baseline Krugman-Armington model: (i) the “Washington apples” effect, and (ii) within a narrowly defined set of goods, high-wage countries export goods that exhibit higher unit values.

1.4.3. Pattern of Competitive Advantage (North vs. South)

This section illustrates patterns of competitive advantage across different products. According to the gravity equation, country \( k \)'s imports of product \( h \) from country \( i \) are characterized by

\[
\lambda_{i|h}^k = \frac{\mu_i (M_{ih}^k)^{\frac{\sigma_{h^{-1}}}{\mu_{i}^{1/\sigma_{h^{-1}}}}} [\tau_{ik} w_{i}]^{(1-\sigma_{h})}}{\sum_{j \in C_h^i} \mu_j (M_{jh}^k)^{\frac{\sigma_{h^{-1}}}{\mu_{j}^{1/\sigma_{h^{-1}}}}} [\tau_{jk} w_{j}]^{(1-\sigma_{h})}}
\]

As evident in the above equation, \( Pure \ wage - \frac{w_{i}}{\mu_{i}^{1/\sigma_{h^{-1}}}} \) determines the market share of country \( i \) in global markets. The lower the pure wage the more competitive the firms from country \( i \), and the higher the market share they absorb in global markets. A novel feature of the present model is that pure wage is product-specific. A country could pay a relatively high pure wage for one product and a relatively low pure wage for another. To illustrate this, I plot pure wage against per capita income once for the (highly differentiated) machinery products and then for Lipsey, Deng, Ma, and Mo [2005] to calculate unit values in the benchmark year, 2000.
the (less differentiated) food products.

Figure 1.4.6 (upper panel) displays the relationship between pure wage and per capita income for food products. As seen, rich countries pay a higher pure wage and are competitively disadvantage for food products. For industrial machinery, however, the trend is the opposite (lower panel in figure 1.4.6). Figure 1.4.6 confirms that rich countries have a clear competitive advantage over poor countries in producing and selling industrial machinery in the global markets – they pay a much lower pure wage to workers who manufacture machinery and consequently charge a lower pure price for their variety of machinery.

To elaborate further, I can compare China with the US. In the least differentiated sector (food) China pays a pure wage (or marginal cost per unit of util) that is less than half of the US. In the most differentiated sector (industrial machinery) the pure wage in China is 33.8 times higher than the US. Clearly, US has tremendous advantage over China in industrial machinery. The advantage stems from differences in production technique (or labor-quality) and is largely immune to tariff reduction or any other policy that targets price rather than labor-quality.

1.4.4. A Gated Globe—the Large Scale of Iceberg Trade Costs

As noted earlier, across-product heterogeneity in differentiation is the driving force behind North-South trade, while national product differentiation is driving force behind North-North and South-South trade. Shutting down either channel leads to an aggregation bias when estimating the iceberg trade costs. Specifically, when both channels are taken into account, the estimated iceberg trade costs are larger in magnitude. When I impose \( \sigma_h \) to be the same for all five products (and equal to 4.2), the estimated trade costs are around 34% lower than the main model. When national product differentiation is also shut down, trade costs are underestimated by an additional 53%.

The estimated trade costs are higher in the new model compared to the baseline setting (and also compared to traditional estimates) due to the following. In the new model, there is more incentive for bilateral trade compared to traditional models of international trade. Across-product heterogeneity in differentiation, induces dissimilar countries to trade. In traditional models of trade (and in the baseline model) this direction of trade is absent. Hence, the new model can match the observed bilateral trade flows conditional on higher trade costs. This implies that in the context of the new model the gains from eliminating trade costs could be much greater than those predicted by traditional models.
Figure 1.4.6: The relationship between pure wage and per capita income (in logs) for the most and least differentiated products. Low-wage countries enjoy competitive advantage in food products (the least-differentiated product), while high-wage countries enjoy competitive advantage in machinery products (the most differentiated). Pure wage is calculated as the quality-adjusted wage in each country, i.e. $\ln \frac{w_i}{\mu + h_i}$.
Average $\tau_{ji}$ | % difference compared to new model
---|---
Main model | 3.28 | ...
No across-product specialization ($\eta = 2.15; \sigma_h = 4.2, \forall h$) | 2.17 | -33.84
No national product differentiation and no across-product specialization ($\eta \to 1; \sigma_h = 4.2, \forall h$) | 1.55 | -52.74%

*Table 1.6:* Comparison of calibrated iceberg trade costs under different specifications.

### 1.4.5. The Sizable Gains From Trade

Highly differentiated products exhibit higher markups, are more profitable to export, and, therefore, are traded more intensely. After a country opens to trade, imports will mostly consist of highly differentiated products. The import bias towards highly differentiated products is even bigger in poor countries. Taking this into account, the gains from trade would be sizable. Precisely speaking, the gains from trade depend on the volume of trade (which is observed in the data), and the elasticity of substitution across varieties of the product that is imported. In the new model when trade is liberalized, countries import predominantly foreign varieties of highly differentiated products. Since foreign varieties of highly differentiated products are not easily substitutable with their domestic counterparts, the gains from importing them are immense – appendix A.1.1 demonstrates this result analytically.

To quantify the gains from trade, I perform a counterfactual welfare analysis. I analyze the welfare effects of opening to trade from autarky (i.e. $\tau_{ij} \to \infty \ \forall i \neq j$). Welfare in each country is characterized by real wage ($w_i/P_i$). In the counterfactual experiment the general equilibrium is resolved for the new trade values, and the new measure of real wage is calculated using the counterfactual (autarky) wage and price index. The change in real wage form the trade to autarky measures the gains from trade. I perform the same counterfactual experiment for two alternative (baseline) models. As before, in the first baseline I restricted the elasticity of substitution to be 4.2 for all products. In the second baseline, I also shut down national product differentiation, i.e. I enforce $\eta \to 1$.

The estimated gains from trade are displayed in table 1.4.7 – and in more detail in table 1.7.
The results suggest that the gains from trade are, by far, larger in the new model. In the new model countries gain on average 15.2% in terms of real wage when opening to trade (from autarky). In the two baseline settings the gains are on average 4.9% and 1% in real wage terms – these numbers are closer to traditional estimates (to illustrate this, in table 1.7, I report the gains from trade quantified by Eaton and Kortum [2002]). Note that in the new model trade costs are supposedly larger, and the immense gains from trade are happening even though countries are moving from autarky to a highly-gated global economy.58

I can also decompose the gains from trade and back out the product-specific gains. Figure 1.4.8 displays the effect of trade on purchasing power (nominal wage relative to prices index of good $h$) for all five products. Every dot displays the change in purchasing power for a given product in one of the 50 countries after opening to the trade from autarky. Each product is indexed by degree of differentiation (x-axis) such that every vertical set of dots (in figure 1.4.8) reference one product. As expected, trade increases purchasing power significantly more for the highly differentiated products (e.g. electronics and machinery). For food products, which are the least differentiated, the gains are small and occasionally negative.

---

58 In the new model the trade equilibrium resembles autarky more than free trade. Under the baseline characterization, however, the trade equilibrium resembles more closely a free trade environment.
Table 1.7: 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 $V = Q_N^{1-\alpha} U_M^{\alpha}$, and hence $d \ln V = \alpha d \ln U_M^i = \alpha d \ln \frac{w_i}{P_i}$.

<table>
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<tr>
<th>Country</th>
<th>ISO code</th>
<th>$% \Delta V$ (main model)</th>
<th>$% \Delta V$ ($\eta = 2.15, \sigma = 4.2$)</th>
<th>$% \Delta V$ ($\eta \to 1, \sigma = 4.2$)</th>
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The gains from trade for different countries in different sectors (characterized by the degree of differentiation—x axis). The numbers on the vertical axis are changes in nominal wage relative to the price of the product (i.e. \( \frac{w_i}{P_i} \)) when switching from the calibrated trade equilibrium to the counter-factual autarky equilibrium.

The drop in purchasing power of food product (after trade) happens mostly in low-wage countries (table A.7). This is due to low-wage countries not being a profitable market for exporters of food products. In low-wage countries, domestic firms supply food products at a very low price, and absorb all the market share. When low-wage countries open to trade, multi-product foreign firms enter the market, crowd out some of the domestic firms, but only supply the most-differentiated products (e.g. electronics and machinery). When domestic firms (that are the main suppliers of food products) leave the market, there is less variety of food products. As a result, the purchasing power (of food) goes down. Consumers are, however, compensated by a disproportionally large increase in their purchasing power of highly differentiated products.\(^{59}\)

Finally, poor countries gain more from trade even though they conduct less trade. The reason is that by engaging in trade, poor countries gain access to the superior production techniques and high-quality labor in rich countries. For highly differentiated products (that are

\(^{59}\)In the CES framework consumers are identical and purchase all the varieties. The asymmetric gains in purchasing power, i.e. product-specific real wage, are 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 low-price less-differentiated products could lose from trade, specially in low-wage countries. Nevertheless, the average consumer in low-wage countries always gains from trade.
the main subject of imports in poor countries) production technique plays an important role—consumers of highly-differentiated products are more concerned about quality than quantity. Thus, importing differentiated products that are produced by high-quality labor in rich countries, generate sizable welfare gains. Pakistan, for example, is one of the main beneficiaries of trade in the new model. After trade is liberalized, Pakistani consumers gains access to electronics from Japan and machinery from Germany, both of which are massively superior (per dollar price) to there Pakistani counterparts. Despite being very intuitive, this direction of gain has never been formally characterized in the existing literature.

1.5. Conclusion

This paper develops a new theory of international specialization that simultaneously captures all the fundamental features of North-North and North-South trade. The explanatory power of the theory spans beyond patterns of North-South (or North-North) trade; it provides an alternative explanation for a host of other well-document facts, most notably the “Washington apples” effect. The theory reconciles facts that previous theories have explained in isolation. Moreover, unlike the existing theories of North-South trade, it requires minimal deviation form conventional assumptions. The pattern of (across-product) specialization emphasized by the new theory are unlike any other in the literature. The new theory is consistent with disaggregated trade data, and generates gains from trade that are substantially larger than traditional models.

I fit the model to data in two steps. First, I estimate the structural demand parameters using disaggregated data. Then, I use the first the step estimates to calibrate the model to aggregate trade flows, and to quantify the gains from trade. The main empirical findings are the following: (2) low-income countries specialize in less-differentiated products while high-income countries specialize in highly differentiated products; (1) the gap in competitiveness between high and low-income countries is strikingly large in highly differentiated sectors; (3) US employment in highly differentiated (i.e. low elasticity) industries is largely insulated from import penetration by low-wage countries; (4) the realized gains from trade (relative to autarky) are immense when we account for all directions of trade; and (5) in the main model (with North-South trade), the estimated trade costs are 51% larger than the baseline Krugman model (without North-South trade).
The new theory provides a tractable framework to analyze trade policy. In contrast to the “new trade theories” (e.g. Krugman, Melitz, Eaton-Kortum), the present framework is well-suited to analyze trade between the US and developing nations like China. Meanwhile, the framework retains both tractability of the “new trade theories”, and their explanatory power regarding North-North trade. A simple extension of the theory will provide a framework to analyze the unequal gains from trade (across consumers). Specifically, if trade costs are lowered, purchasing power of highly differentiated products would rise dramatically at the expense of lower purchasing power for less differentiated products. The effect is more prominent in low-income countries. This would imply unequal gains from trade across consumers if the underlying demand structure were nested logit rather than nested CES. Specifically, trade liberalization would greatly benefit the average consumer, but would harm consumers that buy (only) the least-differentiated of the products.
2. Apples and Oranges: Iceberg Trade Costs Revisited

The iceberg trade cost assumption is embodied in all major models of International trade. However, empirical evidence to support this rather conventional assumption is lacking. This paper provides such evidence by developing a simple model of international transportation. The model links shipping cost to the f.o.b. price of the shipment, and demonstrates that shipping cost per count is more iceberg-like than shipping cost per kilogram – existing studies have generally looked at shipping cost per kilogram for goods that are measured primarily in counts (e.g. TVs, cars). To address this finding, I first calculate price and shipping cost on a per-count basis for goods that report count as the primary unit of measurement in US import data. Then, I estimate the dependence of shipping costs on f.o.b. price. Estimation results strongly support the iceberg specification. Specifically, for every 1% increase in f.o.b. price (per count), the shipping cost (per count) increases by 0.91%. The paper then estimates the “Washington apples” effect: the dependance of export f.o.b prices on shipping costs. The effect is estimated to be stronger in industries where shipping costs are more iceberg-like. This suggests that, contrary to common belief, per-unit trade costs cannot be the only driving force behind the “Washington apples” effect. The paper then proceeds to find strong empirical support for an alternative force.

2.1. Introduction

The iceberg (multiplicative) trade cost assumption is embodied in all major models of International trade. The iceberg specification states that trade costs are proportionally higher for goods that exhibit a higher price—for example, if the price of a 40” TV is twice that of a 20” TV, the shipping rate charged for a 40” TV is also twice as much. The alternative specification is that trade costs are per-unit (additive), and do not depend on the price of the transported
Despite the theoretical success of the iceberg specification, empirical studies have generally rejected it in favor of per-unit trade costs. Such empirical studies fall into two general categories. The first group directly analyze data on shipping costs to identify the correct specification of trade costs (e.g. Hummels and Skiba [2004]). The second group identify additive trade costs conditional on the “Washington apples” effect (e.g. Irarrazabal, Moxnes, and Opromolla [2013]). More precisely, these studies assume that the “Washington apples” effect is due to per-unit trade costs. Then, by looking at the magnitude of the “Washington apples” effect they estimate the (magnitude of) per-unit trade costs.

This paper takes the former approach, and provides a major step forward in understating across-product differences in trade costs. To this end, I first develop a simple model of international transportation that establishes a structural relationship between trade costs and f.o.b. prices. Then, I use data on shipping costs to estimate this relationship. I show that shipping rate per count is more iceberg than shipping rate per kilogram. Existing studies (e.g. Hummels and Skiba [2004]) have generally looked at shipping rate per kilogram, but for goods that are measured primarily in units of count—examples of such goods are cars, TVs, etc.

To conduct the estimation, I use highly disaggregated US import data which documents imports of over 13,000 HS-10 product categories. The data includes both products that report count as the primary unit of measurement and products that report kilogram as the primary unit. I calculate f.o.b. price and shipping rate in terms of the primary unit of measurement for each observation. This is the main point of departure from the literature—Hummels and Skiba [2004], for example, calculate f.o.b. price and shipping rate on a per-kilogram basis for goods measured primarily in units of count. Then, I estimate the elasticity of shipping rate to f.o.b. price for both classes of goods.

Shipping costs for goods measured in counts closely resemble iceberg costs. Specifically, for every 1% increase in f.o.b. price (per count) the shipping rate per count increase by 0.91%. This is the first empirical confirmation of iceberg trade costs for a large class of goods—in fact, the big majority of goods in US imports. Shipping costs per kilogram are a hybrid of per-unit and iceberg costs. Precisely, a 1% increase in f.o.b. price per kilogram, increases the shipping rate per kilogram by around 0.56%.

Freight companies charge rates based on weight. More expensive goods are more expensive to ship (per kilogram) because (i) expensive goods require more labor for proper packaging.
and handling, and (ii) expensive goods are subject to higher insurance rates. These effects, combined, increase the shipping rate per kilogram by 0.56% for every 1% increase in price per kilogram. Shipping rate per count is even more sensitive to f.o.b. price (per count), because high-price goods are heavier per count. For example, a 40” TV is more expensive to ship than a 20” TV because (i) it is more costly to insure and handle a 40” TV, and (ii) 40” TVs are heavier. This (additional) second effect increases the elasticity of shipping rate per count to price (per count) by more than 60% (from 0.56 to 0.91). As a result, shipping costs are iceberg-like for TVs, cars, and other goods that come in counts.

In the second stage of my empirical analysis, I estimate the “Washington apples” effect: the effect of trade costs on f.o.b. export prices. Higher trade costs significantly increase f.o.b. export prices. The effect is significant both within an HS-10 product category, and across HS-10 products within the same industry. In other words, exporters that face higher trade costs, (1) selectively export HS-10 products that (on average) exhibit a higher f.o.b. price, and (2) export a higher price variety of the same HS-10 product. According to the Alchian-Allen conjecture (which is the standard explanation) this effect is due to additive trade costs. Surprisingly, and in contrast to the Alchian-Allen conjecture, the “Washington apples” effect is significantly stronger for goods measured in counts—even though these goods are subject to iceberg shipping costs. This result is quite remarkable, and suggests that we should seek other theories to complement the Alchian-Allen conjecture.

Apart from the Alchian-Allen conjecture, the literature does provide other explanations for the “Washington apples” effect. The first alternative explanation is pricing to market (PTM). According to Hummels and Skiba [2004], however, PTM cannot explain the large magnitude of the “Washington apples” effect in the US import data. A second alternative theory is the markup ladder theory (MLT) developed by Lashkaripour [2014]. MLT states that exporters switch from low-markup goods to high-markup goods in the presence of higher trade costs—the explanation does not require trade costs to be additive. MLT also predicts that the “Washington apples” effect is stronger in industries with a longer markup ladder. I find strong empirical support for this prediction. MLT also sheds light on why the “Washington apples” effect is stronger for goods measured in counts. Specifically, products that are measured in counts belong to industries that (on average) exhibit longer markup ladders. Therefore, exporters of such products are more reactive to higher trade costs.

The paper proceeds in the following order. Section 2 describes the data and provides some
preliminary facts regarding unit values and shipping costs. Section 3 explains the importance of unit value calculation in specifying the nature of trade costs. Section 4 estimates the elasticity of shipping costs with respect to f.o.b. price, and the magnitude of the “Washington apples” effect. In section 5 the markup ladder theory is presented and tested.

2.2. Data

The analysis in this paper is based on publicly available US import data compiled by Schott [2008]. The data documents US import values and quantities from different countries in various 10-digit HS-10 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 1994.\(^1\)

Each observation in the data refers to an import transaction with an exporting country, recorded at the HS-10 product-level, in a given year, to a given U.S. city. The general layout of the data is illustrated in table 2.1. Each observation documents import quantities, values, and the number of individual export cards (invoices) associated with each shipment. In addition, the data includes tariff, freight charges, and the units in which the reported quantity is measured. Moreover, the data reports whether or not the documented imports were subject to bilateral trade treaties or agreements. To complement the US import data, I use aggregate economic variables (population, GDP, etc.) from the Penn world tables and distance data from the CEPII data set compiled by Mayer and Zignago [2011].

\(^1\)All years beyond 1994 are dropped from the analysis, because the data compiled by Schott [2008] does not report units of measurement for those later years.
HS-10 products (or goods) can be divided into two general categories: product for which quantity is primarily measured in counts; and products primarily measured in units of kilogram. The products that arrive at the US ports exhibit a price, which is not directly observed in the data. However, the unit value (or price) associated with each shipment can be calculated as the total value of each shipment divided by quantity. Unit value (or price) will have the following composition for imported goods:

\[
\text{c.i.f price} = \frac{\text{Value}}{\text{Quantity}} + \frac{\text{Freight Charge}}{\text{Quantity}} + \frac{\text{Duty Charge}}{\text{Quantity}}
\]

\[
\text{c.i.f price is the price of imported goods inclusive of shipping costs and tariffs. The f.o.b component of price is, however, the main object of interest. The f.o.b price is reflective of the marginal cost and markup charged for each good. It is usually viewed as a reasonable proxy for quality within a narrowly defined set of goods. The other two components of c.i.f. price (tariff and shipping cost) represent the additional cost incurred by exporters. The goal of this paper is to parametrize the dependance of shipping costs on f.o.b price, if any. Table 2 provides some summary statistics regarding the magnitude of shipping costs and tariffs relative to the f.o.b price. Row 3 in table 2 reveals that the US imports an HS-10 product from various sources, but at extremely different prices – a pattern that is very puzzling indeed.} \]
Table 2.2: Summary statistics of US import prices. The first row describes the relative importance of shipping costs to f.o.b price. The second row describes the relative importance of tariff and shipping costs combined. The last row illustrates the tremendous amount of (within HS-10 product) price variation across various exporters.

\[
\begin{array}{cccc}
\% \text{ Shipping Cost} & 4.5 & 0.6 & 17 \\
\% \text{ Shipping Cost + Tariff} & 10.6 & 1.7 & 35 \\
\text{(Max f.o.b price)} & 36.2 & 2.9 & 3881.7 \\
\text{(Min f.o.b price)} & & & \\
\end{array}
\]

2.3. Empirics

2.3.1. A Simple Model of International Transportation

Shipping costs are usually charged based on weight. If a shipment of TVs weighs 1000 kilograms, the freight company will charge based on 1000 kilograms and irrespective of the number of TVs being shipped. The following quote from the IATA website very well describes the weight-based shipping costs:

Airline freight rates are based on a “chargeable weight”, because the volume or weight that can be loaded into an aircraft is limited. The chargeable weight of a shipment will be either the “actual gross mass” or the “volumetric weight”, whichever is the highest.

To deliver a shipment, transportation firms employs \( \epsilon \) units of labor from exporter country \( i \) and \( \iota \) units of labor from importer country \( j \). The firm can transport \( P_{ji}^{f.o.b}(h) = T_{ji}^{f.o.b}(h)^{\alpha \epsilon \iota^{1-\alpha}} \) kilograms of good \( h \) from country \( i \) to country \( j \). The transportation technology is good and importer-exporter specific. Moreover, transporting technology depends on \( P_{ji}^{f.o.b}(h) \): per kilogram f.o.b price of goods produced in country \( i \). In other words, it involves more labor to transport one kilogram of coal than to transport one kilogram of diamonds. Goods imported by country \( i \) from country \( j \), are also subject to ad valorem tariffs with rate \( t_{ij} \).

Transportation firms are perfectly competitive. Denote by \( p_{ji}^{f.o.b}(h) \) the c.i.f price of good \( h \) produced in country \( i \) and sold in country \( j \) (in terms of the primary unit of measurement). If a good is primarily measure in units of Kilograms , then \( p_{ji}^{f.o.b}(h) = P_{ji}^{f.o.b}(h) \). If a good is measured primarily in units of counts then \( p_{ji}^{f.o.b}(h) = P_{ji}^{f.o.b}(h) P_{ji}^{f.o.b}(h) \), where \( P_{ji}^{f.o.b}(h) \) is weight per count of good \( h \) that is produced in country \( j \) and sold in country \( i \).
Suppose that country \( j \) delivers \( q_{ji}(h) \) units of good \( h \) to country \( j \neq i \) – the units could be either counts or Kilograms. The transportation firm transporting good \( h \) from country \( i \) to country \( j \) solves the following problem:

\[
\max_{e_{ji}^h, t_{ji}^h} p_{ji}^{c.i.f}(h)q_{ji}(h) - t_{ji}P_{ji}^{f.o.b}(h)q_{ji}(h) - w_i e_{ji}^h - w_j t_{ji}^h
\]

\[\text{s.t. } q_{ji}(h) = \rho_{ji}(h)\tau_{ji}(e_{ji}^h, t_{ji}^h)\]

The cost of shipping every unit of variety \( jih \) will be \( T_{ji}p_{ji}^{f.o.b}(h)w_i^\alpha w_j^\beta \rho_{ji}(h) \), and the c.i.f price is be given by

\[
p_{ji}^{c.i.f}(h) = t_{ji}p_{ji}^{f.o.b}(h) + T_{ji}p_{ji}^{f.o.b}(h)w_i^\alpha w_j^\beta \rho_{ji}(h)
\]

2.3.2. Kilogram vs Count

In this section I demonstrate the importance of units in which quantity is measured. The correct specification of trade costs depends critically on the units in which quantity, shipping cost and price are measured. Specifically, when quantity (and hence price) is measured in terms of counts rather than kilogram, shipping costs are more iceberg-like.

First consider the case in which quantity is measured in units of Kilogram, and price (shipping cost) is calculated as price (shipping cost) per per unit of Kilogram. Let \( f_{ji}(h) \) and \( \tilde{p}_{ji}(h) \) denote shipping cost and price per Kilogram of good \( h \) shipped from country \( i \) to \( j \) – good \( h \) could be primarily measured in units of counts like TVs or cars. Since weight per Kilogram is unity (i.e. \( \tilde{\rho}_{ji}(h) = 1 \) the (per kilogram) c.i.f price is given by

\[
\tilde{p}_{ji}^{c.i.f}(h) = t_{ji}p_{ji}^{f.o.b}(h) + T_{ji}w_i^\alpha w_j^\beta \tilde{p}_{ji}^{f.o.b}(h)\rho_{ji}(h)
\]

Let \( \tilde{\beta} \) denote the elasticity of shipping cost to f.o.b price when price and shipping cost are measure on the per-kilogram basis.

\[
\tilde{\beta} = \frac{\partial \ln f_{ji}(h)}{\partial \ln p_{ji}^{f.o.b}(h)}
\]

According to equation 2.3.2, \( \tilde{\beta} = \kappa \). The above equation enables me to characterize two extreme specifications of trade (or shipping) costs:
Remark 1. Let $\hat{\beta}$ denote the elasticity of shipping costs to f.o.b price when quantity is measured in units of Kilogram, and price ($\hat{p}$) and shipping cost ($\hat{f}$) are calculated as value/rate per Kilogram. Then

i. $\hat{\beta} = \kappa$

ii. If $\hat{\beta} = \kappa = 0$ shipping costs are per unit.

iii. If $\hat{\beta} = \kappa = 1$ shipping costs are ad valorem or iceberg-like.²

Equation 2.3.2 parametrizes the dependence of shipping costs when both price and shipping cost are measured on the per kilogram basis. There are, however, two general class of goods: goods for which quantity is measured primarily in kilograms; and goods measured primarily in units of counts. Hummels and Skiba [2004] confine their analysis to a subset of goods measured primarily in counts, but calculate price and shipping cost on the per kilogram basis for these goods. They estimate the elasticity of shipping cost with respect to f.o.b price ($\beta$) to be 0.12. Therefore, they conclude that shipping costs resemble per-unit (or additive) costs more than iceberg costs.

Now I will demonstrate how calculating unit value and shipping cost on the per count basis modifies the estimated elasticity of shipping cost with respect to price. As noted earlier, $\tilde{f}_{ij}(h)$ denotes shipping cost per kilogram of good $h$. Similarly, let $f_{ij}(h)$ denote shipping cost per count of good $h$ shipped from country $i$ to $j$. Also, let $p_{ji}^{f.o.b}(h)$ be the per-count f.o.b price of good $h$ produced in country $i$ and sold in country $j$. From equation 2.3.1, the dependence of (per-count) shipping cost $f_{ji}(h)$ on (per-count) f.o.b price $p_{ji}^{f.o.b}(h)$ is given by

$$f_{ji}(h) = T_{jih}p_{ji}^{f.o.b}(h)^{\kappa}w_i^{\alpha}w_j^{1-\alpha}\rho_{ji}(h) = p_{ji}^{f.o.b}(h)^{\kappa}\rho_i(h)^{1-\alpha}T_{jih}w_i^{\alpha}w_j^{1-\alpha}$$

(2.3.3)

The above equation follows from the fact that $p_{ji}^{f.o.b}(h) = \frac{p_{ji}^{f.o.b}(h)}{\rho_{ji}(h)}$. Weight per count $- \rho_i(h) -$ can be calculated (using shipment data) as

²Specifically, when $\kappa = 0$, then

$$\tilde{p}_{ij}^{c+1/}(h) = t_{ji}\tilde{p}_{ji}^{f.o.b}(h) + T_{jih}w_i^{\alpha}w_j^{1-\alpha}$$

per-unit cost

and when $\kappa = 1$, then

$$\tilde{p}_{ji}^{c+1/}(h) = \tilde{p}_{ji}^{c+1/}(h) [t_{ji} + T_{jih}w_i^{\alpha}w_j^{1-\alpha}]$$

iceberg cost
\[
\rho_{ji}(h) = \left( \frac{\text{net weight of shipment of good } h}{\text{count of good } h \text{ in the shipment}} \right)_{ji,h}
\]  
\tag{2.3.4}

As I will soon demonstrate, unit weight (or weight per count) and f.o.b price are strongly correlated; heavier goods tend to be more expensive. To incorporate this into equation 2.3.3, suppose that \( \rho_{ji}(h) \) depends on \( p_{ji}^{f.o.b}(h) \) according to the following equation

\[
\rho_{ji}(h) = \mu_{jih} p_{ji}^{f.o.b}(h)^\alpha
\]
\tag{2.3.5}

Plugging equation 2.3.5 into equation 2.3.3 will result in

\[
f_{ij}(h) = p_{ji}^{f.o.b}(h)^{\kappa + \alpha(1-\kappa)} w_i^\alpha w_j^{1-\alpha} \hat{T}_{jih}
\]
\tag{2.3.6}

where \( \hat{T}_{jih} = \mu_{ih}^{1-\beta} T_{jih} \) denotes the non-price and non-wage factors that affect shipping costs. Let \( \beta \) denote the elasticity of shipping cost to f.o.b price, when price and shipping costs are measured on a per-count basis.

\[
\beta = \frac{\partial \ln f_{ji}(h)}{\partial \ln p_{ji}^{f.o.b}(h)}
\]

Equation 2.3.6 indicates \( \beta = \kappa + \alpha(1-\kappa) \). For every one percent increase in the per-count price of commodities, freight companies charge a shipping rate (per-count) that is \( \kappa + \alpha(1-\kappa) \) percent higher. The following remark describes the correct specification of trade cost when quantities and prices are measured in units of counts.

**Remark 2.** Let \( \beta \) denote the elasticity of shipping costs to f.o.b price when quantity is measured in units of count, and price \( (p) \) and shipping cost \( (f) \) are calculated as value/rate per count. Then

i. \( \beta = \kappa + (1-\alpha)\kappa \)

ii. if \( \beta = \kappa + \alpha(1-\kappa) = 0 \), shipping costs are per-unit or additive.

iii. if \( \beta = \kappa + \alpha(1-\kappa) = 1 \), shipping costs are *ad valorem* or iceberg-like.

The above result has two implications. First, if \( \alpha > 0 \), goods measured in counts will be subject to a more iceberg-like shipping cost compared to goods measured in kilograms. Second, as
Calculation of f.o.b price in 
Hummels and Skiba [2004]

\[ p_j(h) = \left( \frac{\text{Value of Shipment}}{\text{Net Weight of Shipment}} \right)_{jh} \]

Calculation of f.o.b price based on 
the primary unit of measurement

\[ p_j(h) = \left( \frac{\text{Value of Shipment}}{\text{Count of Objects in Shipment}} \right)_{jh} \]

**Table 2.3:** Goods (at the HS-10 level of disaggregation) that are measured primarily in terms of counts are also assigned a measured weight in the US import data. Unit value of the imported goods (for this class of HS-10 products) can be calculated using both measure of quantity (note that Hummels and Skiba (2004) confine their analysis to only goods measured primarily in counts). This table demonstrates both methods of unit value calculation for this class of goods.

Noted earlier, goods that are measured primarily in units of counts can be also and alternatively measured in units of weight/kilogram. We can think of one unit of TV as either one count of TV or one kilogram of TV. Shipping costs are more iceberg-like per count of TV and bear more resemblance to per-unit costs for each kilogram of TV. **Hummels and Skiba [2004]** look at shipping cost per kilogram for (TV-like) goods that are measured primarily in counts. Hence, they estimate \( \beta \) – as opposed to \( \beta + \alpha (1 - \beta) \) – and find that shipping cost per kilogram increases only 10% with every one dollar increase in per-kilogram price. Therefore, they conclude that shipping costs closely resemble per-unit costs. They also take this as a confirmation of the Alchian-Allen effect: the more expensive one kilogram of a good, the smaller the (percentage) effect of shipping costs on final price.

The intuition for why per-count shipping costs are more iceberg-like (than per-kilogram shipping costs) is straightforward. Suppose a freight company charges $1 for shipping both 1-kilogram of TV and 1-kilogram of Radio to a foreign market. The price of 1-kilogram of TV is $1 and the price of 1-kilogram of radio is $1.5. From this perspective radios are more expensive, but ship at the same cost as TVs. However, one count of TV is 10-kilogams while one count of radio is 1-kilogram. Hence, one count of TV is priced at $10 and costs $10 to ship. One count of radio is priced $1.5 and costs $1 to ship. Looking at it this way, the shipping cost is higher for each count TV proportional to its higher price (per count).

**The dependence of unit weight on f.o.b price.** Here, I demonstrate that expensive goods are indeed heavier per count. In other words I show that \( \alpha > 0 \). To this end, I plot the f.o.b
Figure 2.3.1: The positive correlation between unit weight (weight per count) and f.o.b price (per count) in US imports data. The graph only includes HS10 products that report counts as the primary unit of measurement.

value per count (price) of HS-10 goods imported by the US from various countries against the weight per count of the same good. The result is displayed in figure 2.3.1; there is a very strong relation between unit value and unit weight. For every 100% increase in the f.o.b price of a good, it becomes 69% heavier. In a nutshell, expensive goods are heavier and cost more to ship. The pattern holds when comparing only goods that belong to the same HS-10 category. To see this, I log-linearize equation (3) and estimate \( \alpha \) in the presence of HS-10 fixed effects

\[
\ln p_{jt}^{f,o.b}(h) = 0.492 \ln p_{jt}^{f,o.b}(h) + \delta_h + \ln \mu_{jht}
\]

where \( \ln \mu_{jht} \sim N(-1.291, \sigma_\mu) \). \( \delta_h \) is an HS-10 product code fixed effect and \( t \) indexes the year (1989-1996) in which the transaction took place. The equation is estimated for 3,864 HS-10 products (that are measure in counts) and 179,432 observations. The standard errors are displayed in the parenthesis and the \( R^2 \) is equal to 0.295. A simple OLS estimation with no fixed effects will estimate \( \alpha \) to be 0.695 at the 1% confidence level, with an \( R^2 \) equal to 0.637.

In the next section I will estimate \( \beta \) and \( \hat{\beta} \) separately. Before that, however, a back of envelope calculation reveals how important of a role units of measurement play in correctly specifying shipping costs. Hummels and Skiba [2004] estimate \( \beta \) (in equation 1) to be 0.125 for goods that
report count as the primary unit of measurement. Based on the data exercise I just performed, let $\alpha \approx 0.5$. Consequently, every cont of an HS-10 good would be subject to a shipping cost that increases with price at an elasticity equal to $\beta + \alpha(1 - \beta) = 0.125 + 0.5 \times 0.875 = 0.562$. This is a far cry from the per-unit trade cost specification – a specification that Hummels and Skiba [2004] are seeking.

### 2.3.3. Estimating the Dependence of Shipping Cost on Unit Value

This section estimates the elasticity of observed shipping cost (per unit of good) with respect to unit value. The estimated elasticity allows me to take a stance on the correct specification of shipping (or trade) costs. Specifically, the goal of this section is to estimate $\beta$ in the equation 1.

Writing equation 2.3.6 (or equation 2.3.2) in log-linearized form yields the following equation:

$$\ln f_{ji}(h) = \beta \ln p_{ji}^{f.o.b}(h) + \alpha \ln w_i + (1 - \alpha) \ln w_j + \ln T_{jih}$$  (2.3.7)

Where $i$ here is a US city (port of entry). Hence, for all observations $w_i = w_{US}$ is a constant. $\ln T_{jih}$ consists of all the non-price and non-wage variables that affect shipping costs. Specifically, $\Gamma_{jih}$ is given by the following

$$\ln T_{jih} = a_1 \ln WGT_{jih} + a_2 \ln DIST_j + a_4 D_{lang}^j + a_5 D_{contig}^j + \ln z_{jih}$$

The inclusion of shipment size is due to Hummels and Skiba [2004]. They argue that “shipment size ($WGT_{jih,t}$) affects shipping cost through three channels: increasing returns to scale, discount for larger scale shipments, and second degree price discrimination due to monopoly in the shipping industry.” The other elements, distance ($DIST_j$), common language ($D_{lang}^j$), and contiguity ($D_{contig}^j$) are standard determinants of trade costs in the literature. I assume that transportation efficiency $\ln z_{jih}$ can be decomposed into two components: (1) an exporter-specific component ($z_j$), which can be approximated by exporter’s wage and (2) a mean zero (error) component unobserved by the econometrician.

---

3The log-linearized formulation of equation 2.3.2 will – precisely – be

$$\ln f_{ji}(h) = \tilde{\beta} \ln p_{ji}^{f.o.b}(h) + \alpha \ln w_i + (1 - \alpha) \ln w_j + \ln T_{jih}$$

4The US import data allows me to either use gross weight of shipment $jih,t$ or the net weight of the shipment to control for shipment size – Hummels and Skiba [2004] use net weight. Intuitively, gross weight seems to be more relevant if we are concerned with economies of scale in transportation industry. In this paper, I use gross weight to control for shipment size. The estimation results are, however, very robust to using net weight instead of gross weight.
\[ \ln z_{jih} = \hat{\theta} \ln z_j + \hat{\epsilon}_{jih} = -\theta \ln w_j + \epsilon_{jih} \]  

(2.3.8)

Apart from technological heterogeneity specific to shipment \( jih \), the error term \( \epsilon_{jih} \) could reflect measurement error, as well as unobserved cost shifters such as regulatory. Plugging equation 2.3.8 into equation 2.3.7 will give us the following equation

\[ \ln f_{ji,t}(h) = \beta \ln p_{ji,t}^{f.o.b}(h) + (\alpha - \theta) \ln w_{j,t} + a_1 \ln WG_{jih,t} + a_2 \ln DIST_j + a_3 D_{lang}^j + a_4 D_{contig}^j + \mu_{ht} + \epsilon_{jih,t} \]  

(2.3.9)

where \( t \) denotes year (1989-1994) and \( \mu_{ht} \) represent the HS10 product–year fixed effect. \( w_{j,t} \) is approximated by per capita GDP of country \( j \) in year \( t \) — I am looking at within product–year (across-exporter) variations in shipping costs and f.o.b prices to identify \( \beta \).

The key difference between the empirical analysis in the present paper and the one conducted by Hummels and Skiba [2004], is the manner in which price and shipping costs are calculated. As noted earlier, Hummels and Skiba [2004] restrict their analysis to goods measured primarily in units of count. They, however, calculate price/shipping cost as price/rate per kilogram. In this paper, I calculate price/shipping in terms of the primary unit of measurement assigned to each good. For a shipment of TVs price is calculated as price per count of TV, and for a shipment of coal price is calculated as price per Kilogram of coal. The price \( p_{ji,t}^{f.o.b}(h) \) and shipping cost \( f_{ji,t}(h) \) associated with shipment \( jih, t \) are, therefore, calculated as

\[
\begin{align*}
\{ f_{ji,t}(h) &= \left( \frac{\text{total freight bill}}{\text{quantity in primary units}} \right)_{jih,t} \\
p_{ji,t}(h) &= \left( \frac{\text{f.o.b value}}{\text{quantity in primary units}} \right)_{jih,t}
\end{align*}
\]  

(2.3.10)

Before estimating equation 2.3.9, we should take into account simultaneity between f.o.b prices and shipping costs. Trade costs affect the f.o.b price of exported goods through various channels of self-selection: (1) when trade costs are per unit, exporters that face higher trade costs selectively export higher-price goods or charge higher markups (Alchian and Allen [1983]; Martin [2012]); (2) exporters are also likely to specialize in high-markup goods when trade costs are high and exporting is subject to fixed costs (Lashkaripour [2014]); and (3) high-quality varieties could be the most competitive and, hence, the only to make it into remote markets (Baldwin and Harrigan [2011]).
Inline with the existing literature (e.g. Hummels and Skiba [2004]; Baldwin and Harrigan [2011]), I characterize the dependence of f.o.b unit values on shipping costs with the following equation

$$\ln p_{f.o.b}^{j, i, t}(h) = \phi \ln f_{j, i, t}(h) + \gamma w_{j, t} + \ln GDP_{j, t} + \tau DRTA_{j, t} + \rho h_{t} + \nu_{j, i, t, t}$$

(2.3.11)

where $t_{j, i, t}(h)$ is the tariff rate imposed on shipment $jih$ – I could either use tariff rate directly or proxy for it with a dummy that control for any tariff-reducing trade agreement with the US that is specific to product $h$. $w_{j, t}$ is the per capita GDP (as a proxy for wage) of country $j$ in year $t$. $GDP_{j, t}$ denote the GDP of the exporter in year $t$ (Hummels and Skiba [2004], unlike most other studies, do not control for GDP however as I will show estimation results are robust to the inclusion of exporter’s GDP as an additional control). Finally, The error term ($\nu_{j, i, t, t}$) captures technological (or quality) shocks specific to varieties in shipment $jih, t$. The error term also includes measurement error in prices, which is common in highly disaggregated trade data.

**Instrumental Variables.** Equations 2.3.9 and 2.3.11 indicate that there is simultaneity between f.o.b unit value and shipping cost. Moreover, there is simultaneity between shipping costs ($f_{j, i, t}(h)$) and quantity imported ($WGT_{jih, t}$). To handle simultaneity I adopt the instrumental variable approach when estimating each equation. I instrument for f.o.b price using the exogenous variables in equation 2.3.11, and I instrument for shipping cost using the exogenous variable in equation 2.3.9. Precisely, in equation 2.3.9, I instrument for f.o.b price ($p_{f.o.b}^{j, i, t}(h)$) and total quantity ($WGT_{jih, t}$) with tariff rates ($t_{j, i, t}(h)$), GDP of the exporter $j$, and membership of exporter $j$ in WTO/GATT. In equation 2.3.9 I instrument for shipping costs ($f_{j, i, t}(h)$) with distance ($DIST_{j}$), common language ($D_{j}^{lang}$), and contiguity ($D_{j}^{contig}$).

Table B.2 reports the instruments used in the present paper to the instruments used by Hummels and Skiba [2004].

**Results.** Table 2.4 reports estimates of equation 2.3.9 – table2.5 reports estimates of equation 2.3.9 using an ordinary least square (OLS) estimator. The first two columns (in tables 2.4 and

5Hummels and Skiba [2004] include tariff rate directly as a determinant of f.o.b price. As a robustness check, I estimate equation 2.3.11 replacing $DRTA_{j, t}$ with tariff rate $t_{j, i, t}(h)$. The results are reported in table B.4.

6When estimating the f.o.b price equation, Hummels and Skiba [2004] assume that quantity $WGT_{jih, t}$ is exogenous to f.o.b price. Hence, they use $WGT_{jih, t}$ as an instrument for shipping cost when estimating the determinants of f.o.b price. However, as all classical models of supply and demand have suggested, it is hard to argue that quantity is exogenous to price. To be safe, I do not include $WGT_{jih, t}$ as an instrument for shipping cost $f_{j, i, t}(h)$ when estimating equation 2.3.11.
2.4) report results for an estimation which pools all HS-10 products. The second two columns report results for a sub-sample of HS-10 products that report count as the primary unit of measurement. The last two columns report estimates for a sub-sample of HS-10 products that report Kilogram as the primary unit of measurement. In summary, the estimation results in table 2.4 imply the following parameter values

i. $\beta = \kappa + (1 - \alpha)\kappa \simeq 0.91$

ii. $\tilde{\beta} = \kappa \simeq 0.59$

Consistent with my theory, products that are measured in units of counts are subject to iceberg-like shipping costs. For every 1 percent increase in f.o.b price per count, the shipping cost per count increases by 0.92% (which is near proportional). Moreover, for larger shipments shipping costs are lower (the coefficient on $WGT_{j,t}$ is negative). Distance increases shipping cost, while common language and contiguity lower the shipping cost. Finally, high-wage countries pay lower shipping costs (even though they pay higher wages to workers) due to their superior transportation technology ($\alpha - \theta < 0$).

2.3.3.1. The relationship between shipping cost per Kilogram and price per Kilogram for products measured primarily in counts.

In this section I demonstrate how calculating price and shipping cost on a per Kilogram basis for product measures primarily in counts could affect the estimation results – this approach is taken by Hummels and Skiba [2004]. To this end I estimate equation 2.3.9, but calculate shipping cost and f.o.b price for all products as

$$
\begin{align*}
\tilde{f}_{ji,t}(h) &= \left(\text{total freight bill} \over \text{Net weight of shipment in Kilograms}\right)_{jih,t} \\
\tilde{p}_{ji,t}(h) &= \left(\text{f.o.b value of shipment} \over \text{Net weight of shipment in Kilograms}\right)_{jih,t}
\end{align*}
$$

As I showed earlier, for products that are measured that are measured primarily in units of counts, we have the following relationship

$$
\begin{align*}
\frac{\partial \tilde{f}_{ji,t}(h)}{\partial p_{ji,t}(h)} &= \kappa \\
\frac{\partial \tilde{f}_{ji,t}(h)}{\partial \tilde{p}_{ji,t}(h)} &= \kappa + (1 - \alpha)\kappa
\end{align*}
$$
Determinants of shipping cost $\ln f_{j,t}(h)$ – IV Estimation

<table>
<thead>
<tr>
<th>Regressor</th>
<th>All Products</th>
<th>Counts</th>
<th>Kilograms</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln p_{f.o.b.}^{j,t}(h)$</td>
<td>0.69***</td>
<td>0.92***</td>
<td>0.71***</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.004)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>$\ln WGT_{jih,t}$</td>
<td>-0.33***</td>
<td>-0.08***</td>
<td>-0.44***</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.005)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>$\ln DIST_j$</td>
<td>0.40***</td>
<td>0.36***</td>
<td>0.43***</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>$\ln w_{j,t}$</td>
<td>-0.12***</td>
<td>-0.09***</td>
<td>-0.17***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.002)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>$D_{j}^{lang}$</td>
<td>-0.12***</td>
<td>-0.08***</td>
<td>-0.26***</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.004)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>$D_{j}^{contig}$</td>
<td>-0.08***</td>
<td>0.09***</td>
<td>-0.30***</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.010)</td>
<td>(0.021)</td>
</tr>
<tr>
<td>Observations</td>
<td>4,250,764</td>
<td>1,688,671</td>
<td>1,153,167</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.49</td>
<td>0.72</td>
<td>0.19</td>
</tr>
<tr>
<td>Number of HS10–years</td>
<td>73,007</td>
<td>19,457</td>
<td>29,739</td>
</tr>
</tbody>
</table>

Table 2.4: Determinants of shipping costs (Note: The estimating equation is equation 2.3.9 in the text. Price and quantity are instrumented by tariff rates, exporter GDP, and export’s membership in WTO/GATT).
Determinants of shipping cost $\ln f_{ji,t}(h)$ – OLS Estimation

<table>
<thead>
<tr>
<th>Regressor</th>
<th>All Products</th>
<th>Counts</th>
<th>Kilograms</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln p^{f.o.b.}_{ji,t}(h)$</td>
<td>0.85***</td>
<td>0.91***</td>
<td>0.58***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>$\ln WGT_{jih,t}$</td>
<td>-0.06***</td>
<td>-0.04***</td>
<td>-0.14***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>$\ln DIST_j$</td>
<td>0.22***</td>
<td>0.30***</td>
<td>0.15***</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.004)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>$\ln w_{j,t}$</td>
<td>-0.07***</td>
<td>-0.08***</td>
<td>-0.04***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>$D_{j}^{\text{lang}}$</td>
<td>0.00</td>
<td>-0.03***</td>
<td>0.02***</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>$D_{j}^{\text{contig}}$</td>
<td>0.00</td>
<td>0.01</td>
<td>-0.09***</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.010)</td>
<td>(0.011)</td>
</tr>
</tbody>
</table>

Observations 4,254,793 4,254,793 1,689,287 1,689,287 1,154,847 1,154,847 1,154,847
R-squared 0.63 0.63 0.72 0.72 0.55 0.55
Number of id3 77,036 77,036 20,073 20,073 31,419 31,419

Table 2.5: Determinants of shipping costs under an ordinary least square (instead of the IV) estimation (Note: The estimating equation is equation 2.3.11 in the text).
Determinants of shipping cost per-Kilogram $\ln \tilde{f}_{ji,t}(h)$

<table>
<thead>
<tr>
<th></th>
<th>IV Estimation</th>
<th>OLS estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All products</td>
<td>Counts</td>
</tr>
<tr>
<td>$\ln \tilde{p}_{ji,t}(h)$</td>
<td>0.34***</td>
<td>0.67***</td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td>(0.016)</td>
</tr>
<tr>
<td>$\ln DIST_j$</td>
<td>0.39***</td>
<td>0.35***</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.011)</td>
</tr>
<tr>
<td>$\ln w_{j,t}$</td>
<td>-0.10***</td>
<td>-0.10***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>$\ln WGT_{jih,t}$</td>
<td>-0.45***</td>
<td>-0.26***</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>Observations</td>
<td>2,344,365</td>
<td>202,096</td>
</tr>
<tr>
<td>$R^2$</td>
<td>-0.11</td>
<td>0.57</td>
</tr>
<tr>
<td>Number of HS10–years</td>
<td>49,559</td>
<td>2,186</td>
</tr>
</tbody>
</table>

Table 2.6: Determinants of shipping costs when shipping cost, $\tilde{f}_{ji,t}(h)$, and f.o.b price, $\tilde{p}_{ji,t}(h)$, are calculated on a per-Kilogram basis (Note: The estimating equation is equation 2.3.9 in the text. Price and quantity are instrumented by tariff rates, exporter GDP, and export’s membership in WTO/GATT). The first column – “All products” – reports the estimation for all products that report Kilogram as either the secondary or primary unit of measurement. The second column – “Counts” – reports estimates for a subset of product that are primarily measured in units of counts, but report Kilogram as a secondary unit.

Where $p_{ji,t}(h)$ and $f_{ji,t}(h)$ are f.o.b price and shipping cost per count respectively. The take-away message is that calculating price on a per-Kilogram basis, significantly (downward) biases the elasticity of shipping cost to price. Table 2.6 demonstrates this result. It reports the estimates for equation 2.3.9 under the alternative price and shipping costs calculation. The first column reports the estimation for all products that report Kilogram as either a secondary or primary unit of measurement. The second column reports estimates for a subset of product that are primarily measured in units of counts, but report Kilogram as a secondary unit.

### 2.3.4. The “Washington Apples” Effect

In this section I test the “Washington Apples” effect by estimating equation 2.3.11. The results are reported in table B.4 – table 2.8 reports estimates of equation 2.3.11 using an ordinary least square (OLS) estimator. The results strongly support the “Washington Apples” effect. Within an HS-10 product category, exporters that face higher shipping costs export goods that exhibit
Determinants of f.o.b price $\ln p_{ji,t}^{f.o.b}(h)$ – IV Estimation

<table>
<thead>
<tr>
<th>Regressor</th>
<th>All Products</th>
<th>Counts</th>
<th>Kilograms</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln f_{ji,t}(h)$</td>
<td>0.68***</td>
<td>0.63***</td>
<td>1.01***</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>$\ln w_{j,t}$</td>
<td>0.16***</td>
<td>0.19***</td>
<td>0.09***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>$D_{jh,t}^{RTA}$</td>
<td>0.69***</td>
<td>0.63***</td>
<td>0.98***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>$\ln GDP_{j,t}$</td>
<td>0.05***</td>
<td>0.03***</td>
<td>0.05***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
</tbody>
</table>

Observations: 4,757,653 4,757,653 1,895,002 1,895,002 1,337,409 1,337,409
Number of HS10-years: 75,957 75,957 20,094 20,094 31,198 31,198
$R^2$: 0.61 0.61 0.61 0.60 0.44 0.39

Table 2.7: Determinants of imported f.o.b prices (Note: The estimating equation is equation 2.3.11 in the text. Shipping costs are instrumented by distance, common language and contiguity).

Higher f.o.b prices. Along with the “Washington apples” effect the following two patterns can also be observed:

i. HS-10 products that are measured in units of counts are subject to iceberg-like shipping costs. These, products, exhibit a stronger positive relation between f.o.b price and shipping cost.

ii. HS-10 products that are measured in units of Kilogram are subject to shipping costs that more closely resemble per-unit costs. These products, however, exhibit a weaker positive relationship between f.o.b price and shipping cost.

Even though per-unit (or additive) shipping costs could be one explanation behind the “Washington Apples” effect, they are not consistent with the above pattern. Therefore, we need an alternative mechanism that does not rely on per-unit trade costs to explain the “Washington apples”, specifically for goods measure in units of counts. The literature sets proposes two such mechanisms. First, is a theory suggested by Baldwin and Harrigan [2011]. They incorporate across-product quality differences into the Melitz framework. They assume that quality is so important to consumers that high-quality products experience the highest de-
mand and generate the highest profits. Hence, high quality firms are the most competitive and are the only exporters that can break it into markets for which shipping costs are extremely high. The second explanation is the markup ladder theory by Lashkaripour [2014]. He develop-
os a model with across-product differences in level of (horizontal) differentiation. Monopolis-
tically competitive firms charge higher markups for the highly-differentiated products. Highly differenti-
ated–high markup products both exhibit a higher f.o.b price and are more profitable to export. When firms face high shipping costs, they only export the high-markup goods that generate the highest profits. This selection effect is stronger in industries with a longer markup ladder.

In the next section, I test the markup ladder theory (MLT) and find strong support for the theory in the US import data.

### 2.4. The Markup Ladder Theory of Shipping the Good Apples Out

In this section I lay out a simple characterization of the Markup Ladder Theory (MLT) developed by Lashkaripour [2014]. There are $N$ symmetric countries located on a circle. Each
The country is populated with a large pool of homogeneous firms. There are many (SITC-5) industries, and consumers (are identical and) have a Cobb-Douglas utility aggregator across industries—αs share of total expenditure is spent on goods from industry s. Suppose industry s is comprised of two HS-10 products H and L. Each product comes in different firm-specific varieties. Preferences are nested CES

\[ U^s = \left[ \sum_{h \in \{H, L\}} \left( \sum_{\omega \in \Omega_h} q_{\omega}(h) \frac{\sigma_h^{-1}}{\sigma_h} \right) \right]^{\frac{1}{\sigma_h - 1}} \]

where \( \omega \) indexes a firm. \( H \) indexes the highly-differentiated product and and \( L \) indexes the less-differentiated product. \( \sigma_h \) is the elasticity of substitution across varieties of good \( h \), and by definition, \( \sigma_L > \sigma_H \). The marginal cost of manufacturing one unit of goods \( H \) is \( L \) is the same and equal to one—note that countries are symmetric and wages are normalized to one. Firms are monopolistically competitive, and charge the following good-specific f.o.b price

\[ p^{f.o.b}_{\omega}(h) = \frac{\sigma_h}{\sigma_h - 1} \]

Exports from country \( j \) to \( i \) are subject to an iceberg trade cost \( \tau_{ji} \). The c.i.f. price of varieties exported from country \( j \) to \( i \) is therefore

\[ p^{c.i.f.}_{ji}(i) = \frac{\sigma_h}{\sigma_h - 1} \tau_{ji} \]

Note that (firms are homogenous and) every firm exporting from country \( j \) to \( i \) charges the same c.i.f. price. Demand in country \( i \)—in c.i.f. value terms— for an individual variety \( \omega \in \Omega_{ji} \) from country \( j \) is the following

\[ x_{ji}(h) = \left( \frac{p^{c.i.f.}_{ji}(i)}{P_h} \right)^{1-\sigma_h} \left( \frac{P_h}{P_s} \right) \frac{\alpha_s L_i}{1-\varepsilon} \]

where \( \alpha_s L_i \) is total expenditure (in country \( i \) with population \( L_i \)) on industry \( s \) goods. Total exports of good \( h \) form country \( j \) to \( i \) are \( X_{ji}(h) = M_{ji}(h)x_{ji}(h) \), where \( M_{ji}(h) \) is the mass of firms exporting good \( h \) from country \( j \) to \( i \) — \( M_{ji}(h) \) is pinned down by the free entry condition. The product-specific prices index \( P_h \) and the industry wide price index \( P_s \) are given the
\[ P_h = \left( \sum_{\omega \in \Omega} \left[ p^{c.i.f.}_\omega (h) \right]^{1-\sigma_h} \right)^{\frac{1}{1-\sigma_h}}, \quad h \in \{ H, L \} \]

\[ P_s = \left[ P^1_{H} + P^1_{L} \right]^{\frac{1}{1-\epsilon}} \]

Demand for country \( j \) varieties of product \( h \), relative to country \( k \) varieties of the same product is

\[ \frac{x_{ji}(h)}{x_{ki}(h)} = \left( \frac{\tau_{ji}}{\tau_{ki}} \right)^{1-\sigma_h} \]

Given the above equation if \( \tau_{ji} > \tau_{ki} \) then

\[ \frac{x_{ji}(H)}{x_{ji}(L)} > \frac{x_{ki}(H)}{x_{ki}(L)} \quad (2.4.1) \]

Let \( \lambda_{ji}(H) = \frac{x_{ji}(H)}{x_{ji}(L)+x_{ji}(H)} \) denote the share highly differentiated products in the export bundle of country \( j \) to \( i \). The average f.o.b price of exported varieties from country \( j \) will, therefore, be

\[ p^{f.o.b}_{ji} = \lambda_{ji}(H)p^{f.o.b}(H) + \left[ 1 - \lambda_{ji}(H) \right] p^{f.o.b}(L) \]

Inequality 2.4.1 implies that \( \lambda_{ji}(H) > \lambda_{ki}(H) \): the mix of goods exported by country \( j \) is more differentiated and exhibits on average a higher markup. Hence, goods exported by country \( j \) to \( i \) will on average have a higher f.o.b. price than those exported by country \( k \). In other words, higher trade costs imply higher f.o.b. export prices

\[ \frac{\partial p_{ci}^{f.o.b}}{\partial \tau_{ci}} > 0 \]

Where \( c \) indexes a country. The above inequality is the “Washington apples” effect. Define the markup ladder in industry \( s \) (comprising of goods \( H \) and \( L \)) as the following

\[ \text{markup ladder}_s = \frac{\sigma_H - 1}{\sigma_L - 1} \]

The markup ladder represents the difference in (1) f.o.b price, and (2) the price elasticity of demand between the highly differentiated and the less-differentiated good in an industry. Obviously, the “Washington apples” effect is stronger in industries with a longer markup ladder.
\[
\frac{\partial}{\partial \sigma_{L-1}} \left( \frac{\partial p_{c}^{f.o.b}}{\partial \tau_{c}} \right) > 0
\]

The above result represents two effects. First, when the markup ladder is longer the self-selection effect is stronger; firms are more inclined to switch to the high-markup good when facing higher trade costs. Second, the price ladder is longer in industries with a long markup ladder. Hence, different countries exporting a different mix of goods results in a larger price differential across the exporting countries.

**2.4.0.1. Testing the Markup Ladder Theory.**

In the previous section I estimated equation 2.3.11 by pooling all HS-10 products that belonged to various SITC-5 industries. To test the alternative theory, I estimate the equation 2.3.11 separately for all SITC-5 industries. I conduct the estimation under two different specifications. First I estimate equation 2.3.11 for each SITC-5 industry with HS-10 fixed effects. Under this specification, I am identify the “Washington apples” effect within HS-10 products that belong to the same SITC-5 industry. Second, I estimate equation 2.3.11 for each SITC-5 industry without HS-10 fixed effects. This specification allows me to identify the “Washington apples” effect across (and within) HS-10 products.

**The “Washington apples” effect: within versus across HS-10 products.** When exporters face higher trade costs, they could either be exporting higher price varieties of the same HS-10, or alternatively they could be switching form low-price HS-10 products to high-price ones. I could identify the within HS-10 product switching by estimating equation 2.3.11 with HS-10 fixed effects. I can identify the across (and within) HS-10 product switching by equation 2.3.11 without product fixed effects. I plot the elasticity of price to shipping costs under each estimation in figure 2.4.2. For most SITC-5 industries the across-product switching complements the within-product switching. Overall, figure 2.4.2 suggests that the “Washington apples” effect is an across-product phenomenon as much as it is a within-product phenomenon – the alternative theory is consistent with both aspects.

The estimation suggests that f.o.b prices are positively related to shipping costs at the (SITC-5) industry level. This implies that the “Washington apples” effect is partly due to exporters. 

---

7For some SITC-5 the “Washington apples” effect is violated both within and across HS-10 products. In some SITC-5 industries, when facing higher trade costs, firms switch to higher price varieties within HS-10 products, but switch across HS-10 codes in the opposite direction (from high-price to low-price ones).
switching across HS-10 products in response to higher shipping costs – the effect is also partly
due to exporters switching to high-price alternatives within an HS-10 category. Denote $\beta_s$ as
the elasticity of f.o.b unit price to shipping costs, when equation 2.3.11 is estimated specifically
for industry $s$ ($\beta_s = \left( \frac{\partial p_{\text{f.o.b}}(h)}{\partial f_{ji}(h)} \right)_{h \in s}$). I am interested in the relationship between $\beta_s$ and the
length of the markup ladder. For an SITC-5 industry consisting of many HS-10 products, I
calculate the markup ladder as the standard deviation of $\frac{1}{\sigma_{h} - 1}$ across HS-10 products, where
$\sigma_{h} - 1$ is the price elasticity of demand for HS-10 product $h \in s$.

$$\text{markup ladder}_s = \text{S.D.} \left( \frac{1}{\sigma_{h} - 1} \mid h \in s \right)$$

The markup ladder is longer for industries where some HS-10 products are highly-differentiated
and have a low price elasticity while some other HS-10 products have a high price elasticity
of demand. In response to high shipping costs, exporters switch from high-elasticity to low-
elasticity HS-10 products. To check whether or not this is the case, I plot $\beta_s$ against the length
of the markup ladder in figure 2.4.1. The resulting graph reveals a strong positive relationship
between the magnitude of the “Washington apples” effect – captured by $\beta_s$ – and the length of
the markup ladder in an industry. I also perform the following simple ordinary least square
(OLS) regression to further asses this relationship

$$\ln \beta_s = \varphi_1 \ln \text{markup ladder}_s + \varphi_2 + \epsilon_s$$  (2.4.2)

where $s$ denotes an SITC-5 industry. The results of the estimation are provided in table 2.9,
and correspond to a strong positive relationship between the length of the markup ladder in
an industry and the magnitude of the “Washington apples” effect.

### 2.5. Conclusion

This paper compliments the vibrant literature on trade costs. First, it develops a simple theory
of international transportation and illiterates how two different class of goods are subject to
different trade cost. Goods measure in units counts are subject to shipping costs (per count)
that are iceberg-like. Goods measure in units of kilogram, on the other hand, are subject to
shipping costs (per kilogram) that are a hybrid of iceberg and per-unit costs. The literature
has attribute the “Washington apples” effect to per-unit shipping cots – this is referred to as
Figure 2.4.1: The relationship between the length of the markup ladder in an SITC-5 industry and the magnitude of the “Washington apples” effect.

Table 2.9: Testing the markup ladder theory. The table reports OLS estimates of equation 2.4.2 – the relationship between the length of the quality ladder and the magnitude of the “Washington apples” effect.
the Alchian-Allen conjecture. This paper shows that even the “Washington apples” effect is observed for all goods. However, in contrast to what the Alchian-Allen conjecture would predict, the effect is stronger for goods measured in units of count – f.o.b price per count is strongly related to iceberg shipping costs per count. This implies that we need alternative theories to complement the Alchian-Allen conjecture. I test the alternative markup ladder theory developed by Lashkaripour [2014], and find strong empirical support for it in the US import data.
3. Quality, Taste and the Margins of World Trade

The value of trade depends on the number of goods traded, the quantity of each good that is shipped, and the prices they are sold for. While gravity equations are massively successful in explaining the value of trade, they do not provide much insight about the decomposition of trade. In this paper I develop a novel framework that provides, consistent with data, predictions about not only the value of trade but the composition of trade values. I relax the conventional assumption that consumers are identical, and allow for demand heterogeneity across consumers. I also allow for quality heterogeneity across varieties. The model explains the effect of distance and per capita income on trade along the intensive margin, the extensive margin and the price margin—all of which are well-documented in the empirical literature. It also provides a novel theoretical foundation for the higher price of tradables in developed countries. To further assess the model, I evaluate two predictions, of the model, regarding the price of traded goods and one prediction regarding the extensive margin of trade. The exercise confirms that all three predictions are borne out in the data. The model provides a framework to investigate the (across-consumer) distributional effects of trade liberalization. I show that, despite the aggregate gains, the poorest consumers experience losses in face of trade liberalization.

3.1. Introduction

For some time now trade literature has been exploiting supply side heterogeneity to explain patterns of international trade. Supply side heterogeneity has allowed models to match many additional facts that emerged with the availability of disaggregated trade data. On the flip side though, these models seem to ignore many empirical facts these data-sets provide about
the extensive and quality margins of trade. For instance no standard trade model provides a unified explanation for the following facts

i. Rich countries trade more intensively and extensively.

ii. Rich countries trade higher qualities

iii. Countries on average import less extensively but higher qualities from distant exporters.

iv. Individual firms selectively export higher qualities to distant markets.

v. Trade flows are absent among many country pairs and the probability of zero trade increases with distance between the two countries.

vi. Distance decreases the extensive margin of exports for a firm. It also shrinks the range of qualities a country exports within an industry\(^1\)

Various studies have tried to explain these facts individually; but have not provided a framework that captures all of them at once\(^2\). What these studies have in common is shutting down demand side heterogeneity and assuming that a representative consumer with CES utility is buying all the goods. By dropping the “representative consumer” assumption and allowing for interaction between demand and supply heterogeneity I provide a framework that explains all these facts in one unified model. My general equilibrium framework, provides predictions on four margins of trade: (1) Intensive margin, (2) Extensive margin, (3) Quality margin, and (4) Firm participation.

My model fits into a literature that assume flexible demand systems to model the international economy. One line of research starting with Flam and Helpman [1987] have incorpo-

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1. The two facts about rich countries trading more is documented by Hummels and Klenow [2005]. The facts on the extensive margin of trade are reported by Bernard, Jensen, Redding, and Schott [2007], using disaggregated firm level trade data. The positive relation between distance and the average unit value of exports has been documented by Baldwin and Harrigan [2011] among many others. They use product level US export data to demonstrate this relationship. Bastos and Silva [2010] show that this relationship holds very significantly even at the firm level. Using firm level Portuguese data they show every firm ships out on average higher quality goods to distant markets.

2. There is a long list of papers that have tackled each of these patterns independently. Fierer [2011] proposes a modified version of Eaton and Kortum [2002], that allows for different income elasticities of demand across goods. Her model explains why rich countries trade more intensively. To explain the extensive margin, trade models have usually interpreted the extensive margin as the number of firms. By associating each firm with one product they have tried to explain the extensive margin of trade (Chaney [2008]). Firm level data though shows that the patterns of extensive trade hold, even when looking at individual firms. The standard explanation in trade literature for the positive effect of distance on unit value is the Alchian-Allen effect. The effect assumes additive transportation costs and imposes some other restrictive assumptions on product substitutability. I show that the Alchian-Allen cannot explain the positive relation between unit value and distance in the US import data. Try to explain the relationship between distance and quality under the assumption of iceberg costs. To achieve this they develop a modified version of Melitz [2003] to specifically explain this positive relationship.
rated quality into their demand. Another line of trade models allow for non-homotheticity in demand (Fieler [2011] and Hunter (2001)). In these models each country is represented by one consumer, so there is only cross-country heterogeneity in demand. Faigelbaum et al. [2011] are one of the very few studies that allow for heterogeneity in demand across consumers within a country. They however shut down heterogeneity on the supply side. They also associate each firm with one particular variety-quality pair. Each firm produce it’s own variety that comes in only one quality. Their model therefore also shuts down trade on the extensive margin. The biggest draw back of their model is that they assume perfect complementarity between the differentiated and the homogeneous good. This assumption makes their model very tractable; but leaves it difficult if not impossible to estimate. The standard assumption in the nested logit demand models, which I also use, is imperfect substitutability between the differentiated and the homogeneous good. This assumption is widely used in the IO literature because it makes the demand system estimable.

The results of my model depend heavily on demand heterogeneity. My demand has a nested logit structure, which has been developed by McFadden et al. [1978] and Anderson, De Palma, and Thisse [1992] among others. On the supply side firms can differ technologically on the intensive and extensive margins. All firms in a country are identical in the cost of production but can produce a variety that is horizontally differentiated from others. Although varieties from the same country are substitutable to a degree; varieties from different countries are not. All firms can potentially produce all qualities. I model the cost of production similar to Flam and Helpman [1987]; but with a twist. Exporters have to pay extra to introduce a new quality to a foreign market. They also have to pay a sunk cost to enter the market. Exporters are disadvantaged compared to domestic firms along the three different margins. Along the intensive margin they incur iceberg costs. Along the extensive margin they are disadvantaged because of the extra cost they incur to introduce new qualities. Finally foreign firms have to pay a relatively higher sunk cost to enter the market.

The main property of my model, which I test using product level import data, is the dependence of taste on quality. Quality is a common valuation that consumers unanimously attach to a product. There is no difference among consumers in how they assess the quality of a product. Taste on the other hand is a value each consumer individually attaches to a variety. Different consumers can have very different tastes. In my model I assume that at higher qualities, goods are more differentiated in the eyes of the consumers. For example if a consumer is
buying an economy car he will most likely opt for the cheapest available variety. Because to
the consumer, economy cars are all very similar. However if the same consumer is buying a
luxury car with higher quality, he will care more about the brand, because varieties or brands
are more differentiated in the high quality market. The consumer might choose a relatively
more expensive luxury car from a German manufacturer, because he highly values the hor-
izontal attributes that only that brand or variety offers. This dependence of taste on quality
is the main building block of my theoretical model, and is also what I will estimate using US
import data.

In the first section I lay out my theoretical model. In my model exporters are price disad-
vantaged due to all the extra costs they incur. This disadvantage fades away as quality rises,
because consumers care more about the horizontal attributes each foreign variety offers. As a
result trade happens more intensively at higher qualities. Also at higher qualities firms charge
a higher markup due to varieties being more differentiated. The range of qualities a country
exports is affected by distance among many other things. As distance increase the range of
exported qualities becomes narrower. This happens at both tails. Distant countries don’t ex-
port the lower qualities because they are non profitable. The highest qualities are profitable
for the distant exporter; but are not affordable for the consumer. On the intensive margin the
distance disadvantage forces remote exporters to focus mostly on the highest qualities where
price disadvantages matter less.

In the second section, I show how variations in technology rank countries in terms of income
and the intensity, extent and quality of their imports/exports. In my model, the extensive
margin of trade is different from the number of firms. Each firm can export a broad range of
products with different qualities. My model though still provides patterns of firm participation
consistent with the data. Higher technology countries are richer and trade more on all the
margins. The intuition behind this result is that rich countries on average consume higher
qualities for two reasons: (1) They are less sensitive to price\(^3\) and (2) They can afford higher
qualities that poor countries cannot. Given that rich countries consume higher qualities their
demand is more dispersed over different varieties. Rich countries therefore end up importing
these different varieties from abroad. For rich countries, not only are the imports on average
higher quality; but they also include a broader range of qualities. Moreover, there are more

\(^3\) Rich countries are less sensitive to price of the homogeneous good because the price of the substitute good (the
homogeneous good) is higher in those countries.
firms exporting to the rich countries, and at the same time sales per firm are also higher.

I consider two extensions to my model. I first allow for variations in income across consumers in a country. I show that income heterogeneity affects the extensive margin of exports. I then consider a model in which the entry decision is made for each quality level independently. This setting makes firms from one country differ from one another in their export margins. The prediction of my model then matches the findings of Arkolakis and Muendler [2010]. Using Brazilian firm level data they find that, “Within destinations, there are few wide-scope and large-sales firms but many narrow-scope and small-sales firms.” In my model, the narrow scope firms are the high quality ones while the wide-scope firms specialize in lower qualities.

I finally provide some results on welfare gains from trade. I focus particularly on composition effects of trade. I show there can be aggregate losses from trade, when product differentiation doesn’t increase with quality at the same pace that production costs do. Opening up to trade creates room for high priced foreign varieties at the expense of cheaper domestic varieties. If these foreign varieties are not different enough from their domestic counterparts, opening up to trade results in an aggregate loss. My model also provides interesting insight into the distributional effects of trade. If consumers perceive varieties to be more differentiated at higher qualities then (as stated before) trade happens mostly at the higher end of the quality ladder. Foreign firms enter the market at the expense of some domestic firms leaving. The foreign firms though sell products that are too high quality for the poor consumers to afford. Poor consumers basically loose domestic varieties without gaining anything from foreign firms entering the market. Rich consumers on the other hand gain more than average from trade liberalization. If product differentiation was less at higher qualities, trade would happen at the lower end of the quality ladder, and poor consumer will be ones who gain the most.

3.2. Theory

In this section I develop a GE model where demand side and supply side heterogeneity coexist. On the supply side countries are different along two margins of production: (1) The quality margin and (2) the extensive margin. On the demand side Countries are different in terms of sensitivity to prices. Within each country consumers are different in terms of their
taste for different varieties. The world consists of $N$ countries, where I denote the set of countries by $C = \{1, 2, ..., N\}$. There are two types of good: (1) A differentiated good which is traded and (2) A homogeneous good which is non-traded. The differentiated good is differentiated along two dimension (1) quality (vertical dimension) and (2) variety (horizontal dimension). Quality is a common value all consumers attach to a good. There is no variation among consumers in how they perceive the quality of a good. Taste on the other hand is the value a consumer attaches individually to horizontal attributes of a variety. Every consumer only consumes “one unit” of the differentiated good, and spends the rest of his income on the homogeneous product. The consumer utilizes from the quality of the differentiated good and from the quantity of the homogenous good.

As for the firms I assume that in every country $j \in C$, there is a large pool of potential entrants that produce the differentiated good. More importantly each country has it’s own specific variety of the differentiated good that only firms in that country can produce. So the set of varieties is equal to the set of countries. Both types of goods are produced with labor alone. The marginal cost of producing the differentiated good is

$$MC^d_j(q) = w_j c_j(q)$$

Where $c_j(.)$ is some country specific (increasing) cost function that takes values greater than one (i.e. the differentiated good is always more costly to produce than the homogeneous good). All firms in country $j$ can potentially produce variety $j$ in all quality levels $q \in Q = [0, q^H]$. There is only one unit of labor required to produce the homogenous good and therefore the marginal cost of producing the good is equal to wage

$$MC^z_j = w_j$$

Market structure is monopolistic competition for the differentiated good and perfect competition for the homogeneous good. Each country (say $i$) is populated with a mass $(N_i)$ of households. Every household in country $i$ is endowed with $\mu_i$ units of effective labor.\(^4\)

---

\(^4\)Later I drop this assumptions and allow for a distribution of income along the continuum of households in every country.
3.2.1. Demand

The utility function for consumer \( h \) in country \( i \) for a variety \( j \) with quality \( q \), is given by

\[
u_{j,q}^h = z + q + \epsilon_{j,q}^h
\]

Where \( z \) is the amount consumed of the homogeneous good. From the consumer’s budget constraint this will be equal to

\[
z = \frac{\mu_i w_i - p_{j}^i(q)}{p_z^i}
\]

\( p_z^i \) is the price of the homogenous good in country \( i \). \( p_{j}^i(q) \) is the price of variety \( j \) good with quality \( q \), in country \( i \). The notation I’m going to follow is denoting the exporter in the subscript and the importer is indexed in the superscript. Since the market for the homogeneous good is perfectly competitive then \( p_z^i = w_i \), where \( w_i \) is wage in country \( i \). Plugging the budget constraint into the utility function we will have

\[
u_{j,q}^h = \alpha \mu_i - \frac{\alpha}{w_i} p_{j}^i(q) + q + \epsilon_{j,q}^i
\]

The above utility function allows for cross country variations in price sensitivity. In Richer countries where wages are higher consumers are less sensitive to price. \(^5\) Since \( \alpha \) and \( w_i \) are not separately identified, I normalize \( \alpha \) to one. The term \( \epsilon_{j,q}^i \) captures the effect of individual taste. Consumers draw their taste independently from a GEV distribution with dissimilarity parameter \( \theta(q) \)

\[
G_\epsilon(\epsilon) = e^{\int_{\epsilon_q \in Q} \left( \sum_{j \in \epsilon_q} -\epsilon_j / \theta(q) \right) \theta(q) dq}
\]

\( \theta(q) \) measures the degree of heterogeneity in preferences over different varieties at quality \( q \). The greater is \( \theta(q) \), the smaller is the correlation between \( \epsilon_j \) and \( \epsilon_k \) for varieties \( j \) and \( k \) at quality level \( q \). therefore the greater \( \theta(q) \) the greater are the perceived differences among the various varieties with quality \( q \). I assume that the dissimilarity parameter is itself a function of \( q \), meaning that differentiation among varieties could be different at different qualities.\(^6\)

---

\(^5\)This assumption is not unpopular in the IO literature; but is implemented in a very mechanical fashion and by assuming \( \alpha \) to be function of income. For example Morey and Waldman [1998] and Goolsbee and Petrin [2004] make this assumption in their models.

\(^6\)Fajgelbaum et al. [2011] assumes \( \theta \) is increasing in quality.
Assuming taste is GEV distributed, my demand system now has a nested logit structure, where products are nested first by quality and then variety (Figure 2). Define $\delta_i^j(q) = \alpha \mu_i - \frac{\alpha}{w_i} p_i^j(q) + q$ as the common utility all consumers attain from consuming variety $j$ at quality $q$. McFadden et al. [1978] shows that, with $\varepsilon_{i,j,q}$ distributed according to a GEV, the fraction of individuals who choose variety $j$ with quality $q$ is given by

$$
\rho_j^i(q) = \rho_{j|q} \cdot \rho_q^i
$$

Where

$$
\rho_{j|q}^i = \frac{\left( n_j^i \right)^{\theta_2} e^{\delta_j^i(q)/\theta(q)}}{\sum_{k \in J_q} \left( n_k^i \right)^{\theta_2} e^{\delta_k^i(q)/\theta(q)}}
$$

Is the fraction of consumers in country $i$ that buy variety $j$ given that they purchase a differentiated product with quality $q$. $J_q^i$ is the set of all available varieties in country $i$ at quality level $q$ (i.e. $J_q^i$ is the set of countries that supply there differentiated good in country $i$ at quality level $q$). $n_j^i$ is the number of firms from country $j$ exporting to country $i$. $\theta_2$ captures dissimilarity among the country specific varieties that are produced by different firms from that country. if one assumes $\theta_2 = 0$ then the firms from country $j$ -for instance-all produce the same product in the eye of the consumer. $\rho_j^i$ is the share of consumers choosing quality $q$, and is given by

$$
\rho_q^i = \frac{\left\{ \sum_{k \in J_q^i} (n_k^i)^{\theta_2} e^{\delta_k^i(q)/\theta(q)} \right\}^{\theta(q)}}{\int_{\omega \in Q} \left\{ \sum_{k \in J_q^i} (n_k^i)^{\theta_2} e^{\delta_k^i(\omega)/\theta(\omega)} \right\}^{\theta(\omega)} d\omega}
$$

Here I would like to emphasize once again that superscripts are used to determine the country that is buying the good, while the subscript is mostly used to denote the country that is selling the good.

3.2.2. The Firm’s problem

In the previous section I characterized demand for a variety-quality pair. From that I can calculate the market share absorbed by each individual firm from country $j$ as $\rho_j^i(q)/n_j^i$. Firms in country $j$ are technologically identical. Every firm decides on (1) The set of qualities they are willing to sell in country $i$: $Q_{ij} \subset Q$, and (2) The price they charge at every quality in country $i$: $p_j^i(q)$. Exporting firms pay extra costs on three margins compared to domestic firms:
Figure 3.2.1: The nesting structure of the nested logit model.

i. The intensive-quality margin: iceberg cost $\tau_{ij}$

ii. The Extensive margin: A country $j$ firm has to employ $f_{ext}^j$ units of labor from country $i$ to introduce a new quality to that market.

iii. Sunk cost: Every potential exporter in country $j$ has to also pay a (once and for all) Sunk cost $w_f$ to enter market $i$.

Due to the iceberg costs, the marginal cost of producing one unit of the differentiated good for market $i$ will be $w_j \tau_{ij} c_j(q)$. The total profits made by a country $j$ firm exporting variety $j$ in qualities $q \in Q_{ij}$ to country $i$ will be given by

$$\Pi_j^i = \int_{q \in Q_{ij}} \left( [p_j^i(q) - w_j (\tau_{ij} c_j(q))] \frac{\rho_j^i(q)}{n_j} N_i - w_i f_{ext}^j \right) dq - w_i f$$

I define the profit density function as $\pi_j^i(q) = [p_j^i(q) - w_j \tau_{ij} c_j(q)] \frac{\rho_j^i(q)}{n_j} N_i - w_i f_{ext}^j$. The overall profits of a country $j$ firm from exports to country $i$ will therefore become

$$\Pi_j^i = \int_{q \in Q_{ij}} \pi_j^i(q) dq - w_i f$$

Prices are set independently for every quality. The firm therefore sets price $p_j^i(q)$ by maximizing the profit density at every quality level separately

$$Max_{p_j^i(q)} \pi(q; p_j^i(q))$$
The above maximization problem will yield a quality dependent markup over their marginal cost\(^7\)

\[
\frac{\partial \pi^i_j(q; p^i_j)}{\partial p^i_j} = 0 \implies p^i_j(q) = w_j \tau_{ij} c_j(q) + w_i \theta(q)
\]

Firms charge higher markups when \(w_i\) is higher because consumers are less sensitive to price. They charge higher markup when \(\theta(q)\) is larger because there product is more different from other varieties, giving them more monopolistic power. Plugging in the optimal price in the profit density function we can write the optimal profit density as

\[
\pi^i_j(q) = w_i \theta(q) \rho^i_j(q) N_i - w_i f^\text{ext}_j
\]

To make the model more tractable I assume the following functional form for \(\theta(q)\), and \(c_j(q)\)\(^8\)

\[
c_j(q) = e^{\gamma^j c q}
\]

\[
\theta(q) = e^{\gamma^\theta (q - q_H)}
\]

My assumption on the functional form of the cost function is similar to Flam and Helpman [1987]. In the above equations the subscript \(c\) refers to cost and the subscript \(\theta\) refers to the dissimilarity parameter. \(\gamma^j c\) can be interpreted as technology in producing quality in country \(j\). Countries with low \(\gamma^c\) have comparative advantage in producing higher quality goods. Another indicator of technology is \(f^\text{ext}_j\), which represents technology on the extensive margin. For the time being I shut down technological differences on the quality margin. I assume all countries are identical in terms of the f.o.b marginal cost they incur for producing the differentiated good

\[
\gamma^j c = \gamma^i c = \gamma^c \forall i, j \in C
\]

Under the above assumption comparative advantage on the intensive and quality margins is affected only by geography. The last assumption I will make in my model is that including the

\(^7\)More precisely \(p^i_j(q) = w_j \tau_{ij} c_j(q) + w_i \theta(q) \) \(1 - w_j \frac{\rho_{ij} (1 - \theta(q) [1 - \rho_{ij}])}{w_i} \) \(w_j \tau_{ij} c_j(q) + w_i \theta(q) \)

\(^8\)This assumption doesn’t really affect the results of this paper. For instance if one’s to assume an power functional form (e.g. \(c_j(q) = (q + 1)^{\gamma^c}\) and \(\theta(q) = \left( \frac{q}{q_H} \right)^{\gamma^\theta}\) the results of the paper will still follow.
transportation cost, the foreign variety is always more expensive than its domestic counterpart:

**Assumption 1.** For every country pair $i$ and $j$: $\tau_{ij} w_j > w_i$

Now that we know $\pi_j^i(q)$, we can determine $Q_j^i$ as the set of all qualities such that $\pi_j^i(w) > 0$. But before calculating the range of qualities firms export, we can draw comparison between different exporters based on their wages and distance to a market. In the following Lemma I show that a depending on $\gamma_\theta$ and $\gamma_c$, a distant exporter can have comparative advantage at either the high end or the low end of the quality ladder. If dissimilarity in taste grows faster with quality than the marginal cost ($\gamma_\theta > \gamma_c$), distant exporters will have comparative advantage in higher qualities. On the other hand if $\gamma_\theta < \gamma_c$, the comparative advantage for distant exporters will be in lower qualities.

**Lemma 3.1.** Consider a subset of qualities $Q' \subset Q$ along which the number of available varieties doesn’t change: $J_q^i = J_q'^i \ \forall q, q' \in Q'$, then

(i) If $\gamma_\theta > \gamma_c$: For every country $j \in J_q'^i$ with above average iceberg cost: $w_j \tau_{ij} > \sum_{k \in J_q'^i} w_k \tau_{ik} \cdot \rho_{k|q}'$, market share ($\rho_{j|q}'$) increases with quality and vice versa.

(ii) If $\gamma_\theta = \gamma_c$: For every country $j \in J_q'^i$, $\rho_{j|q}'$ is independent of $q$ on $Q'$.

(iii) If $\gamma_\theta < \gamma_c$: For every country $j \in J_q'^i$ with below average iceberg costs: $w_j \tau_{ij} < \sum_{k \in J_q'^i} w_k \tau_{ik} \cdot \rho_{k|q}'$, market share ($\rho_{j|q}'$) increases with quality and vice versa.

**Proof.** See Appendix 1. □

Bernard et al. [2007], among many others, report that exporters absorb a very small market share compared to domestic firms. Therefore it’s safe to assume that $\sum_{k \in J_q'^i} w_k \tau_{ik} \cdot \rho_{k|q}' \rightarrow \tau_{ii} = 1$. This assumption leaves all the exporters above the market average in terms of wage times iceberg costs. Lemma 1 then, tells us that if $\gamma_\theta > \gamma_c$, all exporters will have their market share rise with quality. In other words foreign firms will have comparative advantage in selling the higher quality goods. Moreover among the exporters, the distant ones are the most comparatively advantaged at higher qualities. This all results from the fact that products are more horizontally differentiated at higher qualities. Disadvantages in price faced by exporters are therefore less important in these so called high qualities. This pattern of comparative advantage seems to match what we absorb in trade data. To incorporate this pattern I make the following assumption which is critical to my results

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Figure 3.2.2.: The variation of the exporter’s market share with quality under three different cases.
Assumption 2. $\gamma_0 > \gamma_c$

The iceberg nature of transportation costs means that there magnitude will be bigger for higher quality goods with higher price. If iceberg costs were the only thing to set exporters apart from domestic sellers, then exporters will be worse off at the highest qualities. Assumption 2 assures that not only consumers value the horizontal aspects of a variety more as quality rises; but they value the horizontal aspects more to an extent that it outweighs the effect of the higher price associated with foreign varieties. The average quality of exports from country $j$ to country $i$ along the set $Q'$ is be given by

$$E_{ij}^Q(q) = \frac{\int_{q \in Q'} q \rho_j^i(q) dq}{\int_{q \in Q'} \rho_j^i(q) dq}$$

A direct result of lemma 1 is that among two countries exporting all the qualities in a given subset $Q' \subset Q$, the average quality of exports will be higher for the country with higher wage or iceberg costs.

**Corollary 3.1.** Consider a subset of qualities $Q' \subset Q$ such that $J_q = J_q'$ $\forall q, q' \in Q'$. For every $j, t \in J_{Q'}$ if $w_j \tau_{ij} > w_i \tau_{it}$ then $E_{ij}^Q(q) > E_{it}^Q(q)$.\(^9\)

The above corollary compares two exporters only on the intensive margin of quality. But exporters differ on the extensive margin of quality (i.e. they export a different set of qualities), and to compare average quality of exports both margins should be considered.

Given assumption 2, I can solve for the range of qualities firms export. Note that the profits of an exporter are proportional to both it’s market share and markup. As I showed in lemma 1, the conditional market share of exporters increase with quality, because consumers put more emphasis on taste compared to price when shopping for higher qualities. The markup an exporter charges in country $i$ is $w_i \theta(q)$ which also increases with quality. These two channels make the profits of an exporting firm, increasing in quality.

**Lemma 3.2.** Consider a subset of qualities $Q' \subset Q$ such that $J_q^i = J_q^j$ $\forall q, q' \in Q'$ (The set of available varieties in $Q'$ does not change) then $\pi^j_i(q)$ is increasing on $Q'$ for all exporting countries in $J_{Q'}^i$.

**Proof.** See Appendix 1
Figure 3.2.3: The variation of profits with quality. Total profits are the area underneath the profit curve.

Firms will export every quality for which the profit density is positive

\[ Q_j^i = \{ q \in Q \mid \pi_j^i(q) > 0 \} \]

Given that the profits are increasing in quality and \( \pi_j^i(0) < 0 \ \forall j \); there is a zero profit cut-off quality, above which firms are willing to export. Also variety \( j \) at the highest quality might not be not affordable to consumers in country \( i \). Only qualities for which \( p_j^i(q) = w_j \tau_j c(q) + w_i \theta(q) < \mu w_i \) will be bought. Every firm in country \( j \) therefore exports qualities \( Q_j^i = [q_j^{ij}, \bar{q}_j^{ij}] \) to country \( i \). Where \( q_j^{ij} \) is the zero profit cut-off quality

\[
\pi_j^i(q_j^{ij}) = w_i \left\{ \frac{\rho_j^i(q_j^{ij})}{n_j^i} N_i \theta(q_j^{ij}) - f_j^{ext} \right\} = 0
\]
and $\bar{q}_{ij}$ is the affordability cut-off quality for variety $j$ in country $i$:

$$\mu w_i = w_j \tau_{ij} c(\bar{q}_{ij}) + w_i \theta(\bar{q}_{ij})$$

Figure 4 demonstrates a simple case of increasing profits when only three countries (Namely countries 1, 2 and 3) export to country $i$. Note that all firms in these countries are identical and the profit function is the same for all of them. Suppose $\tau_{i1} < \tau_{i2} < \tau_{i3}$. As we move up along the quality ladder, country 1 firms are the first to experience positive profits. Therefore country 1 exports lower qualities that are non-profitable for firms in the other two countries. Country 2 firms start making positive profits at qualities above $q_{i2}^{i2}$. As firms from country 2 enter the market all at once, demand and therefore profits for country 1 firms drop discretely. Profits keep increasing with quality; but consumers stop buying a variety after some point because they cannot afford it. Country 3 which incurs the highest iceberg costs, and was the last to make positive profits along the quality ladder will be also the first to surpass the affordability cut-off and be eliminated from the market. This happens at quality $\bar{q}_{i3}$ and as a result the remaining exporters experience a sudden jump in their profits. As one can see the set of qualities a country exports, shrinks with distance. So if we order exporters to $i$ in terms of their iceberg costs: $\tau_{iN} > \tau_{iN-1} > \ldots > \tau_{i1}$, then

$$Q_{iN} \subset Q_{iN-1} \subset \ldots \subset Q_{i1}$$

Not only the range of exported qualities shrinks with distance; but it shrinks at both ends (Figure 5). The distant exporters do not export neither the lowest nor the highest qualities. As the set of exported qualities shrinks with distance, it eventually disappears for some exporters. Country $k$ does not export to country $i$ at all if $\bar{q}_{ik} < q_{ik}^{i2}$. In my model $q_{ik}^{i2}$ comes out of the zero profit condition and $\bar{q}_{ik}$ comes from the consumers’ budget constraint. So a novel result of my model is capturing the zeros without imposing any restrictive condition on the set of available goods.

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10 Another aspect of this model which I would also like to explore in further detail is that there is a higher probability of occurrence of zero trade flows when either the population $N_i$ or the per capita income $y_i$ of the home country decrease.
3.2.3. Trade Equilibrium

In this section I will characterize the equilibrium conditions. First there is a set of country specific parameters that characterize a country $i$

$$\Gamma_i = \{ \gamma_i, \{ \tau_{ij} \}_{j \in C}, N_i, f_i^\text{exp}, \mu_i \}$$

The set of universal parameters are

$$\Theta = \{ \alpha, \gamma, f, q^H \}$$

The wages: $\{ w_i \}_{i \in C}$, the quality cut-offs: $\{ q^{ij} \}_{i,j \in C}$ and $\{ \bar{q}_{ij} \}_{i,j \in C}$, and the number of firms from country $j$ entering market $i$: $\{ n^i_j \}_{i,j \in C}$, are endogenous variables. They come out of the labor market clearing condition (LMC)$^{11}$, the zero profit cut-off condition (ZP), the affordability cut-off condition (AC) and the free entry condition (FE)

$$\sum_{j \neq i} w_j \tau_{ij} \int_{q^{ij}}^{\bar{q}_{ij}} c(q) \rho_j^i(q) dq = \sum_{j \neq i} N_j w_i \tau_{ji} \int_{q^{ij}}^{\bar{q}_{ij}} c(q) \rho_j^i(q) dq \quad (\text{LMC})$$

$$\frac{\rho_j^i(q^{ij})}{n_j^i} N_i \theta(q^{ij}) = f_j^\text{ext} \quad (\text{ZP})$$

$$\mu w_i = w_j \tau_{ij} c(\bar{q}_{ij}) + w_i \theta(\bar{q}_{ij}) \quad (\text{AC})$$

$$\int_{q^{ij}}^{\bar{q}_{ij}} \left\{ \theta(q) \frac{\rho_j^i(q)}{n_j^i} N_i - f_j^\text{exp} \right\} dq = f \quad (\text{FE})$$

The market for the differentiated good clears because demand per firm is $d_j^i(q) = \frac{\rho_j^i(q)}{n_j^i}$ and

$^{11}$The derivation of the (LMC) equation is provided in appendix 1.
\[ N_i \sum_{j \in C} n_j^i \int_{q \in Q^j} \frac{\rho_j^i(q)}{n_j^i} dq = N_i. \] The market for homogenous goods clears by Walras’ law. Now that we know the range of the exported qualities I can calculate the total volume of trade flows between countries. Recall that every consumer buys only one unit of the differentiated good, and therefore country \( i \) demands in total \( D_i = N_i \) units of the differentiated good. Breaking down the total demand in country \( i \), \( X_{ij} \) units of the differentiated good are imported from country \( j \) where\(^{12}\)

\[ X_{ij} = N_i \int_{q^j} \rho_j^i(q) dq \]

The total quantity of differentiated goods imported by country \( i \) from various destinations is therefore equal to \( X_i = \sum_{j \neq i} X_{ij} \). The average quality of exported goods from country \( j \) to country \( i \) is now

\[ \tilde{q}_{ij}^{avg} = \frac{\int_{q^j} \tilde{q}_{ij} \rho_j^i(q) dq}{\int_{q^j} \rho_j^i(q) dq} \]

The average quality of exports depends on wage and technology in the exporting country, distance to the importer and the wage or income of the importer. There is variation across exporters in the quality, quantity, and range of exports. Also there is variation across countries. I already have showed distant exporters export a narrower range of qualities. In the next proposition I will also show that distant exporters on average export higher qualities and lower quantities. Moreover, the number of exporting firms declines with distance.

**Proposition 3.1.** Suppose countries are ranked according to their distance to market (country) \( i \): \( \tau_{iN} > \tau_{iN-1} > \ldots > \tau_{i1} \) then

(i) \( X_{i1} > X_{i2} > \ldots > X_{iN} \)

(ii) \( Q_{iN} \subset Q_{iN-1} \subset \ldots \subset Q_{i1} \)

(iii) \( n_1^i > n_2^i > \ldots > n_N^i \)

(iv) if \( \mu > 1 + \frac{\tau_{i1}w_j c(q^H)}{w_i} \) \( \forall j \) then \( q_{iN}^{avg} > q_{iN-1}^{avg} > \ldots > q_{i1}^{avg} \)

\(^{12}\)Assuming \( \gamma_\theta = 0 \) then the gravity can be written as:

\[ X_{ij} = N_i \sum_k e^{-w_j \tau_{ik}/w_i \theta} \left( 1 - \Phi^j(q^{ij}) \right) \]

Where \( \Phi^j \) is the CDF of demand for quality in country \( i \).
Figure 3.2.5: The variation of profits with quality when the set of qualities is bounded from above. Total profits are the area underneath the profit curve.

Proof. See Appendix 1.

The condition \( \mu > 1 + \frac{\tau_{jj} w_j}{w_i} c(q^H) \forall j \) implies that all varieties are affordable at the highest quality. This assumption guarantees that the range of exported qualities shrinks only at the low end. This ensures that distant exporters will only export the highest qualities. Figure 6 demonstrates a simple case of 2 exporters when \( \mu \) is large and all qualities are affordable. The distant exporter (from country 2) doesn’t export (only) the lowest qualities because they are not profitable.\(^{13}\) Proposition 4 implies that trade mostly happens at the higher end of the quality ladder where consumers are less price sensitive. If I had allowed for cross-country variation in technology the story might have been different; but the intuition would have been the same. In a world where some exporters had price advantage due to technology, they will make the most out their advantage by selling low qualities—which are less differentiated. In my model though, exporters have price disadvantage because of all the additional export costs. They however partially overcome this disadvantage by exporting high qualities.

As pointed out before wage in country \( i (w_i) \) is endogenously determined by the parameters of the model. What is interesting, is to see how changes in wage due to exogenous shocks will affect imports. There are two sources of cross-country variation in the model; the fixed

\(^{13}\text{Dropping the assumption that every quality is affordable will still enable us to generate the same ranking of export quality among exporters, under some other restrictions. In Appendix 1, I show when I relax this assumption, but make total demand be decreasing in quality; distant countries will still export higher qualities.}\)
cost paid on the extensive margin: \( f_{i}^{ext} \) and the geographical location: \( \{\tau_{ij}\}_{j \in C} \) both of which affect wage/income. Wage in turn will have a secondary effect on the quantity and quality of trade. This indirect secondary effect of wage on imports, is what I call the “income effect” on the imports. The income effect is basically “an increase in imports resulting (indirectly) from an increase in wage”. Country \( i \)’s total imports \( X_i \), are a direct function of the exogenous parameters \( \{\Gamma_j\}_{j \in C} \) and \( \Theta \). It’s also an Indirect function of the endogenous variables of the model

\[
X_i = X_i(\{w_j, n_j^i, Q_j^i\}_{j \in C}; \{\Gamma_j\}_{j \in C}; \Theta)
\]

From the implicit function theorem a change in \( f_{i}^{ext} \) for instance, will affect \( X_i \) according to the following equation:

\[
\frac{dX_i}{df_{i}^{ext}} = \frac{\partial X_i}{\partial f_{i}^{ext}} + \frac{\partial X_i}{\partial w_i} \frac{dw_i}{df_{i}^{ext}} + \sum_j \frac{\partial X_i}{\partial n_j^i} \frac{dn_j^i}{df_{i}^{ext}}
\]

What I denote here as the “income effect” on imports, is simply the term \( \frac{\partial X_i}{\partial w_i} \) in the above equation. “Income effects” are key to the results of my model with regard to rich countries trading more. To predict the direction of income effects, note that the richer a country becomes, demand in that country shifts towards higher qualities. The outcome of this shift in demand would be a larger portion of the households demanding foreign varieties. Why? because at higher qualities horizontal differentiation matters more and there is a higher share of consumers preferring the more expensive foreign varieties. Consumers are willing to pay a price premium for variety specific horizontal attributes. It’s straightforward to show that the income effect on total demand – \( \rho_{q}^i \) – is positive for above average qualities and negative for lower qualities

\[
\frac{\partial \rho_{q}^i}{\partial w_i} = \left\{ AC_i(q) - \int_{\omega} AC_i(\omega) \rho_{\omega}^i d\omega \right\} \frac{\rho_{q}^i(q)}{w_i n_j^i}
\]

Where \( AC_i(q) = c(q) \sum_{k \in J} w_k \tau_{ik} \rho_{kl}^i \) is the average marginal cost of all varieties at quality level \( q \). According to the above inequality an differential increase in \( w_i \) will increase demand in country \( i \), for all qualities \( q > \tilde{q}_i \), where
The main reason demand shifts towards higher qualities as income increases, is that consumers’ sensitivity to price goes down. There is another channel through which, demand discretely shifts towards high qualities. With a rise in income consumers can afford a new set of quality-varieties that were unaffordable before. As a result a portion of them will move from lower quality varieties to the now affordable high quality varieties. At the same time income effects on conditional demand for foreign varieties are also positive

\[
\frac{\partial \rho_{j|q}/n_j^i}{\partial w_i} = \left( w_j \tau_{ij} - \sum_k w_k \tau_{ik} \rho_{k|q}^i \right) \frac{c(q)}{w_j^i \theta(q)n_j^i} \rho_{j|q}^i \approx (w_j \tau_{ij} - w_i) \frac{c(q)}{w_j^i \theta(q)n_j^i} \rho_{j|q}^i > 0
\]

Again this happens because as income increases consumers become less sensitive to price. I already showed that for exporters conditional market share \((\rho_{j|q}^i)\) increases with quality. What the above equations tell me is that and increase in income, shifts demand towards both higher qualities and foreign varieties. Since total demand is fixed and demand adjusts itself only on the variety and quality margins, It follows that income effects are positive on total demand for foreign goods, and negative on total demand for domestic goods

\[
\frac{\partial X_i}{\partial w_i} > 0
\]

The income effect only provide us with an intuition about the channel through which income affects trade. In equilibrium though any change in income is followed by changes in the number of entering firms and the range of traded qualities. The following proposition shows within a GE setting; how differences in the cost of expanding the quality margin, rank countries in terms of income, quality, quantity and range of imports/exports. Countries that have an advantage in expanding their quality margin, not only trade more intensively and extensively; but also trade higher qualities. The main channel through which these variations in income and trade happen are the so-called “income affects”.

**Proposition 3.2.** Consider countries \(i\) and \(j \in C\) that are identical in everything except for country \(j\) being more efficient in introducing new qualities to foreign markets: \(\{\gamma_c^i, \{d_{ik}\}_{k \in C}, N_{\mu_i}^j\} = \)
\( \{ \gamma_j, \{ d_{ik} \}_{k \in C}, N_j, \mu_j \} \) and \( f_i^{ext} < f_i^{ext} \) then

(i) Country \( j \) is richer than country \( i \): \( w_j > w_i \)

(ii) Country \( j \) imports in total more than country \( i \): \( X_j > X_i \)

(iii) Country \( j \) imports in total higher qualities than country \( i \): \( q_j^{avg} > q_i^{avg} \)

(iv) High quality exporters (Exporters that export only above average qualities: \( c(q_j^{ik}) > c(\bar{q}_j) \)) export a broader range of qualities to country \( j \).

Proposition 5 tells us that in a technologically heterogeneous world, the more efficient countries are richer and trade more on all four margins. The intuition behind the proof of Proposition 5 is that in the \((LMC)\) equation below, an increase in \( f_i^{ext} \) will drag down the right hand side (value of exports)

\[
N_i \sum_{j \neq i} \frac{w_j}{w_i} \int_{q_i^j}^{q_j^i} c(q) \rho_j^i(q; \frac{w_j}{w_i}) dq = \sum_{j \neq i} N_j \tau_{ij} \int_{q_i^j}^{q_j^i} c(q) \rho_j^i(q; \frac{w_j}{w_i}) dq \quad (LMC)
\]

It’s worth mentioning that what matters in my model is the relative and not absolute wage of country \( i \). Now given that the right hand side is increasing in \( \{ \frac{w_j}{w_i} \}_{j \neq i} \) and the left hand side is decreasing in \( \{ \frac{w_j}{w_i} \}_{j \neq i} \); the relative wage of country \( i \) will drop so that the equilibrium condition will be satisfied again. A similar argument can be made about the effect of labor.\footnote{The reason a country comparatively advantaged in expanding the extensive margin of its exports, also imports more intensively is that wages will be relatively higher there. As a result, households will be more rich and will demand more variety, some of which has to come from abroad.}

Proof. See Appendix 1. \( \square \)

The above proposition provides a set of results regarding the exports being more intensive and extensive in the technologically advantaged countries which also turn out to be richer. More specifically, in my model trade adjusts on Four margins:

i. The intensive margin

ii. The number of firms

iii. The extensive margin

iv. The quality margin
endowment \( \mu \) on relative wages and the different margins of trade. Consider two identical countries so that they start off with the same wage in equilibrium \( \{ \frac{w_j}{\mu_j} \}_{j \neq i} = \{ \frac{w_i}{\mu_i} \} \). Suppose we slightly increase the endowment of effective labor per individual in country 2 such that \( \mu_2 > \mu_1 \). Country 2 will now be able to afford qualities and varieties that are unaffordable by the country 1 (\( \overline{q}_{ij} > \overline{q}_{2j} \forall j \)). On the intensive margin though because of the quasi-linear nature of my utility function, \( \mu \) has no direct effect on demand: \( \frac{\partial u_i(q)}{\partial \mu} = 0 \). The addition of new qualities will partially shift the demand from low qualities to high qualities, and from the domestic variety to the now affordable high quality foreign varieties. Therefore the left hand side of the \((LMC)\) equation (c.i.f value of imports) increases with \( \mu \) for country 2. For the \((LMC)\) equation to hold again, \( \{ \frac{w_j}{\mu_j} \}_{j \neq i} \) should also increase. An increase in the wages in the rest of the world relative to country 2 will drag up the right hand side (c.i.f value of exports) of the \((LMC)\) equation. In the new equilibrium country 2 will have a lower relative wage; and will be exporting more. This implies that despite the higher relative wage in foreign countries, country 2 is also importing more. This is only possible if households in country 2 are now richer: \( \mu_2 w_2 > \mu_1 w_1 \). So again the country with the higher income (country 2) will be trading more.

**Corollary 3.2.** Consider two identical countries \( i \) and \( j \in C \), that differ only in the skill intensity of workers: \( \mu_j < \mu_i \) (individuals in country \( j \) are endowed with more effective labor) and \( \{ \gamma^i_c, \{ d_{ik} \}_{k \in C}, N_i, f^\text{ext}_i \} = \{ \gamma^j_c, \{ d_{ik} \}_{k \in C}, N_j, f^\text{ext}_j \} \), then

(i) Country \( j \) has higher income per individual: \( \mu_j w_j > \mu_i w_i \)

(ii) Country \( j \) has lower wages: \( w_j < w_i \)

(iii) Country \( j \) trades more: \( X_j > X_i \)

**Income variation across households**

In this section and before exploring the welfare implications of my model I will like to allow for the labor endowment to vary across the Household’s in a country, which will in turn give

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15This happens because \( \rho^i_{j|w} \) is increasing in quality for exporters and decreasing for domestic sellers, and a shift in demand towards high qualities in turn results in a shift towards foreign varieties.

16An increase \( \{ \frac{w_i}{\mu_i} \}_{j \neq i} \) drags down imports for two reason: 1) the foreign variety becomes relatively more expensive 2) as wages in country 2 go down consumers become more sensitive to price and will opt for cheaper domestic varieties.
rise to income variations across the population. Suppose effective labor endowment in country $i$ is distributed according to $G^i(\mu)$. The demand for variety $j$ in quality $q$ is now given by

$$\rho^*_j(q) = E_\mu [\rho^*_j(q; \mu)]$$

Relative demand for foreign varieties in every quality level $\rho^*_{ij}(q)$ doesn’t depend on $\mu$. However, the probability of a consumer going for quality $q$ depends on their labor endowment, because the higher the $\mu$ the larger the set of affordable qualities and therefore the more diverse consumers’ choices of quality. In particular, every quality consumed with probability $\rho^*_j(q)$ by consumers of lower income will be consumed with a lower probability $\rho^*_{ij}(\mu_2) < \rho^*_{ij}(\mu_2)$ by higher income consumers ($\mu_2 > \mu_1$). Then there are high qualities that low income consumers cannot afford ($\rho^*_{ij}(\mu_1) = 0$); but they are consumed by the high income consumers: $\rho^*_{ij}(\mu_2) > 0$. The profits are now increasing and then decreasing in quality until they turn into losses at the highest qualities. In particular the profit density of a firm exporting variety $j$ to country $i$ is given by

$$\pi^*_j(q) = \int_{\mu^{ij}(q)}^{\mu^{ii}(q)} [p^*_j(q) - \tau_{ij} w_j c(q)] \rho^*_j(q) N_i g(\mu) d\mu = [p^*_j(q) - \tau_{ij} w_j c(q)] \rho^*_j(q) (1 - G(\mu^{ij}(q)))$$

Where $\mu^{ij}(q) w_i = p^*_j(q)$ is lowest endowed required for purchasing quality $q$ from country $j$. The markup by the exporter is still equal to $w_i \theta(q)$ and therefore the profit density is

$$\pi^*_j(q) = w_i E_\mu \left[ \theta(q) \rho^*_j(q; \mu) \left( 1 - G(\tau_{ij} \frac{w_j}{w_i} c(q) + \theta(q)) \right) \right] = w_i \theta(q) \rho^*_j(q) \left( 1 - G(\tau_{ij} \frac{w_j}{w_i} c(q) + \theta(q)) \right)$$

At $q = 0$ the profits are still increasing and negative and they are decreasing and negative at the highest affordable quality ($\hat{q}_{ij}$).

$$\frac{d\pi^*_j(\hat{q}_{ij})}{dq} = \frac{d}{dq} \left\{ w_i \theta(\hat{q}_{ij}) \rho^*_j(\hat{q}_{ij}) \right\} \left( 1 - G(\tau_{ij} \frac{w_j}{w_i} c(\hat{q}_{ij}) + \theta(\hat{q}_{ij})) \right) + w_i \theta(\hat{q}_{ij}) \rho^*_j(\hat{q}_{ij}) \frac{d}{dq} \left( 1 - G(\tau_{ij} \frac{w_j}{w_i} c(\hat{q}_{ij}) + \theta(\hat{q}_{ij})) \right)$$

The above inequality follows directly from the fact that $1 - G(\tau_{ij} \frac{w_j}{w_i} c(\hat{q}_{ij}) + \theta(\hat{q}_{ij})) = 0$. 

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and \( \frac{d}{dq} \left\{ 1 - G(\tau_{ij} \frac{w_j}{w_i} c(\hat{q}_{ij}) + \theta(\hat{q}_{ij})) \right\} < 0. \) Also note that \( \frac{d^2 \pi_j}{dq^2} < 0 \ \forall q \) and therefore the mean value theorem implies that profits are non-negative in the quality range \([\hat{q}_{ij}, \bar{q}_{ij}]\) and negative elsewhere. So unlike the previous section the affordability cut off plays no direct role and firms export whatever quality that provides them with positive profits. Since foreign goods are more expensive, and there is variation in the purchasing power of consumers, there is variation across consumers in how much foreign goods they demand. This variation of demand for goods across consumer would lead to variations in gains from trade across consumers as will be shown in the next section. Depending on the behavior of \( \theta(q) \) in some cases lower income consumers can loose from trade while in some others it’s the rich consumers that can loose. Also in some situations the entire economy can loose from the compositional effect of trade.

**Entry and specialization by quality**

In the previous sections I assumed that every firm that enters has to pay a sunk cost and then incur some additional cost to expand the set of goods it exports. Another way of putting firm entry is to allow for firms to enter a market to supply only specific qualities\(^{17}\). Firms enter the

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\(^{17}\)This assumption is made by Fajgelbaum et al. [2011], and the only issue with assuming entry by quality is the possibility of one or few firms being the only active firms at a given quality level undermining the assumption of monopolistic competition.
market until all profits are absorbed at quality level $q$, so production per firm from country $j$ at quality level $q$ selling in country $i$ is given by

$$d_{ij}^*(q) = \frac{f_{ij}^{ext}}{\theta(q)} = \frac{\rho_{ij}^*(q)}{n_{ij}^*(q)}$$

Where demand is the same as before except for the fact that $n_{ij}^*$ depends on quality

$$\rho_{ij}^*(q) = \frac{\left(n_{ij}^*(q)^{\theta^2} e_{ij}^*(q)^{/\theta(q)}\right)^{\theta(q)}}{\sum_{k \in J_i^L} \left(n_{ik}^*(q)^{\theta^2} e_{jk}^*(q)^{/\theta(q)}\right) \left(\sum_{k \in J_i^L} \left(n_{ik}^*(q)^{\theta^2} e_{jk}^*(q)^{/\theta(q)}\right)\right)^{\theta(q)}}$$

Given that fixing the number of exporters from country $j$ will yield increasing profits in quality, a straightforward implication of that is the number of active foreign firms in country $i$ increases with quality if I allow for entry by quality. On the other hand the per firm production equation tells us that sale per firm drop with quality. In other words the higher quality portion of the market is populated with many firms that sell little; while the lower quality end of the market is populated with less firms that mass-produce (Figure 8). The pattern shown in figure 8 is in line with findings of Arkolakis and Muendler [2010]. Using Brazilian firm level data they find that “Within destinations, there are few wide-scope and large-sales firms but many narrow-scope and small-sales firms.”

Welfare Analysis

To calculate gains from trade, I will look at changes in welfare when moving from the autarky equilibrium to the trade equilibrium by lowering iceberg costs in a symmetric world where all countries are identical. Therefore in every equilibrium $w_j = w_i \forall i, j \in C$ which shuts down the possibility of gains from increase in relative wage when going from the autarky equilibrium to the trade equilibrium. I will also assume entry by quality to make the analysis more tractable.
I will first characterize absolute gains, and then provide insight into distributional gains from trade in my model. As McFadden (1978) has shown, the average welfare of consumers in country $i$ can be represented by

$$V_i(w^i) = \int_{q \in Q} \left[ \sum_k n_k^i(q) \theta_2 e^{(\mu - \frac{w_k q}{w_i} c(q) - q)/\theta(q)} \right]^{\theta(q)} d\omega = e^{\mu - 1} \int_{q \in Q} \left[ \sum_k n_k^i(q) \theta_2 e^{-\frac{w_k q}{w_i} c(q) + q}/\theta(q) \right]^{\theta(q)} d\omega$$

I allow autarky to be the state in which $\tau_{ij} \to \infty \forall i \neq j \in C$. In autarky there is no trade because export profits are always negative due to the high fixed costs. As we lower iceberg costs the change in welfare will be given by

$$dV^i/V^i = e^{\mu - 1} \left\{ \int_{q \in Q} \sum_k \theta_2 \theta(\omega) \frac{dn_k^i(q)}{n_k^i(q)} \rho_k^i(q) d\omega + \int_{\omega \in Q} \sum_{k \neq i} \frac{w_k q}{w_i} \tau_{ij} c(q) \rho_k^i(q) d\omega + \int_{\omega \in Q} \sum_{k \neq i} \frac{w_k q}{w_i} c(q) \left( \frac{dw_i/w_k}{w_i/w_k} \right) \rho_k^i(q) d\omega \right\}$$

The last term is gains from relative wage. Depending on there characteristics some country will gain and some will lose from relative wage adjustment. The assumption that the countries are identical will enable us to ignore changes in relative wages, $dw_i/w_k = 0$. A country can only gain from trade through the first two terms which are the composition effect and the price effect. The price affect on welfare is positive because foreign varieties are now available.
at a lower price. The composition effect of opening up to trade is also positive when there is no income variation across households and $\gamma_\theta > \gamma_c$. To see why note that demand per firm $d^j_i(q) = N_i \rho^j_i(q)/n^j_i(q)$ is not affected by iceberg costs and $\int_\omega \sum_k n^j_k(q)d^j_i(q) = N_i$. Therefore we will have

$$\int_\omega \sum_k \frac{dn^k_i(q)}{n^k_i(q)} \rho^k_i(q)dq = 0$$

$\frac{dn^j_i(q)}{n^j_i(q)} > 0$ for foreign varieties $j \neq i$, and negative for the domestic variety at all qualities. Also If $\gamma_\theta > \gamma_c$ then $\rho^j_i(q)$ is increasing in quality for all imported varieties, and $\theta(q)$ is also increasing. As a result

$$\int_\omega \sum_k \frac{dn^k_i(q)}{n^k_i(q)} \theta(q) \rho^k_i(q)dq > \int_\omega \sum_k \frac{dn^k_i(q)}{n^k_i(q)} \rho^k_i(q)dq = 0$$

Therefore there are welfare gains from the composition effect. When $0 < \gamma_\theta < \gamma_c$ then $\rho^j_i(q)$ and $\theta(q)$ move in the opposite directions and therefore there will be welfare losses from the composition effect. Foreign firms will enter at the qualities were consumers don’t care about variety as much, and knock out of the market the cheaper domestic varieties. When $\theta < 0$ then both $\rho^j_i(q)$ and $\theta(q)$ are decreasing in quality and therefore there will be compositional welfare gains from trade. The following proposition summarizes the results on welfare gains resulting from the compositional effects of trade.

**Proposition 3.3.** In the absence of income variations, the composition effects of trade liberalization on Welfare are

(i) Positive if $\gamma_\theta > \gamma_c$ or $\gamma_\theta < 0$

(ii) Negative if $0 < \gamma_\theta < \gamma_c$

Also note that the magnitude of gains from trade always depend on $\theta_2$. Also if $\theta(q) = \theta$, doesn’t depend on quality there will be no compositional gains from trade. Compositional gains from trade happen because consumers loose varieties at the lower end of the market, as a result of new varieties being added at the higher end of the quality ladder. Since consumers care about varieties more at higher qualities, they gain from this compositional effect of trade. Also it’s worthwhile to mention that the second fundamental welfare theorem doesn’t hold because of the imperfections in the market, which in turn shows up in firms charging markups over their marginal cost.
Now suppose we have a distribution of labor endowment and therefore income varies across consumers. For consumers with endowment level $\mu$ the composition effects of trade can be written as

$$\left[ dV^i(\mu)/V^i(\mu) \right]^{\text{comp}} = \theta_2 \int_Q \theta(q) \sum_k \frac{dn_k^i(q)}{n_k^i(q)} \rho_k^i(q; \mu) dq \quad (**)$$

The market clearing condition again implies

$$\int \omega \sum_k \frac{dn_k^i(q)}{n_k^i(q)} \rho_k^i(q) dq = \int \omega \sum_k \frac{dn_k^i(q)}{n_k^i(q)} \int \mu \rho_k^i(q; \mu) d\mu dq = 0.$$

For consumers with lowest $\mu$ since they consume relatively less foreign varieties and the negative terms in the integral have more weight I will have

$$\int \omega \sum_k \frac{dn_k^i(q)}{n_k^i(q)} \rho_k^i(q; \mu) dq < 0.$$

Therefore even if $\gamma_\theta > \gamma_c$ these consumers can lose from the composition effects of trade. On the other hand the rich consumers will gain more than before because they consume relatively more foreign varieties. The intuition is that the available varieties are the same for all consumers and common across the market. So when foreign varieties arrive at the expense of domestic varieties, poor consumers lose varieties they were consuming at the expense of varieties they cannot afford. On the other hand rich consumers see foreign varieties they want to consume arrive at the expense of domestic varieties they were not purchasing.

### 3.3. Testing the Predictions of the Model

In this section I will like to point out three first order predictions of the model that are confirmed by trade data. These three facts and the other six facts mentioned in the introduction, are patterns that are explained altogether in my framework.

#### 3.3.1. Data

I use two different datasets in this paper. For the gravity estimation, I use industry level data on international trade compiled by COMTRADE. The data includes trade values and quantities among all country pairs at the four digit industry level. I use data from from 2001 to 2006 to estimate a modified version of the gravity equation.

The second dataset I use is product level US import data from 1989 to 1996. The dataset is compiled by Feenstra et al. [2002] and is publicly available. The data is disaggregated at the
ten-digit HS product level. I also observe which 5 digit SITC industry each product belongs to, which enables me to break down my dataset into large subset in which unit values are comparable. Table 1 shows the layout of the data. For each exporter in every year the data documents the value and quantity of imports. The data also reports tariffs and transportation costs for each entry. I also observe the units in which the imported commodity is measured in. Finally for every country I see whether or not the imports were subject to to a bilateral trade treaty or agreement. The list of these treaties is provided in the appendix.

Using the reported import values and quantities I can construct the c.i.f price as

\[
price^{c.i.f} = \frac{price^{f.o.b}}{value^{Quantity}} + \frac{insurance}{value^{Quantity}} - \frac{freight}{value^{Quantity}} + \frac{tariff}{value^{Quantity}}
\]

The f.o.b component of price is of primary interest, since it picks the effect of marginal cost and markup and is reasonable proxy for quality within a narrowly defined commodity classification. The other two components of price (tariff and freight) capture the extra cost exporters pay on the margin. As reported in table 2, tariff and freight actually constitute a considerable share of the c.i.f price.

I trim the data along several dimensions, first I drop all the observations reporting varieties in which the quantity imported is “one unit” or the imported value is less than $7500 in 1989 dollars\(^18\). Then within every 10-digit product category I exclude varieties which unit value of lies above the 95 percentile or below the 5 percentile of that industry.\(^19\) On the large scale, I’m

\(^18\)My results are robust to these cut-offs, as I estimate the model dropping once values less than $5000, and then once again dropping values less than $10000 without seeing in significant change in estimation results.

\(^19\)I also estimate model for different price cut-off and my results are robust to the selected cut-off.
looking at 19 sectors in the data, and table 3 show a summary of statistics for these sectors.

**Prediction 1: Sensitivity of trade flows to distance is less for high quality industries and high income countries**

The standard gravity model predicts that trade flows will fall with distance. Using bilateral trade data I will show that trade flows are less sensitive to distance when: (1) The industry is high quality and (2) The importer is richer. I use industry level data on international trade compiled by COMTRADE. The data includes trade values and quantities among all country pairs at the four digit industry level. I use data from from 2001 to 2006 to estimate a modified version of the gravity equation. I proxy quality with unit values which is a standard practice in trade literature. For the sake of consistency I only consider goods measured in weights. So basically I’m comparing unit value per Kilogram to unit value per Kilogram. To test my hypothesis I estimate the following gravity equation using trade flow data for all country pairs in all digit SITC4 industries

\[
\ln X_{ij}^s = \psi_i + \zeta_j + \mu_i + \beta_1 \ln (GDP_i \times GDP_j) + \beta_2 \ln d_{ij} + \beta_3 \ln d_{ij} \times \ln P^s + \beta_4 \ln d_{ij} \times \ln \left( \frac{GDP_i}{N_i} \right) + \lambda_{ij} + \epsilon_{ij}
\]

\(X_{ij}^s\) is the value of imports by country \(i\) from country \(j\) in industry \(s\). \(\psi_i\) and \(\zeta_j\) are exporter and importer fixed effects. \(d_{ij}\) is distance between country \(i\) and \(j\), and \(N_i\) is population in the importing country. \(P^s\) is the global average unit value of traded goods in industry \(s\) (I use this as a proxy for the relative quality of goods in an industry). \(\lambda_{ij}\) is a set of pairwise dummies that are used in standard gravity estimations. The importer and exporter fixed affects capture the effect of “multilateral frictions” as seen in Anderson and Van Wincoop [2004]. I assume “multilateral frictions” do not change within the time span of five years (2001-2006).

What I’ve added to the standard gravity are two interaction terms; one between distance and quality and another between distance and per capita GDP. The results of the gravity estimation are provided in the table 1. The coefficients on the both the “distance and unit value” and “distance and per capita GDP” interaction terms are positive and significant. This indicates a significant reduction in the elasticity of imports volumes to distance, when either the quality of goods is higher or the importer is richer. The fact that imports are less elastic to distance for higher quality industries, suggests a higher level of differentiation among products in high
qualities. More differentiation allows the disadvantaged exporters to export more because they have something different to offer. I also estimate the standard gravity without the interaction terms separately for each industry. I then plot the coefficient on distance against the average unit value of traded goods within that industry. The result can be seen in Figure 1. There is a clear correlation between sensitivity to distance and the quality of the goods. For high quality industries distance affects trade flows less negatively.

Figure 3.3.1.: The elasticity of trade volumes to distance in a gravity equation, plotted against the average unit value of goods trade for an industry. The Gravity equation is estimated using bilateral trade data from 2001 to 2006 for all four digit SITC2 industries using COMTRADE data.
Table 3.3: Gravity Estimation; year dummies omitted.

Prediction 2: There is a positive relation between distance and f.o.b prices in U.S. imports, in the presence of iceberg trade costs

The standard explanation for many quality/unit value related facts in trade data is the Alchian-Allen effect. The effect explains why high quality goods are shipped to distant markets.\(^{20}\)

The Alchian-Allen effects depend on how transportation costs vary with the f.o.b price of the product. Suppose the transportation costs between countries \(i\) and \(j\) are given by the following equation

\[
\text{trans}_{ij} = p_j^\beta X_{ij}
\]

\(^{20}\)Ricardian models predict distant countries will ship out goods with lower unit value compared to nearby exporters. The reason simply being that the distant countries have to incur higher iceberg costs and to be competitive the goods they export should have lower a f.o.b price.
Where $\beta$ is the elasticity of transportation costs with respect to price, and $X_{ij}$ is a function of non-price factors-most importantly distance. If $\beta = 0$ then the transportation costs are additive, while if $\beta = 1$ the transportation costs are basically iceberg costs. $? \text{ show that when } \beta < 1 , \text{ and if firms export high and low quality goods that are substitutes the Alchian-Allen effects are present. These effect become smaller and finally absent as } \beta \text{ increases and approaches 1. As distance to a market increase, the Alchian-Allen effect predicts demand to shift from the high quality product a firm produces to the low quality product}^{21}. \text{ Now I will show that Alchian-Allen effects are inconsistent with the relation between quality and distance in US import data. The data I use is compiled by Feenstra et al. [2002], and provides the value and quantity of US imports from each country within every 10 digit HS product category from 1989 to 1996. The data also includes tariffs and transportation costs for each observation.}

Since I’m comparing unit values across different products, I divide products into two comparable categories: (1) Goods measured in counts, and (2) Good measured in weights. I estimate the effect of distance on the f.o.b unit value of the goods for each category, using the following equation

$$
\ln (P_{cht}) = \lambda_{ht} + \alpha_1 \ln \left( \frac{\text{dist}_c}{\text{dist}_h} \right) + \alpha_2 \ln \left( \frac{\text{GDP}_{ct}}{\text{pop}_{ct}} \right) + \alpha_3 \ln (\text{GDP}_{ct}) + \alpha_4 \ln (\text{exchange}_{ct}) + \epsilon_{cht}
$$

$P_{cht}$ is the f.o.b price, where $c$ denotes the exporting country, $h$ is an HS10 product category. $t$ refers to the year the trade observation took place. I include a fixed effect for every HS10 code/year. Per capita GDP on the right hand side captures both the effect of factor price (wage) in the exporting country and technology. The last two terms on the right hand side are total income and exchange rate in the exporting country. The results from the estimation are provided in table 2. Per capita GDP of the exporter pushes up the quality as expected. Wages are higher in high income countries so this could be due to consumer’s being less sensitive to

$^{21}$Even from a theoretical point of view, if one is to assume that transportation costs are additive rather than ad-valorem the Alchian-Allen effect imposes very limiting assumptions to explain why a country will import on average higher unit value goods from distant exporters: (i) The effect assumes that products a country produces at different qualities are substitutes. In practice though one would expect that products from different countries at the same quality levels to be substitutes. If the price of the high quality good from a country increases consumers will substitute it with high quality goods from other countries, and (ii) The Alchian-Allen effect only takes into the account the substitution effect and ignores the income effect. If iceberg costs are higher; even though demand relatively shifts towards high quality goods; but demand in total falls for all goods. In the presence of sunk costs, distant exporters might actually not export the higher qualities; but drop all qualities because demand is not large enough for them to overcome the sunk cost. In this paper for example I use a nested logit demand system, and even when transportation costs are additive the demand system does not yield a Alchian-Allen type effect.
### Table 3.4: The determinants of the unit value of exports to the US.

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln(GDP/pop)</td>
<td>0.29***</td>
<td>0.25***</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Ln(GDP)</td>
<td>-0.04***</td>
<td>-0.01**</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Ln(dist)</td>
<td>-0.14***</td>
<td>0.15***</td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Ln(exchange)</td>
<td>-0.02***</td>
<td>0.01***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.28***</td>
<td>-1.51***</td>
</tr>
<tr>
<td></td>
<td>(0.043)</td>
<td>(0.044)</td>
</tr>
</tbody>
</table>

Observations: 258,925 113,375
R-squared: 0.09 0.12
Number of HS/year fixed effects: 4,777 2,073
Adj. R-squared: 0.09 0.12

Robust standard errors in parentheses
*** p < 0.001, ** p < 0.01, * p < 0.1

the higher prices at higher qualities. The positive effect of per capita GDP on quality can also be due to better technology at producing high qualities. Distance affects quality negatively for goods measured in counts; but affects quality positively for goods measured in weights.

Assume the Alchian-Allen effects are the explanation for how distance affects quality. Then Transportation costs should be very additive for goods measured in weights, and iceberg-like for goods measured in counts. To test this I estimate the following equation suggested by ?

\[
\ln(\text{trans}_{cht}) = \lambda_h + \lambda_t + \beta \ln(p_{cht}) + \gamma \ln(\text{quantity}_{cht}) + \delta \ln(\text{dist}_c) + \epsilon_{cht}
\]

As the estimation results in table 3 show; the estimated \( \beta \) is 0.52 for goods measured in counts—a number close to the estimate provided by ?. However when I estimate the model for HS10 codes in which goods are measured in weights, the elasticity of transportation costs relative to price is 0.98, which means transportation costs act as iceberg costs. The Alchian-Allen effects Therefore predict a relationship between distance and quality opposite to what we actually see in US import data.
**Prediction 3: The quality ladder of exports shrinks with distance at both ends.**

Bernard et al. [2007] report that distance reduces the extensive margin of trade. As countries become distant they drop products from the set of traded goods. The question is “which products are dropped?” Are the low quality products dropped, or the high quality products or some of both? Within an industry I define quality ladder as the difference between the highest f.o.b valued HS10 product and the lowest f.o.b valued HS10 product a country exports to the US:

\[
\text{Quality Ladder}_{ct}^S = \max_{h \in S} \{ p_{cht}^{f.o.b} \} - \min_{h \in S} \{ p_{cht}^{f.o.b} \}
\]

Where \(c\) denotes country and \(h\) and \(S\) refer to a HS10 product and an SITC industry respectively. The quality ladder is exporter and industry specific and is calculated for US imports. Results in table 3 suggest that distance shrinks the ladder while higher GDP and GDP per capita both expand the ladder. It is no surprise that the quality ladder shrinks with distance; but the question that remains is “which qualities are dropped from the ladder?” To answer this I estimate the effect of distance on the highest quality and lowest quality HS10 product a
Table 3.6: The determinants of the price ladder of exports to the US

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln(dist)</td>
<td>-0.41*** (0.020)</td>
<td>-0.22*** (0.013)</td>
</tr>
<tr>
<td>Ln(GDP/pop)</td>
<td>0.20*** (0.011)</td>
<td>0.07*** (0.006)</td>
</tr>
<tr>
<td>Ln(GDP)</td>
<td>0.68*** (0.012)</td>
<td>0.32*** (0.008)</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.81*** (0.245)</td>
<td>-1.55*** (0.157)</td>
</tr>
</tbody>
</table>

Observations | 45,269 | 27,383 |
R-squared     | 0.29   | 0.26   |
Number of HS/year fixed effects | 1,463 | 1,057 |
Adj. R-squared | 0.29  | 0.26   |

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.1

country exports to the US within each industry. Again I proxy quality with f.o.b unit value.
The results (Table 5) indicate that Shrinking of the quality ladder happens at both tails. Both
the highest and the lowest quality move more towards the average quality of exports as dis-
tance to the US increases. As a result the set of exported qualities is more compact for more distant exporters. Exports from these countries are geared towards a very small set of qualities.

3.4. Conclusion

This paper presents a framework for explaining patterns of trade relying mostly on heterogeneity in consumer demand. I incorporate a nested logit model of demand in which households consume a good which is both horizontally and vertically differentiated. The consumer decides on the quality and variety of the good she consumes, where variety is determined by the country of origin. The key element of my model is allowing for dissimilarity among varieties to increase with quality. This leads to a country’s consumption bundle to be more diversified at higher quality levels. Richer countries consume higher qualities and will want more variety. This results in rich countries trading more in order to achieve their desire to consume variety. In general expensive foreign varieties are demanded relatively more in high qualities,
and as a result trade happens mostly at the higher end of the quality ladder. Moreover exporters disadvantaged by their distance, can ship out and sell only the highest quality goods. All of this simply happens because the importance of horizontal attributes rises with quality. Finally the income constraint faced by the consumers in every country will allow consumers to purchase only varieties that they can afford. In some cases it’s profitable for a country to ship out only goods that are so high quality and expensive that only very few (if any) consumers in the home market can afford. In this case there will be zero trade between the two countries. This explanation of zero trade flows is more natural than the standard explanation which relies on a truncated set of goods. Unlike standard trade models that assume a representative consumer with CES preferences, my model parts away from that assumption and yields interesting results on heterogeneous gains from trade across consumers. Even when the economy as a whole gains from trade, some consumers loose because they consume predominantly domestic varieties.

I test several first order predictions of my model. My estimations confirm my predictions and are in line with my assumption that taste matters more than price at high qualities. I also Show that although the trade literature relies on Alchian-Allen effects to explain some of these first order results; the Alchian-Allen effect doesn’t do a good job when applied to the US import data.
Discrete choice models are gaining prominence among trade economist, due to fact that they account for consumer taste and quality in a very natural and simple way. Khandelwal [2010] uses these preferences to estimated quality ladders without relying on price as a proxy for quality and Fajgelbaum et al. [2011] provide a model which relies exclusively on consumer demand to explain the direction and quality of trade among countries. The bottom line of my paper and these models is that demand heterogeneity is critical in understanding patterns of trade, and that policy makers should consider consumer taste and quality when implementing trade policies. My model for instance implies a country which has a high cost of production due to different reasons like high transportation or labor costs, should shift attention to higher quality goods. On the other hand protective price policies will work best when imposed on lower quality goods where consumer care bout the price relatively more. On the other hand removing tariffs on all foreign products, although welfare improving at the aggregate level, can leave the poor consumers worse off. Structurally estimating a multi-country discrete choice model of international trade in a similar fashion to the heterogeneous firms models could be the next line of research in adopting discrete choice preferences in trade models.
Bibliography


Paulo Bastos and Joana Silva. The quality of a firm’s exports: Where you export to matters.


Arnaud Costinot and Andrés Rodríguez-Clare. Trade theory with numbers: Quantifying the


Appendices
Appendix A. (Chapter 1)

A.1. Proofs and Additional Results

A.1.1. 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 \( h = h, \forall h \) and \( \eta \to 1 \). 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.\(^1\) 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.\(^2\) 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].\(^3\) Small changes in real wage (i.e. indirect utility) as a result of slightly lowering the

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\(^1\)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: \( \eta \to 1^+ \).

\(^2\)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.1.2 for a formal argument on this.

\(^3\)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.

\(^4\)In this section when I talk about the gains from trade I am referring to the change in the indirect utility from
iceberg trade costs (or any exogenous shock) will be given by

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

(A.1.1)

Using the free entry condition and some algebra the above equation can be re-written as

\[ d \ln \frac{w_i}{P_i} = \int_h -d \ln \lambda_{ih}^{\hat{\sigma}_i} \lambda_h^i \frac{dh}{\sigma_h - 1} \left[ 1 - \frac{1}{\eta \sigma_h - 1} \frac{\lambda_h^i dh}{\lambda_h^i dh} \right] \]  

(A.1.2)

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

\[ d \ln \frac{w_i}{P_i} = -d \ln \lambda_{ih}^{\hat{\sigma}_i} \frac{\lambda_h^i}{\sigma_h - 1} + \frac{d \ln M_i}{\eta \sigma_h - 1} \]  

(A.1.3)

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). 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 \( \sigma_h < \sigma_d \) then \(-d \ln \lambda_{ih}^{\hat{\sigma}_d} > -d \ln \lambda_{ih}^{\hat{\sigma}_h}\). Therefore, changes in the import flows (i.e.

---

5For a derivation of equations (11) and (12) see appendix A.4. The second term, i.e. \( \int_h \frac{1}{\eta \sigma_h - 1} \lambda_h^i dh \) 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.

6As \( \eta \rightarrow 1 \) 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 \( d \ln \lambda_{ih}^{\hat{\sigma}_h} \rightarrow 0 \). The other possibility that could arise is switching to cheapest alternative that could possibly be non-domestic and in that case \( d \ln \lambda_{ih}^{\hat{\sigma}_h} \rightarrow \infty \). The term in the braces disappears under two circumstances: (1) if \( \eta \rightarrow \infty \) 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.

7note that if entry was once and for all markets (as in Arkolakis et al. [2012]) rather than per-market, then \( \frac{d \ln M_i}{\delta x - 1} = 0 \).

8A 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: \( \nu_i^h(h) = 1 \). 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.

9This is true in the symmetric equilibrium. In an asymmetric equilibrium this is true for two disconnected in-
\[-d \ln \lambda_{i|h} = \sum_{j \neq i} d \lambda_{j|i} \text{ are larger in more differentiated products where consumers benefit more from having the foreign varieties. Putting it differently, foreign varieties are concentrated where consumers want them to be.}\]

The above result is closely related to two studies. Arkolakis, Klenow, Demidova, and Rodriguez-Clare [2008] argue that the gains from variety are not that much.\(^{10}\) 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 new varieties would measure up to be small. Ossa [2012] makes a similar argument, but the contribution of this paper is that it generalizes his result. Ossa [2012] fixes expenditure shares on industries to an exogenous number by assuming a cross-industry Cobb-Douglas utility aggregator—which is very special case of the CES aggregator used in this paper.

To dig deeper, I look at what happens underneath the large aggregate gains from trade. As noted 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 \( d \ln \lambda_{i} \approx 0 \) since there will be barely any foreign entry (in those products) and changes in welfare will be

\[d \ln w_i \approx \frac{d \ln M_{i}}{\eta \sigma_h - 1} < 0\]

where \( dM_{i} < 0 \) 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.\(^{11}\) A simple de-

\(^{10}\) 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 gains in Arkolakis et al. [2008] are driven by weighting the new varieties with a high aggregate elasticity.

\(^{11}\) In the CES context the model implies gains from trade for all households. In general, the CES framework with
piction of how lowering iceberg trade costs affect purchasing power (i.e. \( \frac{w_h}{P_h} \) for product \( h \)) along the product differentiation ladder is displayed in figure A.1.1.

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.\(^{12}\) 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 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.\(^{13}\)

**Proposition A.1.** Conditional on (the same) observed import shares (i.e. \( \sum_{j \neq i} \lambda^j_i = 1 - \lambda^i_i \)), the underlying gains from trade are larger in the new model relative to the baseline Krugman-Armington model (in the baseline model \( \eta \to 1 \) and the cross-country elasticity is constant across all products and equal to the average economy-wide elasticity \( \sigma = \int_h \sigma_h \lambda^h_i dh, \ \forall h \in H \)).\(^{14}\)

---

\(^{12}\)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.

\(^{13}\)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.

\(^{14}\)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 \( \lambda^h_i \)). They may, as well, be expenditure shares in the autarky equilibrium, i.e. \( \sigma = \int_h \sigma_h \lambda^h_i, A \) dh, \( \forall h \).
Figure A.1.1.: A simple demonstration of changes in purchasing power across different products \( \frac{w_i}{P_h} \) when a country opens up to trade from autarky.

**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

\[
d \ln \frac{w_i}{P_i} = -\frac{1}{1-\epsilon} d \ln \left\{ \int_{h \in H} (P_h^i)^{1-\epsilon} dh \right\}
\]

(A.1.4)

Given that \( d (P_h^i)^{1-\epsilon} = (1-\epsilon) d \ln P_h^i (P_h^i)^{1-\epsilon} \), the above equation can be re-written as

\[
d \ln \frac{w_i}{P_i} = -\int_h d \ln P_h^i \left( \frac{P_h^i}{P_i} \right)^{1-\epsilon}
\]

(A.1.5)

where

\[
d \ln P_h^i = \sum_j d \ln P_j^i \left( \frac{P_j^i}{P_h^i} \right)^{1-\sigma_h}
\]

(A.1.6)

and
\[ P_{ij}^i = \tau_{ji} w_i \left( \mu_j M_{jh}^i \right)^{\frac{1}{1-\sigma_h}} \]  

(A.1.7)

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

\[
d \ln \frac{w_i}{P^n} = \sum_j d \ln w_j \tau_{ji} \lambda_{j}^i + \int_h \sum_j \frac{1}{1-\eta \sigma_h} d \ln M_{jh}^i \lambda_{j}^i
\]

(A.1.8)

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

\[
d \ln \lambda_{j|h}^i - d \ln \lambda_{i|h}^i = (1 - \sigma_h) [d \ln w_j + d \ln \tau_{ji}] + \frac{1 - \sigma_h}{1 - \eta \sigma_h} [\ln M_{jh}^i - \ln M_{ih}^i]
\]

(A.1.9)

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

\[
d \ln \frac{w_i}{P^n} = - \left\{ \int_h \sum_j \left( \frac{d \ln \lambda_{j|h}^i - d \ln \lambda_{i|h}^i}{1 - \sigma_h} \right) \lambda_{j|h}^i \lambda_{h}^i + \int_h \frac{1}{1 - \eta \sigma_h} d \ln M_{jh}^i \lambda_{h}^i \right\} = \int_h \frac{d \ln \lambda_{i|h}^i \lambda_{h}^i}{1 - \sigma_h} - \int_h \frac{1}{\eta \sigma_h - 1} d \ln M_{ih}^i
\]

given that \( \sum_j \lambda_{j|h}^i = 1 \) the above equation simplifies to

\[
d \ln \frac{w_i}{P^n} = \int_h \frac{-d \ln \lambda_{i|h}^i \lambda_{h}^i}{\sigma_h - 1} dh + \left[ \int_h \frac{1}{\eta \sigma_h - 1} \lambda_{h}^i dh \right] d \ln M_{ih}^i
\]

(A.1.10)

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

\[
d \ln \frac{w_i}{P^n} = \frac{-d \ln \lambda_{i|h}^i \lambda_{h}^i}{\sigma_h - 1} + \frac{d \ln M_{ih}^i}{\eta \sigma_h - 1}
\]

**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

\[
d \ln \frac{w_i}{P^n} = \int_h \frac{-d \ln \lambda_{i|h}^i \lambda_{h}^i}{\sigma_h - 1} dh + \left[ \int_h \frac{1}{\eta \sigma_h - 1} \lambda_{h}^i dh \right] d \ln M_{ih}^i
\]

From the entry condition we have

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\[
\left( \frac{1}{M_i} \int_{h \in H} \frac{\lambda^i_{ijh} \lambda^i_h}{\sigma - 1} dh \right) \hat{L}_i = f^e
\]

Then
\[
d\ln M^i = \frac{d\ln \lambda^i_{ijh}}{\sigma - 1} \implies d\ln M^i = \frac{\int_{h \in H} \frac{d\lambda^i_{ijh}}{\sigma - 1} dh}{\int_{h \in H} \frac{\lambda^i_{ijh}}{\sigma - 1} dh}
\]

The above inequality follows from writing the FE condition as \( \frac{M^i}{L_i} = \int_{h \in H} \frac{d\lambda^i_{ijh}}{\sigma - 1} dh \), which in turn implies
\[
d\ln \frac{w^i}{P^i} = \int_h \left\{ -\frac{d\ln \lambda^i_{ijh} \lambda^i_h}{\sigma - 1} dh \right\} \left( 1 - \left[ \int_h \frac{1}{\eta \sigma - 1} \lambda^i_{ijh} dh \right] \right) d\ln \frac{\lambda^i_{ijh}}{\sigma - 1} dh
\]

In autarky, and close to autarky a good approximation will be \( \lambda^i_{ijh} \approx 1 \) which allows me to write the above equation as
\[
d\ln \frac{w^i}{P^i} = \int_h \left\{ -\frac{d\ln \lambda^i_{ijh} \lambda^i_h}{\sigma - 1} dh \right\} \left( 1 - \left[ \int_h \frac{1}{\sigma - 1} \lambda^i_{ijh} dh \right] \right) d\ln \frac{\lambda^i_{ijh}}{\sigma - 1} dh
\]

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. \( \int_h -d\ln \lambda^i_{ijh} \lambda^i_h dh = \left( \int_h -d\ln \lambda^i_{ijh} \lambda^i_h dh \right) \text{baseline} \)), the new model would generates more gains. Note that in the symmetric equilibrium \( p^i_{ijh} > p^i_{jih} \) 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) \( \frac{d\ln \lambda^i_{ijh}}{d\ln \lambda^i_{ijh}} \) is increasing in \( \frac{1}{\sigma - 1} \), and (ii) \( \frac{\lambda^i_{ijh}}{\lambda^i_{jih}} \) is non-decreasing in \( \frac{1}{\sigma - 1} \). (i) and (ii) together imply that \( \int_h -d\ln \lambda^i_{ijh} \frac{\lambda^i_h}{\sigma - 1} dh > \left( \int_h -d\ln \lambda^i_{ijh} \lambda^i_h dh \right) \text{baseline} \).

Moreover the term in the parenthesis on the RHS goes to zero as \( \eta \to 1 \) which is another channel which pushes down the gains in the baseline model.

\[\square\]

A.1.2. 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. \( \sum_{j \in C^i} M^j \)) 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 col-
lectable 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\(^{15} \)

\[
R_i = \left\{ \int_{h \in H} \frac{1}{\eta \sigma_h} \lambda_h dh \right\} w_i L_i
\]

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 effects 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 A.2.** Consider a baseline model in which cross-country elasticity is constant across all products and equal to the average economy-wide elasticity (in autarky) \( \sigma = \int_h \sigma_h \lambda_i^A \lambda_i^h dh, \forall h \in H \)

(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

\[
\left( \int_{h \in H} \frac{\lambda^i_{j|h|} \lambda^i_h}{\eta \sigma_h} dh \right) L_i = M^i_j f^e + f \int_h M^i_j dh
\]

(A.1.11)

summing up (22) for all countries \( I \) will have

\[
\left( \int_h \frac{1}{\eta \sigma_h} \lambda^i_h dh \right) L_i = \sum_j M^i_j f^e + f \sum_{j \neq i} \int_h M^i_{jh} dh
\]

(A.1.12)

The total revenue that firms can collect in country \( i \). First, from Jensen’s inequality we have

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

Where \( \sigma = \int_h \sigma_h \lambda^i_h dh \). The above inequality implies that in every equilibrium there are more

\(^{15}\)See proof of proposition 3 for the derivation of the revenue equation.
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

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

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

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

The above inequalities imply that \(\int_{h \in H} \frac{1}{\sigma_h} \lambda_h^i \, dh > 0\). 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\(^{16}\)

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

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

\[\Box\]

### A.1.3. Calculating Markups

The firm’s problem is the following

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

\(^{16}\)In an asymmetric world where wages differ across countries the condition will be:

\[
d \sum_j w_j M_j^i > d \left( \sum_j w_j M_j^i \right)_{\text{baseline}}
\]
The F.O.C will be

\[ q_{\omega j h}^i (p) + (p - \tau_{ji} w_j) \frac{dq_{\omega j h}^i (p)}{dp} = 0 \]

From the CES demand equation we have

\[ q_{\omega j h}^i = \left( \frac{p_{\omega j h}^i}{P_{jh}^i} \right)^{(1-\gamma_h)} \left( \frac{P_{jh}^i}{P_h^i} \right)^{1-\sigma_h} \left( \frac{P_h^i}{P_i^h} \right)^{1-\epsilon} \alpha w_i L_i \]

Taking derivatives

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

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

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

Then

\[ p_{\omega j h} = \frac{\gamma_h}{\gamma_h - 1} \tau_{ji} w_j, \ \forall \omega \in \Omega_j \]

**A.1.4. Proof of Proposition 1**

Consider the labor market clearing condition

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

\[ (LMC) \]

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

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 \(\mu_jw_j^{1-\sigma_h} > \mu_iw_i^{1-\sigma_h}\) –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) \((\tau_{ik}q_{ih}^k) = 1 > (\tau_{jk}q_{jh}^k) \forall k \neq i\) and (ii) \(\frac{\partial q_{ih}^k}{\partial h}\) 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

\[
\begin{aligned}
w_i > w_j \\
M_i^j f^e + \int_{h \in H_i} q_{ih}^j M_i^j dh < M_j^j f^e + \int_{h \in H} q_{jh}^j M_j^j dh \\
\sum_{k \neq i} M_i^k f^e + \int_{h \in H} (\tau_{ik}q_{ih}^k + f) M_i^k \nu_i^k(h) dh > \sum_{k \neq i} M_j^k f^e + \int_{h \in H} (\tau_{jk}q_{jh}^k + f) M_j^k \nu_j^k(h) dh
\end{aligned}
\]

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

\[
\int_{h \in H} \frac{\sigma_h}{\sigma_h - 1} M_j^j q_{jh}^j dh > \int_{h \in H} \frac{\sigma_h}{\sigma_h - 1} M_i^i q_{ih}^i dh
\]

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

\[
\lambda_j^i = \frac{\int_{h \in H} \frac{\sigma_h}{\sigma_h - 1} w_j M_j^j q_{jh}^j dh}{w_j L_j} > \frac{\int_{h \in H} \frac{\sigma_h}{\sigma_h - 1} w_i M_i^i q_{ih}^i dh}{w_i L_i} = \lambda_i^j
\]

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. \(\square\)

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

\[
\frac{\lambda_i^h}{\lambda_i^{h'}} = \left[ \frac{\eta \sigma_h}{\eta \sigma_{h'} - 1} \right] \left( \frac{\sigma_h}{\sigma_{h'} - 1} \right) \left( \frac{w_k \pi_k}{w_k \pi_{k'}} \right) \left( \frac{1}{\tau_{h-k}} \right) \left( \frac{1}{\tau_{h'-k'}} \right) \left( \frac{1}{\pi_j} \right) \left( \frac{1}{\pi_j'} \right) \left( \frac{1}{\pi_j} \right) \left( \frac{1}{\pi_j'} \right)
\]

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

\[
\left( \frac{\lambda_i^h}{\lambda_i^{h'}} \right)' = t \cdot \frac{\lambda_i^h}{\lambda_i^{h'}}
\]

if \( \sigma_h < \sigma_{h'} \) if follows that \( \left( \frac{\lambda_i^h}{\lambda_i^{h'}} \right)' > \frac{\lambda_i^h}{\lambda_i^{h'}} \). Putting it differently; if the number of supplied varieties in country \( i \) increases, then country \( i \) will spend relatively more on highly differentiated products.\(^{17}\)

A.3. 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 \( V_{\omega jh} \)

\[
V_{\omega jh}^n = \ln \left( \frac{w_i}{p_{\omega jh}} \right) + \ln \mu_j + \nu_{\omega jh}^n
\]

Where \( p_{\omega jh} \) is the price of variety \( \omega jh \) in country \( i \), and \( \frac{w_i}{p_{\omega jh}} \) is the amount of the variety \( \omega jh \), consumer \( n \) in country \( i \) with income \( w_i \) can purchase. Every household is endowed with one units of effective labor so that income is equal to wage \( w_i \) in country \( i \). \( \mu_j \) is the common

\(^{17}\)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.
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 \( \nu_{\omega jh}^n \). I assume that every consumer independently and separately draws (a continuum of) taste shocks from the following general extreme value (GEV) distribution

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

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 et al. [1992] show, the nested-logit demand structure (described above) is equivalent to a nested CES demand structure. The aggregate demand for variety \( fjh \) in country \( i \) resembles that of a nested CES demand and is given by

\[
q_{\omega jh}^i = \left( \frac{p_{fjh}^i}{p_{jh}^i} \right)^{1-\eta \sigma_h} \left( \frac{p_{jh}^i}{p_h^i} \right)^{-\sigma_h} \left( \frac{p_h^i}{p_i} \right)^{-\epsilon} \frac{w^i L^i}{p_{\omega jh}}
\]

where \( q_{\omega jh}^i \) is the “quantity” demanded of variety \( \omega jh \) 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

\[
P_{jh}^i = \left\{ \sum_{\omega' \in F_{jh}^i} \left( \frac{p_{\omega' jh}^i}{p_{jh}^i} \right)^{1-\eta \sigma_h} \right\} ^{\frac{1}{1-\sigma_h}}
\]

\[
P_h^i = \left\{ \sum_{k \in C_h^i} \mu_k \left( \frac{p_{k h}^i}{p_h^i} \right)^{1-\sigma_h} \right\} ^{\frac{1}{1-\sigma_h}}
\]

\[
P^i = \left\{ \int_{h \in H} \left( \frac{p_h^i}{p_i} \right)^{1-\epsilon} dh \right\} ^{\frac{1}{1-\epsilon}}
\]

McFadden et al. [1978] show the expected utility of an average consumer...
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
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<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table A.1.: 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.*

flows with only price variations. As a result, the elasticity of trade values with respect to prices will be over-estimated.\(^{18}\)

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.\(^{19}\)

\(^{18}\)Helpman et al. [2008] make a similar argument, but implement their argument differently. Their estimates also indicate a upward bias in traditional elasticity estimates.

\(^{19}\)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.
A.4.2. Additional Patterns

Pattern 1: The US import basket is more (horizontally) diversified for HS-10 products that exhibit high levels of differentiation

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 A.4.1 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 A.4.1 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.

Figure A.4.1: The positive relation between product differentiation (in logs) and the number of country-specific varieties per dollar imported—in an HS-10 product code. All values are reported in logs. Each point in the graph corresponds to 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 $\frac{1}{\sigma_h}$.
Pattern 2: US Employment is insulated from low-wage import penetration in highly differentiated industries

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

\[
\ln \text{employment}_{S,t} = -0.0513 \ln LWP_{S,t} + 0.046 \ln LWP_{S,t} \times \ln \frac{1}{\sigma_S} + 2.78 \tag{20}
\]

where \(\text{employment}_{S,t}\) is U.S. employment in industry \(S\) in year \(t\). \(LWP_{S,t}\) is low-wage import penetration index calculated 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 R² 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.

### A.5. Additional Tables and Figures

![Figure A.5.1](image_url)

**Figure A.5.1:** An example of an SITC-5 industry in the US import data (compiled by Feenstra et al. [2002]). The figure only displays a representative group of HS-10 codes that belong to SITC-5 industry 71620.

---

20NAICS 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.
Afghanistan    Chad    Haiti    Niger
Albania        China    India    Pakistan
Angola         Congo    Kenya    Rwanda
Armenia        Equatorial Guinea Lao PDR    Samoa
Azerbaijan     Ethiopia    Madagascar    Sierra Leone
Bangladesh     Gambia    Malawi    Sri Lanka
Benin          Georgia    Mali    Sudan
Burkina Faso   Ghana    Mauritania    Togo
Burundi        Guinea    Moldova    Uganda
Cambodia       Guinea-Bissau Mozambique    Vietnam
Central African Republic    Guyana    Nepal    Yemen

**Table A.2.** 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])

**Figure A.5.2.** Scatter plot of the average estimated quality in the HS-10 code against the level of differentiation in that HS-10 product code.

<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 NESO 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 A.3.** Layout of the US import data compiled by Schott [2008]
Figure A.5.3.: Price elasticity of demand for various car products in the U.S. (source: Berry et al. [1995]).

Figure A.5.4.: 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.
Figure A.5.5.: Comparison of country-specific quality estimates by Hallak and Schott [2011] with the estimated “national production 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.

Figure A.5.6.: The scatter plot of “national production 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.
Figure A.5.7: Scatter plot of “national production quality" $\ln \mu_i$ against nominal country wage $\ln w_i$ in 2000.
<table>
<thead>
<tr>
<th>Sector (SIC-2)</th>
<th>Industry (SITC-5) (1)</th>
<th>Products (HS-10) (2)</th>
<th>Average GDP (3)</th>
<th>Skill Intensity (4)</th>
<th>Capital intensity (5)</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>
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</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>
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<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 A.4.: 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])
<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>
<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>
<td>Taiwan</td>
<td>20.19</td>
<td>41.96</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>
<td>Venezuela</td>
<td>4.80</td>
<td>13.93</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>
<td>New Zealand</td>
<td>12.92</td>
<td>39.46</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>
<td>Argentina</td>
<td>10.87</td>
<td>22.26</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>
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<td>Israel</td>
<td>19.09</td>
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</tr>
<tr>
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<td>1.03</td>
<td>2.74</td>
<td>Austria</td>
<td>25.11</td>
<td>69.93</td>
<td>Singapore</td>
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<td>66.70</td>
<td>Netherlands</td>
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<td>70.14</td>
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<td>55.69</td>
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<td>26.36</td>
<td>Malaysia</td>
<td>3.50</td>
<td>11.35</td>
<td>Finland</td>
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<td>67.109</td>
<td>Poland</td>
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<td>Peru</td>
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<td>Hong Kong</td>
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<td>Philippines</td>
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<td>Australia</td>
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<td>60.31</td>
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<td>17.15</td>
<td>Norway</td>
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<td>Chile</td>
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<td>14.10</td>
<td>Thailand</td>
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<td>South Africa</td>
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<td>Czech Rep.</td>
<td>3.49</td>
<td>15.96</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table A.5: Description of the most and least differentiated HS-10 product codes.

Table A.6: The estimated “national production quality” parameters. $\mu_i$ is adjusted by the average elasticity of substitution, i.e. $\hat{\mu}_i = \mu_i^{1/(\alpha^{x+1} - 1)}$. 
<table>
<thead>
<tr>
<th>Country</th>
<th>ISO code</th>
<th>$% \Delta V_h \mid h=1$</th>
<th>$% \Delta V_h \mid h=2$</th>
<th>$% \Delta V_h \mid h=3$</th>
<th>$% \Delta V_h \mid h=4$</th>
<th>$% \Delta V_h \mid h=5$</th>
</tr>
</thead>
<tbody>
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<td>-9.4</td>
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<tr>
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<td>-12.49</td>
<td>-16.99</td>
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</tr>
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<td>CAN</td>
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<td>1.59</td>
<td>-8.4</td>
<td>-22.67</td>
<td>-37.63</td>
</tr>
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<td>-2.82</td>
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<td>-43.7</td>
</tr>
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<td>-17.54</td>
<td>-22.18</td>
<td>-26.76</td>
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<td>-59.04</td>
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</tr>
<tr>
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<td>-12.12</td>
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<td>-6.15</td>
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<td>-1.67</td>
<td>-2.18</td>
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<td>-8.55</td>
<td>-16.08</td>
<td>-24.12</td>
<td>-32.04</td>
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<tr>
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<td>-1.71</td>
<td>-13.75</td>
<td>-28.1</td>
<td>-42.3</td>
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<td>SAU</td>
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<td>-2.74</td>
<td>-7.79</td>
<td>-14.48</td>
<td>-21.57</td>
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<tr>
<td>Singapore</td>
<td>SGP</td>
<td>-15.53</td>
<td>-10.5</td>
<td>-12.19</td>
<td>-16.61</td>
<td>-21.62</td>
</tr>
<tr>
<td>Thailand</td>
<td>THA</td>
<td>1.42</td>
<td>-1.34</td>
<td>-11.77</td>
<td>-25.2</td>
<td>-38.86</td>
</tr>
<tr>
<td>Turkey</td>
<td>TUR</td>
<td>1.53</td>
<td>-2.55</td>
<td>-12.85</td>
<td>-24.9</td>
<td>-36.92</td>
</tr>
<tr>
<td>Taiwan</td>
<td>TWN</td>
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<td>-3.37</td>
<td>-6.6</td>
<td>-11.35</td>
<td>-16.36</td>
</tr>
<tr>
<td>USA</td>
<td>USA</td>
<td>-1.82</td>
<td>-1.07</td>
<td>-1.25</td>
<td>-1.64</td>
<td>-2.1</td>
</tr>
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<td>Venezuela</td>
<td>VEN</td>
<td>0.58</td>
<td>-2.45</td>
<td>-10.48</td>
<td>-20.38</td>
<td>-30.53</td>
</tr>
<tr>
<td>South Africa</td>
<td>ZAF</td>
<td>1.66</td>
<td>0.15</td>
<td>-8.05</td>
<td>-18.83</td>
<td>-30.17</td>
</tr>
</tbody>
</table>

Table A.7.: The gains from trade for different countries in various industries. The table reports changes in purchasing power in each product category, i.e. $\frac{w_i^j}{p_i^j}$, when switching from the calibrated trade equilibrium to the counter-factual autarky equilibrium. Notice that $V = \sum_{i=1}^{N} U_M^\alpha$, and hence $d\ln V^1 = \alpha d\ln U_M^1 = \alpha d\ln \frac{w_i^j}{p_i^j}$. 


Appendix B. (Chapter 2)

B.1. Additional Tables

In the main body of the paper I have estimated the freight rate equation using IV estimation. Here I provide estimation result from a simple OLS method. The coefficient on price-of-course-will be biased because of simultaneity between price and freight rate.

B.2. Within Firm Variations in Unit Value of Exports

The US imports data allowed me to test the effect of freight charges on the f.o.b unit value of exported goods from one country. The effect of distance on the mix of exported goods can be due to within firm and cross firm selection. Using the Bangladesh export data, which documents exports for individual firms at the 8-digit commodity level, I can test the within firm effect of distance (and therefore freight charges) on the unit value mix of exported goods.

To achieve this, I estimate the following equation

\[ 
\ln(p_{jt}^{h,f}) = \alpha_1 \ln(\text{dist}_j) + \alpha_2 \ln(\text{GDP per capita}_{jt}) + \alpha_3 \ln(\text{population}_{jt}) + \delta_{h,f} + \mu_t + \epsilon_{jt}^{h,f} 
\]

Where \( p_{jt}^{h,f} \) is the f.o.b unit value of exports of commodity class \( h \) from firm \( f \) in Bangladesh, to country \( j \) in year \( t \). I control form firm-product fixed effects with \( \delta_{h,f} \), and I also include a year dummy \( \mu_t \). The results of the estimation are given in table 8. As the results indicate, distance increase the f.o.b unit value of the product mix exported by a Bangladeshi firm. Also per capita GDP increase the unit value of the exported commodities which can be due to two reasons:

---

1This is not the first study looks at the within firm covariation of distance and unit value. Bastos and Silva (2011) for instance look at this covariation using firm level export data from Portugal.
Independent variable: Log(weight per unit)

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>OLS</th>
<th>FE</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ln(\text{price}_{f.o.b}) )</td>
<td>0.695***</td>
<td>0.492***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.016)</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.955***</td>
<td>-1.291***</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.055)</td>
</tr>
<tr>
<td>Observations</td>
<td>179,432</td>
<td>179,432</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.637</td>
<td>0.295</td>
</tr>
<tr>
<td>Adj. R-squared</td>
<td>0.637</td>
<td>0.295</td>
</tr>
<tr>
<td>Number of HS codes</td>
<td>3,864</td>
<td></td>
</tr>
</tbody>
</table>

*** p<0.001, ** p<0.01, * p<0.1

Table B.1.: The correlation between per unit weight and f.o.b unit value in the US import data. Estimates for year dummies are not included in the table.

<table>
<thead>
<tr>
<th>Instruments for price and gross weight (equation)</th>
<th>Instruments for shipping cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hummels and Skiba [2004]</td>
<td></td>
</tr>
<tr>
<td>Tariff</td>
<td>Distance</td>
</tr>
<tr>
<td>Per capita GDP</td>
<td>Net weight of shipment</td>
</tr>
<tr>
<td>Present study</td>
<td></td>
</tr>
<tr>
<td>Tariff</td>
<td>Distance</td>
</tr>
<tr>
<td>Per capita GDP</td>
<td>Share of air shipment</td>
</tr>
<tr>
<td>Trade Agreement with US</td>
<td>Openness</td>
</tr>
<tr>
<td>GATT/WTO membership</td>
<td></td>
</tr>
</tbody>
</table>

Table B.2.: Comparison of instruments used in Hummels and Skiba [2004] and the present study. Note that I use gross total weight of shipment (in the freight rate equation) as opposed to Hummels and Skiba who use net total weight of shipment.
### Determinants of shipping cost $\ln f_{ji,t}(h)$ – IV Estimation

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>All Products</th>
<th>Counts</th>
<th>Kilograms</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln p_{ji,t}^{0.81***}^{f.o.b}$</td>
<td>0.81***</td>
<td>0.40***</td>
<td>0.95***</td>
</tr>
<tr>
<td>$\ln WGT_{jih,t}^{0.87***}$</td>
<td>-0.19***</td>
<td>-0.67***</td>
<td>-0.06***</td>
</tr>
<tr>
<td>$\ln DIST_j^{0.33***}$</td>
<td>0.33***</td>
<td>0.53***</td>
<td>0.37***</td>
</tr>
<tr>
<td>$\ln w_{j,t}^{0.87***}$</td>
<td>-0.11***</td>
<td>-0.16***</td>
<td>-0.10***</td>
</tr>
<tr>
<td>$D_{j}^{0.87***}$</td>
<td>-0.14***</td>
<td>-0.08***</td>
<td>-0.23***</td>
</tr>
<tr>
<td>$D_{j}^{0.87***}$</td>
<td>-0.11***</td>
<td>0.05***</td>
<td>-0.27***</td>
</tr>
</tbody>
</table>

**Observations:** 4,250,764 4,250,764 1,688,671 1,688,671 1,153,167 1,153,167  
**R-squared:** 0.59 0.04 0.72 0.70 0.43 -0.39  
**Number of id3:** 73,007 73,007 19,457 19,457 29,739 29,739

**Table B.3:** Determinants of shipping costs (Note: The estimating equation is equation 2.3.9 in the text. Price and quantity are instrumented by regional trade agreements with the US, exporter’s GDP and export’s membership in WTO/GATT).
The table shows the determinants of f.o.b prices with tariff rates (instead of trade agreement with US) as an explanatory variable. The estimating equation is equation 2.3.11 in the text. Shipping costs are instrumented by distance, common language, and contiguity.

### Table B.4: Determinants of imported f.o.b prices with tariff rates (instead of trade agreement with US) as an explanatory variable

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>All Products</th>
<th>Counts</th>
<th>Kilograms</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln f_{ji,t}(h)</td>
<td>0.33*** (0.002)</td>
<td>0.29*** (0.002)***</td>
<td>0.80*** (0.002)</td>
</tr>
<tr>
<td>ln w_{j,t}</td>
<td>0.23*** (0.000)</td>
<td>0.27*** (0.000)***</td>
<td>0.17*** (0.001)</td>
</tr>
<tr>
<td>ln t_{ji,t}(h)</td>
<td>-0.77*** (0.019)</td>
<td>-0.68*** (0.018)</td>
<td>-0.96*** (0.042)</td>
</tr>
<tr>
<td>ln GDP_{j,t}</td>
<td>0.07*** (0.000)</td>
<td>0.03*** (0.001)</td>
<td>0.05*** (0.001)</td>
</tr>
</tbody>
</table>

- **Observations**: 4,757,653 4,757,653 1,895,002 1,895,002 1,337,409 1,337,409
- **Number of HS10-years**: 75,957 75,957 20,094 20,094 31,198 31,198
- **R^2**: 0.47 0.43 0.67 0.67 0.38 0.37

---

i. Rich countries on average demand higher quality products.

ii. Firms charge higher markup in wealthier countries.

Since the Bangladesh exports are concentrated in a small subcategory of commodities (apparel); comparing these exported commodities in terms of their unit value seems acceptable. Therefore it is worthwhile looking at the distribution of the f.o.b unit value of exports across countries and how they compare. Figure 5.1 compares country pairs with similar income levels; but different distances to Bangladesh in terms of the f.o.b unit values of exports from Bangladesh to those countries. There are two observable patterns in these graphs:

i. Distribution of the f.o.b unit value of exports is skewed towards higher unit values, for distant markets.

ii. The distribution of the f.o.b unit value of exports is very condensed for distant markets and dispersed for neighboring markets.

Basically distant countries import higher quality products; but with much less variation in
<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
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<tbody>
<tr>
<td>Ln(GDP per capita of importer)</td>
<td>0.013**</td>
<td>(0.005)</td>
</tr>
<tr>
<td>Ln(Population of importer)</td>
<td>-0.002</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Ln(distance)</td>
<td>0.047***</td>
<td>(0.007)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.667***</td>
<td>(0.092)</td>
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</table>

Observations: 2,619,686
Number of Product-Firm fixed effects: 78,691
Adj. R-squared: 0.006

Robust standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.1

*Table B.5.*: Within firm (and commodity) effects of distance and GDP per capita of importer, on the exported f.o.b unit value of commodities.
quality. Neighboring countries on the other hand import lower qualities on average; but import a wide range of qualities from the very lowest to the very highest.
Appendix C. (Chapter 3)

C.1. Proofs

Proof of Lemma 1

First note again that by definition $\rho_j^i(q) = \rho_j^i \cdot \rho_q^i$. Taking derivatives from $\rho_j^i(q)$ wrt $q$ we will have:

$$\frac{d \rho_j^i(q)}{dq} = \frac{\frac{d \rho_j^i}{dq} c(q) + \sum_{k} w_k \tau_{ik} \rho_k^i \rho_j^i(q)}{\rho_j^i(q)}$$

It’s obvious that $\frac{d \rho_j^i}{dq} < 0$ when $w_j \tau_{ij} > \sum_{k \in \mathcal{J}_Q} w_k \tau_{ik} \cdot \rho_k^i(q)$.

The above equation tells us that $\frac{d \rho_j^i(q)}{dq} > \frac{d \rho_k^i(q)}{dq}$ or in other words $\rho_j^i(q)$ stochastically dominates $\rho_k^i(q)$ when $\tau_{ij} > \tau_{ik}$.

Deriving the (LMC) equation

The labor market clearing condition can be written as

$$\mu N_i = N_i \left( \mu - \sum_j \int_{q \in Q^{ij}} \theta(q) \rho_j^i(q) dq - \sum_j \frac{w_j \tau_{ij}}{w_k} \int_{q \in Q^{ij}} c(q) \rho_j^i(q) dq \right) + \sum_j N_j \int_{q \in Q^{ji}} \tau_{ij} c(q) \rho_j^i(q) dq + \sum_{j \in C} \int_{q \in Q^{ji}} f^{ext} dq - \sum_{j \in C} \int_{q \in Q^{ij}} f^{exp} dq$$

Rearranging (#) we will get
\[
\sum_j \int_{q \in Q^{i_j}} \theta(q) \rho_j^i(q) dq + \sum_j \frac{w_j \tau_j}{n_j} \int_{q \in Q^{i_j}} c(q) \rho_j^i(q) dq = \sum_j N_j \int_{q \in Q^{i_j}} \tau_j c(q) \rho_j^i(q) dq + \sum_{j \in C} n_j^i \int_{q \in Q^{i_j}} f^{ext} dq + \sum n_j^i f^{ext}
\]

From \((FE)\) condition we have

\[
n_j^i f + n_j^i \int_{q \in Q^{i_j}} f^{ext} dq = N_i \int_{q \in Q^{i_j}} \theta(q) \rho_j^i(q) dq \implies \sum_j n_j^i f + \sum_{j \in C} n_j^i \int_{q \in Q^{i_j}} f^{ext} dq = N_i \sum_j \int_{q \in Q^{i_j}} \theta(q) \rho_j^i(q) dq
\]

Plugging the above equation in \((\#)\) will give me

\[
N_i \sum_j \int_{q \in Q^{i_j}} \theta(q) \rho_j^i(q) dq + N_i \sum_j \frac{w_j \tau_j}{n_j} \int_{q \in Q^{i_j}} c(q) \rho_j^i(q) dq = \sum_j N_j \int_{q \in Q^{i_j}} \tau_j c(q) \rho_j^i(q) dq + N_i \sum_j \int_{q \in Q^{i_j}} \theta(q) \rho_j^i(q) dq
\]

\[
\implies \sum_j N_i w_j \tau_j \int_{q \in Q^{i_j}} c(q) \rho_j^i(q) dq = \sum_{j \neq i} N_j w_i \tau_{ji} \int_{q \in Q^{ji}} c_i(q) \rho_j^i(q) dq
\]

**Proof of Lemma 3**

taking derivatives from the profit function wrt \(q\) we will have

\[
\frac{d \pi_j^i(q)}{dq} = \frac{w_i N_i}{n_j^i} \frac{d \theta(q)}{dq} \rho_j^i(q) = \frac{w_i N_i}{n_j^i} \left\{ \theta'(q) - \theta(q) \left( \frac{d}{dq} \frac{w_j \tau_j c(q)}{\theta(q)} - \sum_k d \frac{w_k \tau_k c(q)}{\theta(q)} \rho_k^i(q) \right) \right\} \rho_j^i(q)
\]

Rewriting the above expression will give us

\[
\frac{d \pi_j^i(q)}{dq} = \frac{w_i N_i}{n_j^i} \left\{ \theta'(q) \left( 1 - \theta(q) + \theta(q) \ln \left( \sum_k n_k^i e^{-c_i^j(q) w_k / \theta(q) w_i} \right) \right) + 1 + \sum_k \frac{d}{dq} \frac{w_k c(q)}{\theta(q)} \rho_k^i(q) \right\} \theta(q) \rho_j^i(q)
\]

For the first term on the RHS we have
\[ -\left( \frac{d}{dq} w_j \tau_{ij} c(q) \right) - \sum_k \frac{d}{dq} w_k \tau_{ik} c(q) \rho_{kj} = [\gamma_\theta - \gamma_c] \frac{1}{w_i \theta(q)} \{ w_j \tau_{ij} - \sum_k w_k \tau_{ik} \} \approx [\gamma_\theta - \gamma_c] \frac{1}{w_i \theta(q)} \{ w_j \tau_{ij} - \sum_k \tau_{ik} \} \]

The above inequality is a direct result of assumptions 1 and 2. Moreover we have \( \ln \left( n_k^i \right) - \frac{c(q)}{\theta(q)} \) and as a result

\[ 1 + \theta'(q) \frac{1 - \theta(q)}{\theta(q)} \left( 1 - \theta(q) \right) \ln \left( \sum_k n_k^i \frac{c(q)}{\theta(q)} \right) + \sum_k \frac{d}{dq} w_k c(q) \rho_{kj} = \]

\[ 1 + \gamma_\theta \{ \theta(q) \ln \left( n_k^i \right) + 1 - \theta(q) \} - \gamma_c < 1 + \gamma_\theta \{ \theta(q) \ln \left( n_k^i \right) + 1 - \theta(q) \} - \gamma_c[\mu - \theta(q)] \]

The above inequality holds since \( n_k^i > e^\mu \).

**Proof of Proposition 4**

(i) Taking partial derivative from average quality wrt \( \tau_{ij} \) we have

\[ \frac{\partial q_{ij}^{\text{avg}}}{\partial \tau_{ij}} = \frac{\partial}{\partial \tau_{ij}} \left( \int_{q_{ij}}^{\bar{q}_{ij}} q \rho_j^i(q) dq \right) \frac{\int q \rho_j^i(q) dq}{\int q \rho_j^i(q) dq} + \int_{q_{ij}}^{\bar{q}_{ij}} \frac{\partial \rho_j^i(q)}{\partial \tau_{ij}} \left( \int_{q_{ij}}^{\bar{q}_{ij}} (q - \bar{q}_{ij}) \rho_j^i(q) dq \right) dq \]

\[ = \frac{\partial}{\partial \tau_{ij}} \left( \int_{q_{ij}}^{\bar{q}_{ij}} q \rho_j^i(q) dq \right) \frac{\int q \rho_j^i(q) dq}{\int q \rho_j^i(q) dq} + \int_{q_{ij}}^{\bar{q}_{ij}} \frac{\partial \rho_j^i(q)}{\partial \tau_{ij}} \left( \int_{q_{ij}}^{\bar{q}_{ij}} (q - \bar{q}_{ij}) \rho_j^i(q) dq \right) dq \]

The first term on the right hand side is simply equal to:

\[ \frac{1}{w_i} (\gamma_\theta - \gamma_c) \left( E_{ij}^{q_i} (q_{ij}/\theta(q)) - E_{ij}^{q_i} (q_{ij}/\theta(q)) \right) \]

the above expression is positive given that \( \gamma_\theta > \gamma_c \). For the second term to be positive we need \( \partial \rho_j^i(q)/\partial \tau_{ij} \) to be positive. Given that \( \partial q_{ij}^3/\partial \tau_{ij} = -\partial q_{ij}/\partial \tau_{ij} \mid_{q=q_{ij}} \), \( \partial q_{ij}/\partial \tau_{ij} < 0 \) and \( \partial q_{ij}/\partial q > 0 \) it follows that \( \partial \rho_j^i(q)/\partial \tau_{ij} > 0 \) and hence \( \partial q_{ij}^3/\partial \tau_{ij} > 0 \). Now consider that we continuously decrease a country \( j \)'s distance to \( i \) from \( d_{ij} \) to \( d_{ij-1} \) (the distance of the next closer country) given that \( \partial q_{ij}^3/\partial \tau_{ij} > 0 \); \( q_{ij}^3 \) will continuously decrease and will eventually converge to \( q_{ij}^{\text{avg}} \). and this is
possible if and only if $q_{ij}^{avg} > q_{ij-1}^{avg}$.

Parts (ii) and (iii) are trivial given that $\rho_j^i(q) > \rho_k^i(q) \forall q$ if $\tau_{ij} < \tau_{ik}$. The last result follows from taking derivatives from the $(FE)$ equation wrt to iceberg costs for a given exporter

$$ \frac{1}{n_j^i} \frac{d}{d\tau_{ij}} \int_{q_{ij}}^{\infty} \left\{ \theta(q)\rho_j^i(q)N_i - f_j^{exp} \right\} dq = \frac{1}{(n_j^i)^2} \frac{d}{d\tau_{ij}} \int_{q_{ij}}^{\infty} \left\{ \theta(q)\rho_j^i(q)N_i - f_j^{exp} \right\} dq < 0 \quad (FE) $$

The above equality follows from the fact that $\frac{dp_j^i(q)}{d\tau_{ij}}$, and therefore $\frac{dn_j^i}{d\tau_{ij}} < 0$.

**Proof of Proposition 5**

(i) Taking derivatives wrt $f_j^{ext}$ from the Equilibrium equations we will have

$$ \left\{ \sum_{x_i} \omega_iN_i \int_{q_{ij}}^{\infty} c_i(q) \frac{\partial \rho_j^i(q)}{\partial w_i} dq \right\} \frac{dw_i}{df_j^{ext}} + \sum_{x_i} \omega_iN_i \int_{q_{ij}}^{\infty} c_i(q) \frac{\partial \rho_j^i(q)}{\partial \omega_i} dq \frac{dw_i}{df_j^{ext}} + \frac{\partial}{\partial q} \left\{ \theta(qj^i) \frac{\rho_j^i(qj^i)}{n_j^i} \right\} dqj^i = 0 \quad (ZP) $$

$$ -[1 - \theta(qj^i)] \frac{dw_i}{df_j^{ext}} + \frac{\partial}{\partial q} \left\{ w_j\tau_{ij}c(qj^i) + w_i\theta(qj^i) \right\} \frac{dqj^i}{df_j^{ext}} = 0 \quad (AC) $$

$$ \left\{ \int_{q \in Q_j} \theta(q) \frac{\partial \rho_j^i(q)}{\partial w_i} dq \right\} \frac{dw_i}{df_j^{ext}} + \sum_k \left\{ \int_{q \in Q_j} \theta(q) \frac{\partial \rho_j^i(q)}{\partial n_k^j} dq \right\} \frac{dn_k^j}{df_j^{ext}} + \frac{dqj^i}{df_j^{ext}} \left( \theta(qj^i) \frac{\rho_j^i(qj^i)}{n_j^i} - f_j^{ext} \right) = 0 \quad (FE) $$

First note that $\frac{\partial}{\partial q} \left\{ \theta(qj^i) \frac{\rho_j^i(qj^i)}{n_j^i} \right\} dqj^i = 1$ and therefore $\frac{dqj^i}{df_j^{ext}} > 0$. Also note that $\frac{dw_i}{df_j^{ext}} = \frac{-\tau_{ij}c(q)}{\theta(qj^i) + w_j\theta(qj^i)} \frac{dw_i}{df_j^{ext}} = \Phi^3 \frac{dw_i}{df_j^{ext}}$ where $\Phi^3 < 0$. Also $\frac{\partial}{\partial q} \left\{ w_i c_j(qj^i) + w_i \theta(qj^i) \right\} dqj^i = 0$ which will give us $\frac{dqj^i}{df_j^{ext}} = 0$. On the other hand we have

$$ \frac{\partial \rho_j^i(q)}{\partial n_k^j} = \begin{cases} -\theta_2 \left( \rho_j^i(q)/n_j^i \right) (\rho_k^i(q)/n_k^i) & j \neq k \\ (\theta_2 - 1) \rho_j^i(q)/n_j^i - \theta_2 \rho_j^i(q)^2/n_j^i & j = k \\ \end{cases} $$

In the $(LMC)$ equation since $\frac{\partial \rho_j^i(q)}{\partial n_k^j}/\rho_j^i(q) \propto \frac{1}{n_j^i} \rightarrow 0$ we can neglect the affect of changes in
the number of firms on the labor market clearing condition. Hence the (LMC) equation can be written as

\[
\left\{ \sum_{j \neq i} w_j N_j \int_{q \in Q_i} \tau_{ij} c(q) \frac{\partial \rho_j^i(q)}{\partial w_i} dq \right\} \frac{dw_i}{df_i^{ext}} + \left\{ \sum_{j \neq i} N_j \int_{q \in Q_j} \tau_{ij} c(q) \left( 1 - \tau_{ji} \frac{w_i c(q)}{w_j \theta(q)} \right) \rho_j^i(q) dq \right\} \frac{dw_i}{df_i^{ext}} + \left\{ \sum_{j \neq i} w_i N_j \frac{dq_{ij}}{df_i^{ext}} c_j(q_{ij}) \rho_j^i(q_{ij}) - \frac{dq_{ij}}{df_i^{ext}} c_j(q_{ij}) \rho_j^i(q_{ij}) \right\} = 0
\]

On the RHS \( \Phi_1^i = \sum_{j \neq i} N_j \int_{q \in Q_j} \tau_{ij} c(q) \left( 1 - \tau_{ji} \frac{w_i c(q)}{w_j \theta(q)} \right) \rho_j^i(q) dq < 0 \) because \( c(q) > 1, \theta(q) < 1 \), and from assumption 1 \( w_i t_{j} > w_j \forall j \). The second term on the right hand side is also negative given that \( \frac{dq_{ij}}{df_i^{ext}} > 0 \) and \( \frac{dq_{ij}}{df_i^{ext}} = 0 \forall j \neq i \). Also note that \( \int_{w \in Q} \frac{\partial \phi_i}{\partial w_i} dw = 0 \) and therefore

\[
\int_{\bar{q}}^{q_H} \frac{\partial \rho_j^i}{\partial w_i} dq = - \int_0^{\bar{q}} \frac{\partial \rho_j^i}{\partial w_i} dq > 0
\]

But given that \( \rho_j^i(q) \) is increasing it follows that

\[
\int_{\bar{q}}^{q_H} \frac{\partial \rho_j^i}{\partial w_i} dq > - \int_0^{\bar{q}} \frac{\partial \rho_j^i}{\partial w_i} dq \forall j \neq i \implies \int_0^{q_H} \frac{\partial \rho_j^i}{\partial w_i} dq < 0
\]

As a result \( \sum_{j \neq i} \int_{q \in Q_i} \frac{\partial \rho_j^i(q)}{\partial w_i} dq = - \int_0^{q_H} \frac{\partial \rho_j^i}{\partial w_i} dq > 0 \). Since \( \frac{\partial \rho_j^i(q)}{\partial w_i} \) is increasing in \( q \) and \( \tau_{ij} \), and \( \omega_j \tau_{ij} c(q) \) is also an increasing function of \( q \) and \( \tau_{ij} \) is follows that

\[
\Phi_2^i = \sum_{j \neq i} w_j N_j \int_{q \in Q_i} \tau_{ij} c(q) \frac{\partial \rho_j^i(q)}{\partial w_i} dq > \sum_{j \neq i} \int_{q \in Q_i} \frac{\partial \rho_j^i(q)}{\partial w_i} dq > 0
\]

From the (LMC) equation we know that

\[
(\Phi_2^i - \Phi_1^i - \Phi_2^i) \frac{dw_i}{df_i^{ext}} + \left\{ \frac{dq_{ij}}{df_i^{ext}} c_j(q_{ij}) \rho_j^i(q_{ij}) - \frac{dq_{ij}}{df_i^{ext}} c_j(q_{ij}) \rho_j^i(q_{ij}) \right\} = - \sum_{j \neq i} \frac{dq_{ij}}{df_i^{ext}} c_j(q_{ij}) \rho_j^i(q_{ij}) < 0
\]

Given that \( \frac{d}{df_i^{ext}} \sum_j \int_{2_{ij}} \rho_j^i(q) = 0 \) then we know that \( \left\{ \sum_j \int_{q_{ij}} \frac{\partial \rho_j^i(q)}{\partial w_i} dq \right\} \frac{dw_i}{df_i^{ext}} + \sum_j \frac{dq_{ij}}{df_i^{ext}} \rho_j^i(q_{ij}) = 0 \) and we know that \( \sum_{j \in C} \int_{q_{ij}} \frac{\partial \rho_j^i(q)}{\partial w_i} dq = \int_{w \in Q} \frac{\partial \rho_i}{\partial w_i} dw = 0 \), therefore \( \sum_{j \neq i} \frac{dq_{ij}}{df_i^{ext}} \rho_j^i(q_{ij}) = - \frac{dq_{ij}}{df_i^{ext}} \rho_j^i(q_{ij}) = 0 \)-because \( q_{ij} \) is independent of \( w_i \). Now if \( \frac{dw_i}{df_i^{ext}} > 0 \) from the (AC) equation we will have \( \frac{dq_{ij}}{df_i^{ext}} \geq 0 \), which given that \( \sum_{j \neq i} \frac{dq_{ij}}{df_i^{ext}} \rho_j^i(q_{ij}) = \sum_{j \neq i} \frac{dq_{ij}}{df_i^{ext}} \rho_j^i(q_{ij}) \) and the fact that \( c(q_{ij}) \) and \( \frac{dq_{ij}}{df_i^{ext}} \) are increasing in \( q_{ij} \) will result in \( \sum_{j \neq i} \frac{dq_{ij}}{df_i^{ext}} w_j c_j(q_{ij}) \rho_j^i(q_{ij}) - \frac{dq_{ij}}{df_i^{ext}} c_j(q_{ij}) \rho_j^i(q_{ij}) < 0 \).
\[
\sum_{j \neq i} \frac{dq_{ij}}{dw_i} w_j c_j(q_{ij}) \rho_i(j(q_{ij})) > 0. \] Since \( \Phi_i^2 - \Phi_i^1 > 0 \) this will in turn result in \( (\Phi_i^2 - \Phi_i^1) \frac{dw_i}{df_i^{ext}} + \left\{ \frac{dq_{ij}}{df_i^{ext}} c_j(q_{ij}) \rho_i^2(j(q_{ij})) - \frac{dq_{ij}}{df_i^{ext}} c_j(q_{ij}) \rho_i^1(j(q_{ij})) \right\} > 0 \) which is a contradiction. Therefore we should have \( \frac{dw_i}{df_i^{ext}} < 0 \) - or in other words less technology on the extensive margin will result in lower wages or income per capita. Also note that dropping the negligible terms from the \( (FE) \) equation we have

\[
\left\{ \int_{q \in Q^{i*}} \theta(q) \frac{\partial \rho_i^1(q)/n_i^1}{\partial w_i} dq \right\} \frac{dw_i}{df_i^{ext}} + \frac{d\bar{q}_{ij}}{df_i^{ext}} \left( \theta(\bar{q}_{ij}) \rho_i^1(\bar{q}_{ij})/n_i^1 - f_j^{ext} \right) = \theta_2 \left\{ f + \int_{q \in Q^{i*}} f_j^{ext} dq \right\} \frac{dn_i^1}{df_i^{ext}}
\]

Since \( \frac{\theta(q)/n_i^1}{f + \int_{q \in Q^{i*}} f_j^{ext} dq} \) is increasing in quality and \( \tau_{ij} \) (since it shrinks \( Q^{ij} \)) and \( \frac{\partial \rho_i^1(q)}{\partial w_i} \) is also increasing in quality and \( \tau_{ij} \), we will have \( \sum_{j \neq i} \int_{q \in Q^{i*}} \frac{\theta(q)}{f + \int_{q \in Q^{i*}} f_j^{ext} dq} \frac{\partial \rho_i^1(q)/n_i^1}{\partial w_i} dq > \sum_{j \neq i} \int_{q \in Q^{i*}} \frac{\partial \rho_i^1(q)}{\partial w_i} dq > 0 \). We then will have

\[
(1-\theta_2) \sum_{j \neq i} \frac{dn_i^1}{df_i^{ext}} = \sum_{j \neq i} \left\{ \int_{q \in Q^{i*}} \frac{\theta(q)}{f + \int_{q \in Q^{i*}} f_j^{ext} dq} \frac{\partial \rho_i^1(q)/n_i^1}{\partial w_i} dq \right\} \frac{dw_i}{df_i^{ext}} + \frac{d\bar{q}_{ij}}{df_i^{ext}} \left( \frac{\theta(\bar{q}_{ij}) \rho_i^1(\bar{q}_{ij})/n_i^1 - f_j^{ext}}{f + \int_{q \in Q^{i*}} f_j^{ext} dq} \right) < 0
\]

Because \( \frac{dw_i}{df_i^{ext}} < 0 \) and \( \frac{d\bar{q}_{ij}}{df_i^{ext}} < 0 \). The above inequality tells us that an increase in \( f_i^{ext} \) will make the number of exporting firms to country \( i \) \( (\sum_{j \neq i} n_j^i) \) drops. Also note that the total imports falling happens not because the number of firms drop given that the effect is marginal; but because demand adjusts with wealth and per firm sales will be less in a poor country. Finally the smaller \( \theta_2 \) the bigger the change in the number foreign firms. if \( \theta_2 = 1 \) then any adjustment on demand to wage will be absorbed by domestic firms.

(ii) The effects of \( f_i^{ext} \) on total imports can be captured by taking the derivative of total consumption in country \( i \) wrt \( f_i^{ext} \)

\[
\frac{d}{df_i^{ext}} \left\{ \sum_{j \in C} \int_{q_{ij}}^{q_{ij}} \rho_j^1(q) dq \right\} = \left\{ \sum_{j \in C} \int_{q_{ij}}^{q_{ij}} \frac{\partial \rho_j^1(q)}{\partial w_i} dq \right\} \frac{dw_i}{df_i^{ext}} + \sum_j \frac{dq_{ij}}{df_i^{ext}} \rho_j^1(q_{ij}) - \frac{dq_{ij}}{df_i^{ext}} \rho_j^2(q_{ij}) = 0
\]

Therefore
\[
\frac{dX_i}{df_i^\text{ext}} = \left\{ \sum_{j \neq i} \int_{q_i}^{q_{ij}} \rho_j^i(q) \frac{dq}{\partial q_i} \right\} \frac{dw_i}{df_i^\text{ext}} + \sum_{j \neq i} \frac{d\tilde{q}_i}{df_i^\text{ext}} \rho_j^i(q_i) - \frac{d\tilde{q}_i}{df_i^\text{ext}} \rho_j^i(q_i^j) = \\
- \left\{ \int_{q_i}^{q_{ij}} \rho_j^i(q) \frac{dq}{\partial q_i} \right\} \frac{dw_i}{df_i^\text{ext}} + \sum_{j \neq i} \frac{d\tilde{q}_i}{df_i^\text{ext}} \rho_j^i(q_i) - \frac{d\tilde{q}_i}{df_i^\text{ext}} \rho_j^i(q_i^j) \right\} = - \left\{ \int_{0}^{\tilde{q}_i} \frac{d\rho_j^i(q)}{\partial w_i} \right\} \frac{dw_i}{df_i^\text{ext}} < 0
\]

The above inequality follows from the fact that \( \frac{dw_i}{df_i^\text{ext}} < 0 \), and that \( \frac{d\tilde{q}_i}{dq_j} < 0 \). The value of imports also drops given that when taking derivatives from the (\( LMC \)) equation the right hand side which is exports drops, so should the left hand side. Again since \( \frac{\partial \rho_j^i(q)}{\partial w_i} = \tilde{q}_i \) we can show that \( \frac{d\tilde{q}_i}{df_i^\text{ext}} \sum_{j \neq i} \int_{q_i}^{q_{ij}} \frac{d\rho_j^i(q)}{\partial w_i} < 0 \) or in other words average exports per foreign firm also drop.

(iii) First note that

\[
\frac{d\tilde{q}_i^\text{avg}}{df_i^\text{ext}} = \left\{ \int_{q_i}^{\tilde{q}_i} \frac{q}{\partial q_i} \right\} \frac{dw_i}{df_i^\text{ext}} + \sum_{j \neq i} \frac{d\tilde{q}_i}{df_i^\text{ext}} \rho_j^i(q_i) - \frac{d\tilde{q}_i}{df_i^\text{ext}} \rho_j^i(q_i^j)
\]

Where \( \rho_j^i(q) \) is the total share of exporters in market \( i \), and \( \tilde{q}_i \) and \( q_i^j \) are the lowest and highest exported qualities respectively. Given that \( \sum_{j \neq i} \frac{d\tilde{q}_i}{df_i^\text{ext}} \rho_j^i(q_i) = \sum_{j \neq i} \frac{d\tilde{q}_i}{df_i^\text{ext}} \rho_j^i(q_i^j) > 0 \) and \( \tilde{q}_i > q_i^j \) \( \forall j \) we have \( \sum_{j \neq i} \frac{d\tilde{q}_i}{df_i^\text{ext}} q_i^j \rho_j^i(q_i) - \frac{d\tilde{q}_i}{df_i^\text{ext}} q_i^j \rho_j^i(q_i^j) > 0 \). So to show that \( \frac{d\tilde{q}_i^\text{avg}}{df_i^\text{ext}} < 0 \) it suffices to show that

\[
\int_{q_i}^{\tilde{q}_i} q \frac{\partial \rho_j^i(q)}{\partial q_i} dq > \int_{q_i}^{\tilde{q}_i} q \left( c(q) - \int_{\omega} c(\omega) \rho_j^i(q) \frac{\rho_j^i(q)}{w_i} dq \right) > 0
\]

First it’s straightforward to show that the following inequality holds given that \( \rho_j^i(q) / \rho_j^i(q_i) \) is increasing in \( q \) and \( \rho_j^i(q_i) + \rho_j^i(q) = 1 \)

\[
\frac{\int_{q_i}^{\tilde{q}_i} c(q) \rho_j^i(q) dq}{\int_{q_i}^{\tilde{q}_i} \rho_j^i(q) dq} > \int_{\omega} c(\omega) \rho_j^i(\omega) d\omega
\]

Now it’s straightforward to show that also \( \frac{\int_{q_i}^{\tilde{q}_i} c(q) \rho_j^i(q) dq}{\int_{q_i}^{\tilde{q}_i} \rho_j^i(q) dq} > \int_{\omega} c(\omega) \rho_j^i(\omega) d\omega \). As a result we will have \( \int_{q_i}^{\tilde{q}_i} q \frac{\partial \rho_j^i(q)}{\partial q_i} dq > 0 \) and given that \( \frac{dw_i}{df_i^\text{ext}} < 0 \) it follows that \( \frac{d\tilde{q}_i^\text{avg}}{df_i^\text{ext}} < 0 \).

(v) Imports increase on the extensive margin for countries exporting above average quality \( \tilde{q}_i \). because \( \frac{d\tilde{q}_i}{df_i^\text{ext}} < 0 \).
C.2. Evidence on the relation between comparative advantage and unit value for French and Korean exports

Figure C.2.1 shows the revealed comparative advantage (RCA) of French firms in Germany and the US for all SITC4 manufacturing industries measured in units of number against the average unit value of all goods exported to Germany/US within that industry. The RCA index for country $i$ and good $j$ in country $n$’s market can be defined as:

$$RCA_{in}^j = \frac{V_{in}^j}{V_{in}^W}$$

Where $V_{in}^j$ is the value of the good $j$ exported from country $i$ to country $n$, and $V_{in}^W$ is the value of total exports from country $i$ to country $n$. $V_{in}^W(j)$ and $V_{in}^W$ are the values of exports from the world to country $n$, of good $j$ and all the goods respectively. French firms have comparative advantage in high unit value industries in the distant market; but are comparatively advantaged in the low unit value industries when selling to the neighboring country.

![Image of scatter plots showing the RCA index for French firms exporting to Germany and the US, with fitted values.](image)

**Figure C.2.1:** The scatter plot of the logarithm of revealed comparative advantage (LRCA) for French firms exporting to Germany and the US, in all manufacturing SITC5 industries measured in units of counts, against the average unit value of imports for that industry in that country. The lower panel plots the demand side component of the revealed comparative advantage (ARCA) of French firms.

A high index of revealed comparative advantage could be either due to supply side advantages, or due to advantages coming from consumer taste. To back out the demand component
of comparative advantage (ARCA), I divide the RCA by the technological comparative advantage of the country in that industry. I define technological comparative advantage TCA, of country $i$ in good $j$ as total exports of country $i$ in product category $j$ to total exports of country $i$ in all product categories:

$$TCA^i = \frac{\left(\frac{V^i_W(j)}{V^r_W}\right)}{\left(\frac{V^h_W(j)}{V^r_W}\right)}$$

As seen on the right panel of figure 7 the ARCA is showing an even stronger correlation with the unit value. This can be interpreted as France is comparatively advantaged in high unit value industries in the US because there is relatively more demand for French goods in industries where goods are pricier. The same story holds for Korean firms exporting to Japan and Germany. Figure 8 shows how the RCA and ARCA for Korean exporters in Germany for different industries increases with the average unit value of goods imported within that industry. In the neighboring country, Japan the RCA and ARCA decrease with the average unit value of imports in that industry.
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