Endogenous Vertical Differentiation, Variety, and the Unequal Gains from International Trade[*]

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Abstract

How unequal are the gains from trade? In this paper, I argue that the answer depends crucially on how much exporters vertically differentiate in response to foreign competition and study the consequences of international trade on welfare of consumers across the income distribution. I develop a structural model in which consumer demand for higher-quality goods is non-homothetic and firms endogenously choose the quality of their products. The model can be brought to the data using random coefficients demand estimation techniques and I infer demand and supply parameters for 7,000 highly disaggregated products. I find that competition and market structure strongly influence the quality decisions of firms. Particularly poor households in the EU benefit from trade, but the effect is overstated by about one third when supply side responses are not taken into account.

1   Introduction

The last two decades have seen a tremendous increase in exports from developing countries. China's exports alone have increased twentyfold over the last twenty years, and account now for roughly 13% of worldwide trade flows. Given its sheer magnitude, this trend has not only sparked a discussion on whether or not countries benefit from free trade in general, but if trade is a source of inequality within countries which trade policy could counteract.

Standard trade frameworks assume a representative consumer and therefore incorporate no notion of inequality within a country. There are however two strong arguments for why trade will have asymmetric effects: On one hand, labor from developing countries is a more direct competition to blue collar workers in developed economies and may therefore contribute to the wage gap.[1] On the other hand this might be offset through the expenditure channel: Developing countries typically export cheaper, lower-quality varieties of products which constitute a larger share in the basket of lower-income consumers.

In this paper I focus on the latter channel. Much of the previous literature has focused solely on estimating consumer demand, holding the supply side fixed, which implicitly assumes that the characteristics of a country's products are invariant to international trade. The main contribution of this paper is to relax this assumption, particularly in light of recent evidence suggesting that market structure and competition are important determinants of quality specialization (see e.g. Bloom, Draca, and Van Reenen (2011), and Dingel (2015)). I show that not adequately accounting for supply-side responses significantly overstates how unequal the gains from trade are.

As an example, if Germany, which has a comparative advantage in producing higher-quality goods, were to shut down trade, German consumers would especially lose access to cheaper lower-quality goods produced abroad. On average, this will hurt poorer consumers more than rich ones. However, this also creates incentives for German firms to enter into the lower-quality market segment which was previously dominated by foreign firms. I show that these long run supply side responses greatly reduce how unequal the effects of trade are. Put more generally, international trade allows countries to specialize in producing higher and lower quality goods depending on their comparative advantages. Under an exogenous supply side, these gains from specialization are essentially assumed away.

A major challenge when quantifying the expenditure channel, is that household-

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[1]Despite being a common claim, the empirical evidence on this effect is mixed and subject to an ongoing debate. See for example Goldberg and Pavcnik (2007) or Goldberg (2015) for an extensive literature survey.

level consumption data is rarely available, and if so, it is limited to a single country or a small set of products. This is of particular relevance in this paper, as determining to which degree exporters can actually respond to market conditions requires information on the behavior of the same exporter in multiple markets. My main methodological contribution is to overcome this limitation by developing a demand framework which can be brought to the data using only readily available data on trade flows, quantities and the income distribution in various countries, and at the same time allow inference on the supply side.

My model has four key ingredients: First, consumers are differently productive within and across countries and in turn earn different incomes. Second, demand is non-homothetic in income, i.e. demand for higher-quality varieties is increasing in income. Third, firms in different countries differ in their available production technologies and endogenously choose the quality of their products. Finally, international trade is costly, with both shipping costs and fixed costs of exporting.

Quantifying the consumer gains from trade requires essentially two pieces of information: Consumer preferences and exporters' production technology. The distribution of consumer gains will depend crucially on how different consumers value higher versus lower quality-products as well as on prices and availability of these goods in a country. It is the latter two which are affected by international trade as countries differ in terms of their production possibilities regarding low- and high-quality goods and can hence benefit from specialization. Estimating both household utility and production technologies as well as determining to which degree countries specialize in equilibrium are therefore the essential elements of this paper.

I estimate my model on a dataset of trade flows within and into the European Union as well as matched production data in 7,000 highly disaggregated product categories. Using narrowly defined products is important as it allows me to credibly separate the effects of prices and product quality on consumer demand and welfare. My model predicts a tractable estimation equation which can be estimated similarly to discrete choice random coefficients models of consumer demand in the style of Berry, Levinsohn, and Pakes (1995). Importantly, it can be estimated using only data on market-level expenditure shares, unit values and income distributions, which makes my approach widely applicable.

Information on prices and trade flows of exporters in different markets together with the inferred quality choices allow me then to structurally back out the production possibilities of different countries, i.e. I am able to identify comparative advantages in the production of higher- versus lower-quality varieties. Particularly important in the context of this paper is to understand how the pattern of quality specialization responds to changes in trade costs. For example, in the EU, a high-

quality producer, shutting down trade would predominantly restrict access to lower quality products and hence especially harm lower-income households. At the same time it creates incentives for European firms to switch into producing lower-quality varieties which had previously been produced abroad. Quantifying to which extent EU producers can do so is important in order to understand how unequal the gains from trade are.

I find that the consumer gains from international trade are significantly unequal and counteract income inequality. Within the EU, poorer consumers gain on average 2.87 percentage points (or 53%) more compared to richer consumers as the EU has a comparative advantage in producing high-quality goods. I also find that trade particularly favors poorer consumers in richer economies but has a relatively homogenous effect on consumers in poorer EU countries.

In order to demonstrate the importance of an endogenous supply side, I simulate a shift to autarky with and without supply side responses. I find that with an exogenous supply side, the gap between richer and poorer households would equal almost 5 percentage points compared to 2.87 in the baseline case. Hence, while consumer gains may be highly unequal in the short run, firm responses will substantially mitigate this gap in the long run.

The paper is structured as follows. In the next section I briefly summarize related work. Sections 3 and 4 describe some motivating facts as well as the theoretical model along with its key predictions. In section 4, I lay out my estimation strategy, describe the data, and discuss identification of the model. Section 6 covers the parameter estimates, model fit, and the results of the counterfactual experiments. Section 7 concludes.

2   Related Literature

There is an extensive literature on how unequal the consequences of international trade are. Broadly, these papers can be placed into two categories: (1) The effect of international trade on earnings of workers with different skills and education levels and (2) the effect on the cost of living of different consumer types. Traditionally, the international trade literature has focused more on the first channel (see for example Goldberg and Pavcnik (2007) or Goldberg (2015) for an extensive literature survey).

More recently however, there have been attempts to estimate to which degree trade affects consumer welfare asymmetrically through the expenditure channel. Khandelwal and Fajgelbaum (2014) measure how unequal trade affects consumer welfare based on the almost-ideal demand system (Deaton and Muellbauer (1980)). In their paper however, the supply side is fixed in the sense that countries exogenously

specialize in producing a certain good. In my model, I endogenize this decision, and allow quality specialization by exporters to vary with competition and market structure. The income elasticity of varieties is hence an equilibrium outcome in my model instead of being exogenously given. Further, my framework is not subject to the common drawbacks of the almost-ideal demand system, such as the possibility of negative expenditure shares, and additionally allows direct inference on prices, and the set of available varieties in different countries.

Broda and Romalis (2008) study the heterogeneous impact of Chinese imports on differently rich consumers. Faber (2014) estimates the gains from U.S. imports in Mexico. Both papers use detailed individual-level shopping data which is generally not available for a broad set of countries and goods. In contrast, my approach allows for estimating the unequal gains from trade when only aggregate market level data is available and can therefore be applied to standard international trade datasets and a multitude of countries.

On the supply side, I build on Feenstra and Romalis (2014), who structurally estimate quality choices of firms in different markets. As in their model, I assume that quality is costly to produce, and countries are differently good at producing higher-quality goods. Their model however is based on a representative agent and does therefore not allow statements on unequal consumer gains within countries.

Recent micro evidence supports my hypothesis that endogenous vertical differentiation is quantitatively important for the gains from trade: Khandelwal (2010) estimates product quality for exporters to the U.S. and finds that Chinese import competition had less adverse effects in sectors with large quality heterogeneity. Bloom, Draca, and Van Reenen (2011) make a similar observation and show that manufacturing plants responded to import competition by increasing their R&D investments. Also Amiti and Khandelwal (2011) find evidence for quality upgrading in response to competition from low-wage countries. Using detailed plant-level data, Dingel (2015) shows that home-market demand and skill-abundance are equally important determinants of quality specialization of U.S. firms.

Methodologically, the paper is also related to the literature on non-homothetic consumer demand. Fieler (2011) studies bilateral trade patterns in a model in with two types of goods which differ in terms of their income elasticity in demand. Hummels and Lugovskyy (2008) develop a model of ideal variety in which demand is non-homothetic because richer consumers endogenously decide to pay higher prices to be closer to their ideal variety. Fajgelbaum, Grossman, and Helpman (2011) develop a theoretical model in which the quality of traded differentiated goods and a homogenous outside good are complements in utility. A similar assumption is made by Handbury (2013), who estimates non-homothetic price indexes for U.S. cities us-

ing consumer-level data on grocery purchases. As in her paper, I use a log-logit utility framework governing the decision of consumers between different varieties of a product. I do however extend her framework by explicitly modelling the supply side and adjusting the estimation for the case when only aggregate market level data on consumer income is available.

3   Motivation

In this section, I document empirical facts on trade flows which motivate the setup of my theoretical model as well as the resulting empirical framework.[2] In particular, I want to argue that (1) consumer demand is non-homothetic, (2) countries specialize in producing higher- or lower-quality varieties of products, and (3) there are large unobserved quality differences between exporters.

I use data on trade flows between countries to and within the European Union as well as corresponding unit values within narrowly defined product categories. Eurostat categorizes products into roughly 10,000 8-digit categories. Within these categories, goods are relatively homogeneous in the sense of being similar in terms of their product characteristics. I will describe the data in more detail in section 5. For now however I want to argue that for each of these given products, richer economies in terms of GDP per capita tend to produce and also consume more expensive, higher-quality varieties.
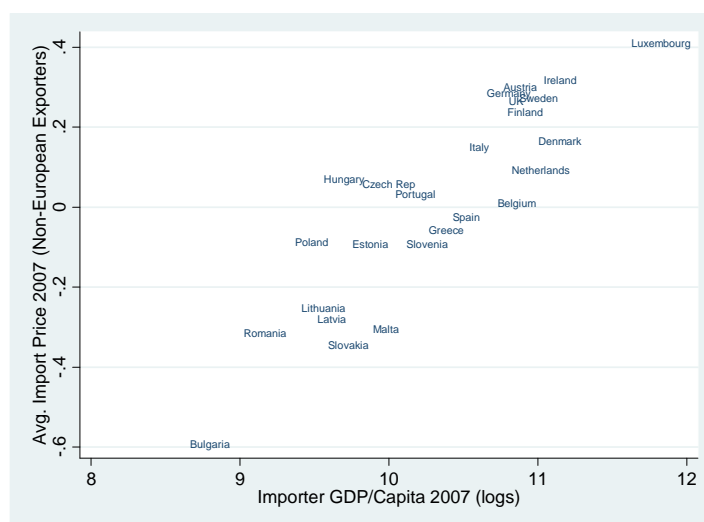

Figure 1: Import prices and importer GDP per capita

Figure 1 shows the first strong empirical regularity in the European trade data: Richer importers in terms of GDP per capita export at higher prices. The figure describes the percentage deviation in the mean import price relative to France. More specifically, it shows the estimates β_j of the regression

$$\log(\text{price}_{jk}) = \beta_0 + \beta_j I\{\text{Importer} = j\} + \varepsilon_{jk} \tag{1}$$

where price_{jk} denotes the average import price in country j in a product category k, weighted by trade volume. I include product fixed effects and exclude within - EU imports to control for the impact of neighboring countries.[3]

I find that the average import price is about 30 - 40% higher in Ireland and Luxembourg compared to France while Bulgaria imports at about 60% lower prices. More generally, there is a strong correlation between importer GDP per capita and the average import price. A regression of average import prices on log GDP per capita of the importer gives a median coefficient of 0.31 with a t-statistic of 8.60 (see table 12).

Figure 2: Import prices and importer GDP per capita

Figure 2 shows that richer countries not only import goods at higher unit values but also export at higher prices. Each point of the plot shows a coefficient β_j in the regression

$$\log(\text{Avg Export Price}_{jk}) = \beta_k + \beta_j I\{\text{Exporter} = j\} + \varepsilon_{jk}, \tag{2}$$

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[3]Otherwise, the average price of exports to Poland would for example be significantly higher as it trades much with Germany, which sells high-priced varieties.

where Avg Export Price$_{jk}$ denotes the average price of exporter j weighted by trade volume when selling a product k to country m. I exclude France in this regression so that β_j can be interpreted as the average percentage deviation of each exporter's prices from those of French firms.

As seen in Figure 2, the highest-priced exports originate in rich countries such as Japan, Switzerland, and the United States.[4] Their exports cost roughly 3 times as much as the lowest-priced varieties. Again, there is a strong correlation between exporter GDP per capita (in logs) and average export prices (in logs) with a coefficient of 0.2134 and a t statistic of 10.06 (see table 14).
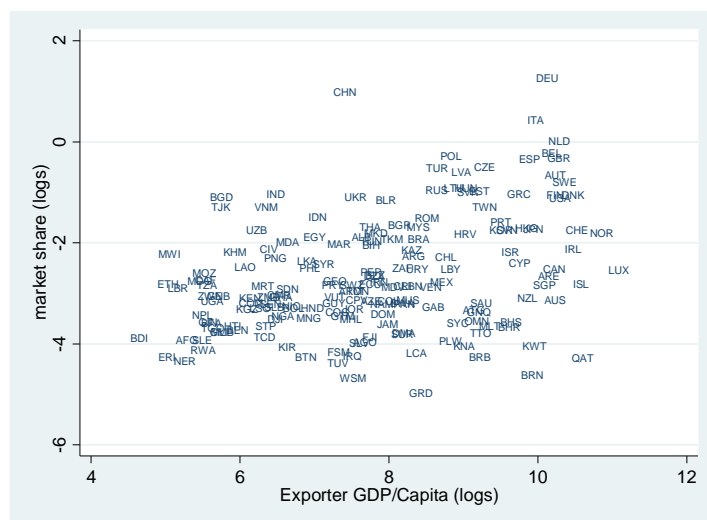

Figure 3: Exporter GDP per capita and market shares

As shown in Figure 3, these higher prices do not appear to translate into lower market shares as one would expect if products were homogeneous. In fact, richer countries have on average slightly higher market shares, despite selling at high unit values. I interpret these two patterns combined as evidence for unobserved quality differences between exporters, even within narrowly defined product categories: Expensive varieties with a high market shares must have some characteristics which make them more attractive to households.

Finally, I document large differences in prices of the same exporter when selling to different markets: The left-hand side of Figure 4 plots the coefficient of variation for export prices of the same exporter selling to different countries. Specifically, the plot shows the coefficients on the country dummies, β_{jk}, of the regression

$$\frac{Sd\left(\text{price}_{jkm}\right)}{Avg\left(\text{price}_{jkm}\right)} = \beta_0 + \beta_{jk}I\{\text{Exporter} = j\} + \varepsilon_{jk}. \tag{3}$$

[4]See table 13 for a detailed overview of export prices for all countries.
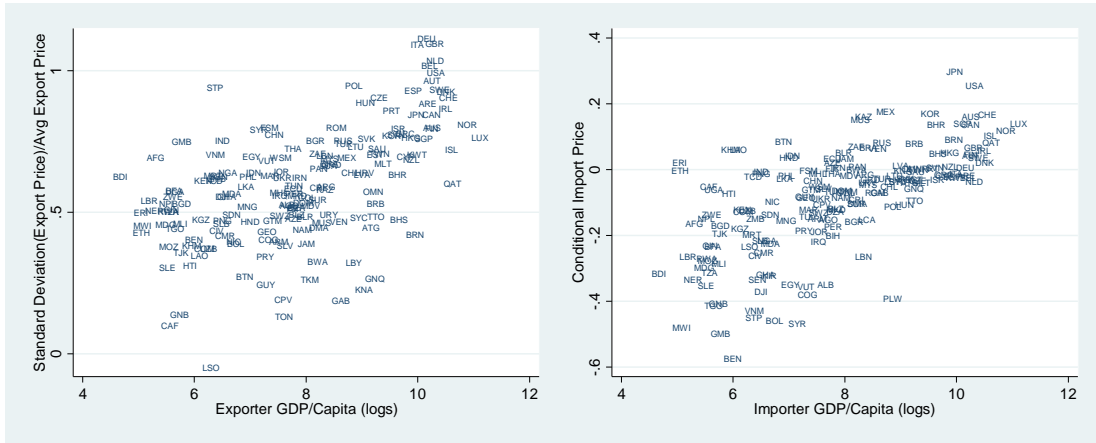
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Figure 4: Coefficient of Variation of Export Prices and Conditional Import Prices

The graph has two main takeaways: First, prices differ significantly across the markets an exporter sells to. For many European exporters for example, the standard deviation is as big as the mean price. Additionally, as shown in the right-hand-side graph of Figure 4, I find that the same exporting country exports at lower prices to poorer countries. On average, the same European exporter will sell products at about 30% higher prices when selling to Japan or the U.S. compared to France, but at about 45% lower prices when selling to Bolivia, Malawi, or Vietnam. Table 15 summarizes the relationship between export prices and the importing country's GDP per capita for each European exporter. On average, a one standard deviation increase in the GDP per capita of the importing country results in an exporter selling at about 17% higher unit values to that country.

I take these observations as suggestive evidence for exporters responding to the conditions in the respective market they are exporting to, particularly to the income distribution. Further, even when controlling for the number of markets sold to, export prices of richer countries have a higher spread than those of poorer countries. This may imply that richer countries can both produce higher and lower-quality products while poorer economies are to some degree restricted in their production possibilities regarding higher-quality varieties.

4   Model

In this section I present a multi-sector model of international trade with four key features, which are motivated by the stylized facts of the previous section. First, consumer demand is non-homothetic, i.e. demand for higher-quality varieties is increasing in income. I model this feature by assuming that services and manufacturing

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goods are complements in utility as in Fajgelbaum, Grossman, and Helpman (2011) and Handbury (2013). Second, countries differ in their available production technologies and endogenously choose the quality of their products. Specifically, I assume that some countries have a comparative advantage in producing higher-quality goods and will select into producing these in equilibrium. Third, trade is costly: There are both per-unit trade costs as well as a fixed cost of selling to a market as in Melitz (2003). Finally, in order to be able to make statements on how unequal the effects of international trade are, each country is populated by a distribution of heterogeneous households which will earn different incomes.

The demand side of the model is similar to Handbury (2013) who estimates a non-homothetic demand system for groceries in the U.S.. I extend her framework by adding a structural supply side in order to analyze to which degree international trade affects the set of available products as well as prices and quality in equilibrium.

4.1 Households

I assume that each country is populated by a distribution of households i which are endowed with l_i units of labor. There are two major types of goods in the economy: A set of differentiated, manufacturing goods, $\mathbf{x}$, and services z. Within the manufacturing sector, there are many different products $k = 1, ..., K$ a household can buy, e.g. cars or coffee, and in equilibrium, each of these products will be consumed at a nonzero amount by each household. I assume that all manufacturing goods are tradable.

Each country produces a different variety $j = 1, ...J$ of these products, e.g. Germany, the U.S., and Japan produce each a certain type of car. These varieties may differ in terms of product quality q_{jk} as well as the price p_{jk} which consumers pay for them. Figure 5 summarizes the consumption decisions of consumers.

I assume that household utility for a variety j is given by

$$u_{jk}^{(i)} = x_{jk} e^{\frac{q_{jk} + \varepsilon_{ijk}}{\alpha(z_i)}} .$$

where x_{jk} denotes the quantity consumed. It is multiplied by a taste shifter which depends on the quality of the product q_{jk} as well as an idiosyncratic valuation of the respective variety, ε_{ijk}. I hence implicitly assume that for example cars made in different countries differ in certain unobservable characteristics which are more or less valued depending on the consumer. Finally, I follow Fajgelbaum, Grossman, and Helpman (2011) and assume that services z and product quality are complements in utility, i.e. the marginal utility of quality is increasing in the consumption of services.
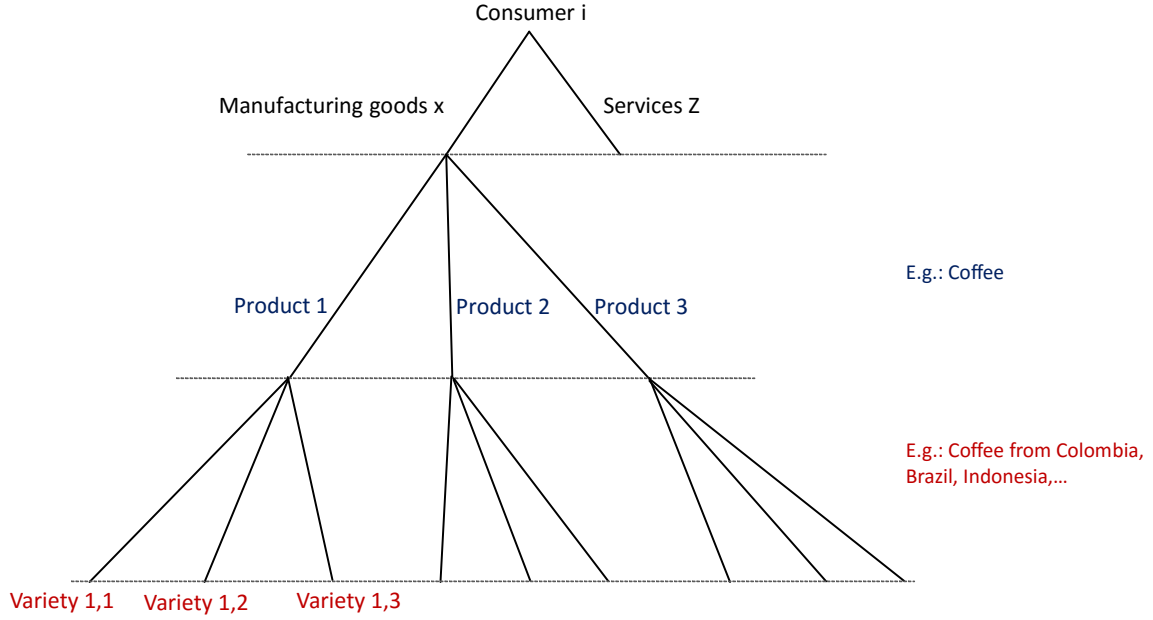
Figure 5: Overview of Consumer Choices

Under this assumption, richer households will have a higher demand for higher quality varieties than poorer households when services are a normal good. Intuitively, this assumption implies for example, that renters of an expensive apartment would benefit more from higher-quality furniture, and vice versa.

Further I assume that the overall utility which a household i receives from buying product k is given by the sum of the individual components $u_{jk}^{(i)}$:

$$u_k^{(i)} = \sum_{j \in J_k} u_{jk}^{(i)}.$$

In this case, it will be optimal for households to buy only one variety of a product. More specifically, households will choose variety j^* if

$$u_{j^*k}^{(i)} \geq u_{jk}^{(i)}$$
$$\Leftrightarrow x_{ij^*k} e^{\frac{q_{j^*k} + \varepsilon_{ij^*k}}{\alpha(z_i)}} \geq x_{ijk} e^{\frac{q_{jk} + \varepsilon_{ijk}}{\alpha(z_i)}}; \qquad \forall j \in J_k,$$

where J_k denotes the set of all varieties that are available to the houseold.

I assume that the idiosyncratic valuation ε_{ijk} can be captured by a distribution. In particular, I make the common assumption that it follows a type 1 extreme value distribution with location parameter $\mu = 0$. This assumption greatly enhances the

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tractability of the household decision. In particular, as shown in Appendix A.1, the probability that a consumer with service consumption z_i chooses variety j^*, can be written in the familiar logit form

$$\Pr(i \mapsto j^*) = \frac{\exp[q_{j^*k} - \alpha(z_i) \ln p_{j^*k}]}{\sum_{j \in J_k} \exp[q_{jk} - \alpha(z_i) \ln p_{jk}]}$$

where p_{jk} denotes the price of a variety j of product k.

This consumer choice probability has a very intuitive interpretation. Varieties with higher quality and lower prices are more attractive to consumers in general and will hence have a higher probability of being chosen. Also notice that the price coefficient α is consumer-specific, a result of quality and service consumption being complements in utility. Ultimately, demand in this framework will be non-homothetic: Higher-income consumers will consume more services.which in turn drives up the marginal utility of quality. As a consequence, the willingness to pay for higher quality varieties will be higher for those consumers.

I assume that the overall utility over manufacturing goods, $U^{(i)}(\mathbf{x}, z)$ is of Cobb-Douglas form with

$$U(\mathbf{x}, z) = \sum_{k=1,\dots K} \omega_k \ln u_k^{(i)}.$$

where $\{\omega_k\}_{k=1}^K$ represent consumption weights for all products $k = 1, \dots K$. Under this specification, households will spend a constant fraction of their manufacturing expenditure on each product category:

$$
\begin{aligned}
E_{ik} \equiv p_{jk} x_{ijk} &= \omega_k(y_i - p_z z_i), & \quad if \ j = j^* \\
&= 0, & \quad \text{otherwise.}
\end{aligned}
$$

Finally, as in Handbury (2013), I do not explicitly model the decision between manufacturing goods and services.[5] I do however, consistent with empirical evidence, allow the share that households spend on services to vary with income, i.e.

$$p_z z_i = \gamma(y_i) y_i \qquad (4)$$

$$p_{jk} x_{ijk} = \omega_k(1 - \gamma(y_i)) y_i. \qquad (5)$$

where $\gamma(y_i) \in (0, 1)$. As richer households typically spend a larger fraction of their income on services, γ will depend positively on y_i.

Putting the pieces together, we can now derive the aggregate expenditure share

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[5] As shown in Handbury (2013), this is fine as long as services are a normal good. As the share of income spent on services is typically even increasing in income, this is arguably a realistic assumption.

of exporter j in market m by taking a weighted average over the individual choice probabilities $\Pr(i \mapsto j^*)$. At this point, I explicitly introduce a subscript m indicating the respective importing country (market) to highlight the channels through which expenditure shares will differ across countries. The expenditure share of exporter j of product k in market m is equal to

$$
\begin{aligned}
s_{jkm} \quad &\equiv \quad \frac{p_{jkm} x_{jkm}}{\sum_{j' \in J_{km}} p_{j'km} x_{j'km}} \\
&= \quad \sum_{i \in I_m} \frac{E_{ikm}}{\sum\limits_{i' \in I_m} E_{i'km}} \Pr(i \mapsto j^*) \\
&= \quad \sum_{i \in I_m} \frac{(1 - \gamma(y_i)) y_i}{\sum\limits_{i' \in I_m} (1 - \gamma(y_{i'})) y_{i'}} \frac{\exp[q_{j^*km} - \alpha(z_i) \ln p_{j^*km}]}{\sum_{j \in J_{km}} \exp[q_{jkm} - \alpha(z_i) \ln p_{jkm}]} \\
&= \quad \sum_{i \in I_m} \frac{(1 - \gamma(y_i)) y_i}{\sum\limits_{i' \in I_m} (1 - \gamma(y_{i'})) y_{i'}} \frac{\exp[q_{j^*km} - \alpha\left(\gamma(y_i) \frac{y_i}{p_z}\right) \ln p_{j^*km}]}{\sum_{j \in J_{km}} \exp[q_{jkm} - \alpha\left(\gamma(y_i) \frac{y_i}{p_z}\right) \ln p_{jkm}]}. \quad (6)
\end{aligned}
$$

E_{ikm} denotes the expenditure of consumer i on product category k and I_m is the set of consumers in market m. The expenditure share of exporter j in market m can hence be expressed sufficiently in terms of household incomes y_i in the respective market, prices p_{jkm}, quality q_{jkm}, as well as the price of services in market m. Non-homotheticity enters this equation through heterogeneity in the effective price coefficient $\alpha\left(\gamma y_i / p_z\right)$ which directly depends on income. Hence, higher- and lower-income consumers differ in terms of how price-elastic they are and therefore in their relative propensity to buy a higher-quality good versus buying a cheaper, lower quality product. It is this trade-off which will make the model consistent with the observation in the data that richer countries import more expensive varieties of products.

Expenditure shares can vary across markets through essentially three channels: First, the set of available varieties J_{km} may differ, i.e. certain countries do not export to others. Second, the same exporting country may offer different products in different markets or sell at different prices. Hence, conditional on J_{km}, equilibrium prices p_{jkm} and qualities q_{jkm} may vary across markets. Finally, even if the set of available products were the same across countries, expenditure shares may differ through demand being non-homothetic. The fact that richer households have a higher demand for high-quality varieties will translate on the aggregate into high-quality producers having higher shares in richer countries.

All three channels will likely depend on each other: The set of available varieties J_{km} will depend on the respective demand in market m, as for example high-quality

producers will face a higher demand in rich countries. In order to run meaningful counterfactuals it will therefore be important to understand how demand and supply jointly determine the set of available products in each market.

4.2 Supply Side

4.2.1 Manufacturing

Each country c is populated by a mass M_c of potential producers which can sell their products abroad and at home. I assume that firms within a country are homogeneous in the sense that they share a common marginal cost function $\widetilde{mc}_{jk}(\cdot)$. In order to simplify the analysis, I additionally assume that they make the same choices regarding prices and quality when selling to a particular market m. This will be the case as long as individual countries differ enough regarding their costs in producing higher-quality varieties. If this cost is sufficiently different, countries will specialize with the result of large across-exporter variation in the produced quality-levels but small within-exporter variation. Also notice that I impose that exporters from the same country make the same choices when selling to a particular market, but not necessarily in general. Hence, I do not exclude the possibility that French exporters for example would want to charge lower prices or offer lower-quality products in poorer countries than in richer ones.[6]

I assume that marginal costs consist of three components. First, quality is costly to produce but this cost may vary by country with some countries being able to produce high-quality varieties in a more efficient way than others. Second, costs depend on wages w_{jk} in the respective home country of firm j. Finally, firms across countries are differently productive for any given quality level. Marginal costs can then generally be written as

$$\widetilde{mc}_{jk} = \widetilde{mc}_{jk}(q_{jkm},\, w_{jk};\, \boldsymbol{\varphi}_{jk})$$

where $\boldsymbol{\varphi}_{jk}$ denotes an exporters productivity in general as well as regarding quality. I further assume that there are constant returns to scale, i.e. the marginal cost is independent of the number of units produced.

Additionally to production costs, shipping of each unit of product k to country m is costly: There are per unit trade costs τ_{jm}^k, so that selling a unit in country m effectively costs $mc_{jkm} = \widetilde{mc}_{jk} + \tau_{jm}^k$. In the empirical application of the model, I will assume an explicit functional form for both $\widetilde{mc}_{jk}$ and trade costs τ_{jm}^k.

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[6]I relax this representative firm assumption when I study the counterfactual scenario of countries moving to autarky as in this case, firms from the same country are much more likely to produce different levels of quality in order to cover demand from low- as well as high-income consumers.

Finally, I follow Melitz (2003) and assume that additional to the variable trade costs τ_{jm}^k, there are also fixed costs f of selling to a market m. Hence, j's total profits when selling to m are equal to

$$\pi_{jkm} = (p_{jkm} - mc_{jkm}) \frac{s_{jkm} E_{km}}{p_{jkm}} - f. \tag{7}$$

Given free entry firms j from country c will in that case enter until net profits are equal to zero, i.e. until

$$\frac{p_{jkm} - mc_{jkm}}{p_{jkm}} s_{jkm} E_{km} = f$$

$$\Leftrightarrow \frac{p_{ckm} - mc_{ckm}}{p_{ckm}} \frac{s_{ckm}}{N_{cm}} E_{km} = f \tag{8}$$

where I have used the assumption that firms from the same country are homogeneous. s_{ckm} denotes the overall expenditure share of firms from country c, which I observe in the data, and N_{cm} is the equilibrium number of firms from c selling in country m.

I follow much of the previous literature, in particular Feenstra and Romalis (2014), and allow firms to simultaneously choose prices p_{jkm} and quality q_{jkm} for each market to which they sell.[7] As derived in detail in Appendix A.2, the first-order condition for prices implies that the markup in percentage terms can be expressed as

$$\frac{p_{ckm} - mc_{ckm}}{mc_{ckm}} = \frac{N_{ckm} \sum\limits_{i \in I_m} E_{ikm} s_{ckm}^{(i)}}{\sum\limits_{i \in I_m} E_{ikm}(-\alpha_i) s_{ckm}^{(i)} \left(N_{ckm} - s_{ckm}^{(i)}\right)}. \tag{9}$$

As for example in Cournot frameworks, the markup will be decreasing in the number of firms N_{ckm} (see Appendix A.2)). In the extreme case of a monopolist, the markup will be infinitively high. This can be easily seen as in this case N_{ckm} is equal to one for the respective country and $s_{ckm}^{(i)}$ equals one for each consumer. The denominator of the right-hand-side of equation (9) is then equal to zero.

This result is mainly due to the Cobb-Douglas assumption that households spend a constant fraction of their income on a product k. In this case, expenditures E_{im}

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[7]Hence exporters can tailor their products to the respective markets they sell to. As noted by Feenstra and Romalis (2014), Volkswagen selling lower-quality versions of their cars in Latin America is an example of such behavior. Departing from this assumption would imply a single first-order condition for quality over all markets instead of one for each (Condition (10)). While this would complicate the estimation, it would certainly be a feasible extension. It would be interesting to see how this changes the results, particularly because in this scenario, home market demand will have a much stronger effect on the quality decisions of firms. I plan to do this in future work, especially in light of empirical evidence that home-market demand is an important determinant of quality specialization (Dingel (2015)).

will be independent of prices and as the monopolist is the only seller, its expenditure share has to be equal to 1. Hence profits will be biggest when $[p_{jm} - mc_{jm}(q_{jm})]/p_{jm}$ is largest, which implies $p_{jm} \longrightarrow \infty$.

The opposite of markups going to zero as N_{ckm} gets large does however generally not hold: As $N_{ckm} \longrightarrow \infty$, the right-hand side becomes $\sum_{i \in I_m} E_{ikm} s_{ckm}^{(i)} / \sum_{i \in I_m} E_{ikm}(-\alpha_i) s_{ckm}^{(i)}$. If households were homogeneous for example, the percentage markup would be equal to the inverse of the price coefficient (in absolute value).

The first-order condition for quality is

$$\frac{\partial mc_{cm}(q_{cm})}{\partial q_{cm}} \frac{s_{cm}}{N_{cm}} = (p_{cm} - mc_{cm}(q_{cm})) \sum_{i \in I_m} \frac{E_{im}}{E_m} \left[\frac{s_{cm}^{(i)}}{N_{cm}} - \left(\frac{s_{cm}^{(i)}}{N_{cm}} \right)^2 \right]. \qquad (10)$$

It has the intuitive interpretation that exporters will increase q_{cm} until the increase in costs (the left-hand side) woud exceed the additional increase in revenue.

4.2.2 Services

As the majority of international trade takes place in the manufacturing and agricultural sector, I model the service sector in a rather simplistic fashion. First, I assume that services z are homogeneous and produced with constant returns to scale and productivity w_c. In that case, the price of services in country c will be equal to the wage. Further, I allow a fraction of services to be freely traded and consider only equilibria in which these services are produced in each country. In that case, the equilibrium price p_z will be equal across countries and can be normalized to 1. Further, the mobility of labor across sectors implies that wages in each country have to be equal to w_c in equilibrium.

These assumptions significantly improve the tractability of the model. In particular, the expression for expenditure shares becomes

$$s_{jkm} = \sum_{i \in I_m} \frac{(1 - \gamma(y_i))y_i}{\sum_{i \in I_m}(1 - \gamma(y_i))y_i} \frac{\exp[q_{j*km} - \alpha(\gamma y_i) \ln p_{j*km}]}{\sum_{j \in J_{km}} \exp[q_{jkm} - \alpha(\gamma y_i) \ln p_{jkm}]}$$

in this case, which depends only on prices and quality of the set of available products J_{km} as well as the income distribution in the respective country. As shown in detail below, this equation can be estimated separately from the supply side whenever instruments for prices are available. The overall expenditure share of firms from

country c can then be written as

$$
\begin{aligned}
s_{ckm} &= \sum_{j \in c,m} s_{jkm} = N_{ckm} s_{jkm} \\
&= N_{ckm} \sum_{i \in I_m} \frac{(1 - \gamma(y_i))y_i}{\sum_{i \in I_m}(1 - \gamma(y_i))y_i} \frac{\exp[q_{c^*km} - \alpha\left(\gamma_i y_i\right) \ln p_{c^*km}]}{\sum_{j \in J_k} \exp[q_{ckm} - \alpha\left(\gamma_i y_i\right) \ln p_{ckm}]} \\
&= \sum_{i \in I_m} \frac{(1 - \gamma_i)y_i}{\sum_{i' \in I_m}(1 - \gamma_{i'})y_{i'}} \frac{\exp(q_{ckm} + \ln N_{ckm} - \alpha(\gamma_i y_i) \ln p_{ckm})}{\sum_{c'} \exp(q_{c'km} + \ln N_{c'km} - \alpha(\gamma_i y_i) \ln p_{c'km})} . (11)
\end{aligned}
$$

The assumption of a freely traded outside good is frequently made in the literature (see for example Chaney (2008)) in order to reduce the complexity of international trade frameworks. It does however come at the cost of potentially abstracting from general equilibrium effects through changes in wages. I therefore do not claim that my framework captures the full extent to which trade affects households in an asymmetric fashion. Instead, the purpose of this paper is to highlight that endogenous differentiation is an important channel affecting the (inequality of) consumer gains from international trade.

4.3   Equilibrium

The equilibrium can be characterized by a set of quantities $\{x_{ckm}, z_{im}\}$, prices $\{p_{ckm}\}$, and quality choices $\{q_{ckm}\}$ such that households maximize utility, firms maximize profits, and the labor and goods markets clear.

Utility maximization results in the conditions regarding product choice (4) and (5), and variety choice (11). The assumption of labor being perfectly mobile across sectors but not across countries together with the assumptions on the service sector imply that wages will be equal to w_c and households will be indifferent between working in each sector.

On the supply side, the free entry condition (8) together with the first-order conditions for prices and quality, (9) and (10), characterize firm behavior in equilibrium. The presence of fixed costs of selling to a market implies the possibility of multiple equilibria. I follow Atkeson and Burstein (2008), and assume that firms enter in a certain order. Given that trade costs have been substantially higher in the past, I select the equilibrium in which firms enter and choose quality in the order of their geographic proximity to the respective country they sell to.[8]

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[8] Atkeson and Burstein (2008) assume that the most productive firms enter first. In my framework, productivity is multidimensional, and it is hence not obvious which notion of productivity to use to predict entry. I do however plan to explore the robustness of my assumption by changing the order of entry. In principle, one may also be agnostic about the order of entry, as for example in Ciliberto and Tamer (2009). I do not follow this approach here though as it would increase the computational burden substantially.

Goods market clearing is evident from the expenditure share equation (11): Given prices and quality set by exporters, households demand quantities **x**, which are readily supplied by exporters. The household budget will hold with equality in equilibrium and Walras' law implies that the labor market has to clear.

5 Data and Estimation

5.1 Data

I use data on trade flows and matched production data for the European Union in highly disaggregated 8 digit product categories between 1989 and 2013. I focus on European data for essentially two reasons. First, Eurostat provides data on domestic production on a high level of disaggregation which can be matched to data on trade flows. As countries generally consume a substantial share of domestic varieties, it is important to account for these when estimating the gains from trade. Second, the assumption that exporters are able to freely choose the quality of their products in the long run is more reasonable for richer economies: Especially as shutting down trade in the EU would imply predominantly exit of lower-quality producers, it is credible that EU countries are capable of producing lower-quality goods (although at potentially high costs). The mirror assumption that e.g. firms from Bangladesh are able to produce luxury cars is arguably a much stronger assumption.

I concord data on trade flows and production using the concordance developed by Van Beveren, Bernard, and Vandenbussche (2012). For extra-EU trade, the data is provided by the respective traders on the basis of customs declarations and covers in principle all imports and exports declared by member states.[9] Intra-EU trade is provided on the basis of so called intrastat declarations. Member states have to ensure that at least 97 % of the country's trade value is covered.

Household income data is taken from Eurostat's database on income and living conditions, which provides data on household income by decile, quartile and the five highest and lowest percentiles for each country and year. I fit these numbers using a log - normal distribution with country-time specific location and scale parameters. As shown in Figure 7 (Appendix B.2) the fitted values match the actual ones very well. Table 16 summarizes the obtained estimates of the parameters of the log-normal normal distribution. The location parameters range from 10.4 for Luxembourg to

---

[9]Before 2010 it was allowed to exclude transactions whose value and net mass were lower than 1000 Euro or 1000 kg. Given that these transactions will mostly cover smaller transactions, I am not concerned that these missing observations will affect my results in a major way. Additionally, as noted by Eurostat, the trend of customs declarations being more and more done electronically has ensured a very high coverage, even when exporters were not legally required to report a transaction.

7.6 for Romania. The scale parameters which reflect the degree of income inequality within a country tends to be small in the Scandinavian countries (0.46 - 0.52) and bigger in Southern and Eastern Europe with values around 0.66 in Portugal or Greece.

In order to allow the relative demand for services to vary with income, I use National Accounts data on consumption of services and other goods from Eurostat. The percentage of service consumption relative to total consumption ranges from 26.6% in Estonia to 56.6% in Spain.

For the estimation I also need data on physical distance: I use the simple geographical distance between the most populated cities as provided by CEPII.[10] Population data is taken from the United Nation's World Population Prospects as well as the National Statistics of Taiwan. Data on GDP per capita is taken from the International Monetary Fund's World Economic Outlook Database.

For my instrumenting strategy I use two additional sources of data. First, I use data on cost, insurance and freight charges of exporters selling to the U.S from 1989 to 2012. This information is collected by the U.S. census bureau and can be downloaded on Peter Schott's website.[11] Finally, data on exchange rates is taken from Feenstra, Inklaar, and Timmer (forthcoming).

5.2   Estimation

In what follows, I drop the product subscripts k to reduce the notational burden. The three main equations which I bring to the data in this section are:

$$s_{cm} = \sum_{i \in I_m} \frac{(1 - \gamma_i) y_i}{\sum_{i' \in I_m} (1 - \gamma_{i'}) y_{i'}} \frac{\exp(q_{cm} + \ln N_{cm} - \alpha(\gamma_i y_i) \ln p_{cm})}{\sum_{j'} \exp(q_{c'm} + \ln N_{c'm} - \alpha(\gamma_i y_i) \ln p_{c'm})} \quad \text{(Exp. Share)}$$

$$N_{cm} = \frac{(p_{cm} - mc_{cm}) s_{cm} E_m}{f p_{cm}} \quad \text{(Free Entry Condition)}$$

$$(q_{jm}^*, p_{jm}^*) = \underset{p_{jm}, q_{jm}}{\arg \max} \; \pi_{jm} = [p_{jm} - mc_{jm}(q_{jm})] \frac{s_{jm} E_m}{p_{jm}} - f. \quad \text{(Profit Maximization)}$$

The estimation steps are as follows: First, I estimate the demand side parameters $\alpha(y_i)$ and infer product quality[12] using data on expenditure shares, unit values and

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[10]Centre d'études prospectives et d'informations internationals

[11]http://faculty.som.yale.edu/peterschott/sub_international.htm. Also, see Schott (2008) for a description of this data.

[12]Quality q_{jm} will at this stage be only jointly identified together with the (log) number of firms N_{cm}.

the income distribution in each country. In order to separate demand from supply side factors I will use an arguably exogenous instrument which shifts the supply curve, holding the demand curve constant.

In the second step, given demand side parameters, I infer marginal costs and the fixed cost of exporting from the first-order conditions for price and quality, as well as the free entry condition.

5.2.1 Demand Side

In order to estimate the above system of equation, I make two functional form assumptions. First, I assume that $\alpha(z_i)$ can be written as:

$$\alpha(z_i) = \widetilde{\alpha}_0 + \widetilde{\alpha}_1 \ln z_i$$

I have two priors for the parameters $\widetilde{\alpha}_0$ and $\widetilde{\alpha}_1$: On the one hand, $\widetilde{\alpha}_0$ should be positive so that the price coefficient will be negative independently of income. On the other hand, $\widetilde{\alpha}_1$ should be negative given the observation in the data that richer countries import higher-price varieties. With $\widetilde{\alpha}_1 < 0$, a higher income and hence service consumption translates into a lower price elasticity and hence a higher relative preference for quality.

Second, I assume that

$$\gamma_i(y_i) = e^{\gamma_0 + \gamma_1 \ln(y_i)}$$

and obtain the parameters γ_0 and γ_1 using information on a country's share spent on services and the respective income distribution.[13] The main estimation equation on the demand side then becomes

$$
\begin{aligned}
s_{cm} &= \sum_{i \in I_m} \frac{E_{im}}{\sum_{i' \in I_m} E_{i'm}} \frac{\exp(q_{cm} + \ln N_{cm} - (\widetilde{\alpha}_0 + \widetilde{\alpha}_1 \ln(e^{\gamma_0 + \gamma_1 \ln(y_i)}y_i)) \ln p_{cm})}{\sum_{j'} \exp(q_{c'm} + \ln N_{c'm} - (\widetilde{\alpha}_0 + \widetilde{\alpha}_1 \ln(e^{\gamma_0 + \gamma_1 \ln(y_i)}y_i)) \ln p_{c'm})}. \\
&= \sum_{i \in I_m} \frac{E_{im}}{\sum_{i' \in I_m} E_{i'm}} \frac{\exp(q_{cm} + \ln N_{cm} - (\alpha_0 + \alpha_1 \ln(y_i)) \ln p_{cm})}{\sum_{j'} \exp(q_{c'm} + \ln N_{c'm} - (\alpha_0 + \alpha_1 \ln(y_i)) \ln p_{c'm})} \quad (12)
\end{aligned}
$$

with $\alpha_0 \equiv \widetilde{\alpha}_0 + \widetilde{\alpha}_1 \gamma_0$ and $\alpha_1 \equiv \widetilde{\alpha}_1(1 + \gamma_1)$. The observables in this equation are s_{cm}, and p_{cm}. I assume that y_i is log-normally distributed and I allow the parameters of this distribution to be different depending on market m, to reflect that countries

---

[13]I infer γ_0 and γ_1 by using that my model predicts that the share of income spent on services in country m equals $p_z z / y = \dfrac{\sum_{i \in I_m} \gamma(y_i) y_i}{\sum_{i \in I_m} y_i} = \dfrac{\sum_{i \in I_m} e^{\gamma_0 + \gamma_1 \ln(y_i)} y_i}{\sum_{i \in I_m} y_i}$. I minimize the distance between right-hand side and left-hand side and get $\gamma_0 = -0.0967$ and $\gamma_1 = 0.0600$ when GDP per capita is denoted in 1000 Euros.

differ in terms of the income distribution:

$$y_i \sim LN(\mu_m, \sigma_m), \quad i \in I_m.$$

As stated above, I obtain μ_m and σ_m by fitting data on income quantiles in each country. Importantly, the resulting distribution fits these quantiles very well as shown in figure 7. In practice, I use 1,000 income draws from the respective distribution for each market when I estimate equation (12) to approximate the income distribution in each country. Increasing this number did not affect my results in a significant way.[14]

Quality q_{cm} and the equilibrium number of firms N_{cm} are not directly observed, and even if the parameters α_0 and α_1 were known, only $q_{cm} + \ln N_{cm}$ would be identified, not its composition. I do not aim to separably identify these two terms in this section but rather want to identify the composit term $\xi_{cm} \equiv q_{cm} + \ln N_{cm}$ as well as the parameters α_0 and α_1. I later use additional information on the overall number of firms together with the supply side equilibrium conditions to decompose ξ_{cm} into quality and the equilibrium number of firms in each market.

Equation (12) can be estimated in a similar fashion to discrete choice random coefficients models of consumer demand in the style of Berry (1994), and Berry, Levinsohn, and Pakes (1995). The term ξ_{cm} in their approach is generally referred to as unobserved heterogeneity of a product, while I follow the recent trade literature, particularly Khandelwal (2010), by calling it quality. The intuition is the same: Whenever, conditional on prices, a variety has a higher expenditure share than another one, it must be of higher quality. More generally, it must have certain characteristics which consumers prefer over others and are hence willing to pay a higher price for.

Identification of α_0 and α_1 requires a valid instrument for p_{cm}. This is necessary as the price will be correlated with the unobserved quality of a product as higher-quality products will typically be more expensive to produce. In order to overcome this identification problem, I assume that quality and entry are long-run choices of a firm and can not adjust as flexibly as prices. In particular, I assume that q_{cm} and N_{cm} are predetermined in the short run but p_{cm} can adjust comparably freely. Under this assumption, exogenous variation in the marginal costs faced by firms will be sufficient to identify α_0 and α_1. I follow Khandelwal (2010) and use shipping costs and exchange rate shocks as instruments for p_{cm}. While exchange rates are equilibrium objects, an individual product category will typically have a very small

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[14]I also demean the resulting draws for $\ln(y_i)$ by subtracting the average log income draw over all markets. This will not affect the resulting estimates for the price coefficients but will make interpreting particular the values for α_1 easier.

impact on the aggregate exchange rate and so changes in exchange rates provide reasonably exogenous shifts in the costs of a firm when selling to market m.

In practice, I normalize the exchange rate of each country versus the U.S. dollar in the first period of my dataset to 1 and use percentage deviations from the value of that year. I also do not have direct data on cif charges for trade flows to the E.U..[15] I therefore construct a measure of trade cost using cif charges for trade flows to the U.S.. In particular, I compute the average charges per kilometer in a given year and weight them by the shipping distance between importing and exporting country. The exact procedure is described in Appendix B.3. My measure of shipping costs is strongly correlated with prices and is decreasing over time. My identifying assumption is that this decline, which disproportionately favors more distant exporters, leads to lower prices over a shorter period of time without immediately affecting entry and quality specialization.

In my baseline specification, I include both the instrument for shipping costs and for exchange rate shocks. I also experimented with using the frequently used instruments in the spirit of Hausmann (1996), which use prices of the same exporter in other markets as an instrument. Including these instruments or not did not change my results in a significant way.

In principle, equation (12) can be estimated by solely using data on prices, expenditure shares and income. However, in order to increase the precision of my estimates, I include exporter fixed effects which capture the average values of $q_{cm} + \ln N_{cm}$ over all years. I also add the logarithm of an exporting country's population as an exogenous shifter of N_{cm}.[16]

Finally, it is well-known that international trade data is subject to measurement error, which is particularly relevant when computing unit values. As some computed unit values are unrealistically high, I trim the data by exluding those values that are 30 times higher than the mean over all exporter-importer trade flows within a product category. Further, while the resulting quality estimates may be too high or too low depending on measurement error, they should not be systematically biased as long as all reporting countries do not systematically over- or understate the values and quantities of traded goods. Additionally, as I estimate production functions such that the predicted quality decisions by firms match the inferred ones on average,

---

[15]In the future I am planning to create a more direct measure by using that exporters typically report trade at their free-on-board (FOB) values, while importers report values including cost, insurance and freight (CIF). The difference therefore provides information on the level of charges faced by exporters.

[16]In Khandelwal (2010), not controlling for country size would frequently identify bigger countries (especially China) as high-quality producers. In my framework this is less of a concern as I explicity allow for $q_{cm} + \ln N_{cm}$ being only jointly identified at this stage. Including population as control did however increase the precision of my estimates for the price coefficient.

individual outliers will still create noise, but will not weight as much as in the case without supply-side responses.

The demand estimation is computationally very demanding, particularly given the number of product categories and markets. Overall, I use more than 30 million observations on trade flows between countries which goes far beyond the usual scale of papers in the industrial organization literature in which random coefficients models of consumer demand have become very common. Traditionally, the estimation of BLP-based frameworks has been very time-consuming as well as unreliable, making a large-scale application of this type of demand system hardly feasible. I therefore benefit greatly from recent advances in the estimation of this type of models, especially, through the use of MPEC (Su and Judd (2012), Dubé, Fox and Su (2012)) which ensures a much more reliable and faster estimation. The reliability is of particular importance here as I need to make sure that my overall results are not driven by incorrect parameter estimates for individual products.

I additionally heavily parallelize the estimation which is possible given that demand for each product category can be estimated separately from each other as well as independently of the supply side. Finally, the use of a C++ based code for BLP increases the speed of the estimation further.[17]

5.2.2 Supply Side

Once the demand side parameters are estimated, i.e. the price coefficients α^0 and α^1 as well as $q_{cm} + \ln N_{cm}$ are identified, I quantify the supply side of the model. The choice variables of firms are prices and qualities of each product along with the decision to enter a market m. These choices will depend on a firm's respective marginal cost as well as market conditions in each country.

As shown in section 4.2, firms behaving optimally will result in the following two first-order conditions for prices and quality:

$$\frac{p_{cm} - mc_{cm}}{mc_{cm}} = \frac{N_{cm} \sum\limits_{i \in I_m} E_{im} s_{cm}^{(i)}}{\sum\limits_{i \in I_m} E_{im}(-\alpha_i) s_{cm}^{(i)} \left(N_{cm} - s_{cm}^{(i)} \right)} \tag{13}$$

$$\frac{\partial mc_{cm}(q_{cm})}{\partial q_{cm}} \frac{s_{cm}}{N_{cm}} = (p_{cm} - mc_{cm}(q_{cm})) \sum\limits_{i \in I_m} \frac{E_{im}}{E_m} \left[\frac{s_{cm}^{(i)}}{N_{cm}} - \left(\frac{s_{cm}^{(i)}}{N_{cm}} \right)^2 \right]. \tag{14}$$

---

[17]I make extensive use of the R package Rcpp (Eddelbuettel and Francois (2011)) which allows integration of R and C++. Especially evaluating the Hessian and Jacobian matrices in C++ provides additional speed gains. Further, I completely rely on open source software, such as the optimizer IPOPT (Wächter and Biegler (2006)) which allows me to overcome server limits, such as the number of available MATLAB or KNITRO licenses. The Rcpp code for BLP, which I have written for this paper, will soon be available on my webpage.

I assume that marginal costs are characterized by the following functional form

$$\widetilde{mc}_{cm} = e^{\widetilde{m}^0_{cm} + m^1_{cm} q_{cm}}$$

where I allow the intercept $\widetilde{m}^0_{cm}$ and m^1_{cm} to be potentially source-destination specific, i.e. it will depend on the respective exporter c when selling to market m. The functional form for marginal costs does not need to be exponential but can for example also be linear or log-linear. A restriction however is that not more than two source-destination specific parameters can be separately identified. But one can easily allow $\widetilde{m}^0_{cm}$ and m^1_{cm} to depend on other observables: Differences in the parameters of this cost functions by exporter c for example will likely stem from differences in labor costs in each source country and from some countries being more productive in producing higher-quality products. Shipping costs are a major argument why the coefficients will not only be source- but source-destination-specific as the shipping distance depends on the respective country-pair. I will evaluate below how the parameters I obtain correlate with these observables.

To be more specific regarding trade costs suppose there are iceberg trade costs $\tau_{cm} > 1$ when a firm from country c sells to destination m, i.e. in order for one unit to arrive in country m, an exporter needs to send τ_{cm} units.[18] In particular, let trade costs be a function of the geographic distance between two countries, in particular:

$$\tau_{cm} = e^{m_{0,d} + m_{1,d} \ln \text{Distance}_{cm}}.$$

The overall marginal cost mc_{cm} will then be equal to

$$
\begin{aligned}
mc_{cm} &= \widetilde{mc}_{cm} \tau_{cm} \\
&= e^{\widetilde{m}^0_{cm} + m^1_{cm} q_{cm}} e^{m_{0,d} + m_{1,d} \ln \text{Distance}_{cm}} \\
&= e^{m^0_{cm} + m^1_{cm} q_{cm}}
\end{aligned}
$$

where $m^0_{cm} \equiv \widetilde{m}^0_{cm} + m_{0,d} + m_{1,d} \ln\text{Distance}_{cm}$.

As I am using aggregate data on trade flows, I do not have data on the number of firms which each trade flow represents. Hence, I have to make an additional assumption on the total number of firms in equilibrium. I assume that the number of firms selling a product k to Germany is a fraction ϕ of the respective number in the United States, i.e.

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[18]Further, I assume that these trade costs are lost, i.e. they for example do not create tariff revenue for the importing country.

$$\sum_{c \in C} N_{c,\text{GER}} = \sum_{c \in C} \frac{(p_{c,\text{GER}} - mc_{c,\text{GER}})s_{c,\text{GER}}E_{\text{GER}}}{fp_{c,\text{GER}}} = \phi \sum_{c \in C} N_{c,\text{USA}}. \qquad (15)$$

In the benchmark specification, I assume that ϕ is proportional to the relative country size measured by the ratio of GDPs of the respective countries.[19] This implies a value of $\phi = \text{GDP}_{\text{GER}}/\text{GDP}_{\text{USA}}{=}0.22$. The robustness of my results regarding this assumption can be easily assessed by for instance imposing a higher or lower number of firms which will be done in future versions of the paper. In any case, a higher value of ϕ for example will scale up the equilibrium number of firms of both low- and high-quality producers and it is not ex ante obvious if this will affect the degree to which the gains from trade are unequal and how supply side responses will affect this inequality.

Equations (13), (14), and (15) pin down marginal costs exactly. To see this notice that (13), and (15) give $C \cdot M + 1$ equations and as conditional on the marginal cost mc_{cm}, N_{cm} is uniquely pinned down by the fixed cost f, it also has $C \cdot M + 1$ unknowns: mc_{cm} and f.

The assumption that fixed costs f do not vary by destination or source country is strong and is likely to matter particularly for separating quality from the number of firms. I therefore plan to relax this assumption in future versions and particularly let fixed costs be a function of country-pair characteristics such as distance, as well as whether or not countries share a common language or religion. This would either require an additional data source on the overall number of firms selling to the respective European markets or could be done through relying on previous estimates.[20]

Once f is known, the number of firms can be backed out via

$$N_{cm} = \frac{(p_{cm} - mc_{cm})s_{cm}E_m}{fp_{cm}}. \qquad (16)$$

This only leaves the exact functional form for mc_{cm} as an unknown but this can be inferred from the first-order condition for quality since

$$m_{cm}^1 mc_{cm} = \frac{(p_{cm} - mc_{cm}(q_{cm}))\sum_{i \in I_m} \frac{E_{im}}{E_m}\left[\frac{s_{cm}^{(i)}}{N_{cm}} - \left(\frac{s_{cm}^{(i)}}{N_{cm}}\right)^2\right]}{s_{cm}/N_{cm}}.$$

Given mc_{cm}, this equation pins down the slope m_{cm}^1. Notice that this equation also implies that m_{cm}^1 will be positive and so quality has to be costly to produce. If

---

[19]In practice, in order not to rely too much on a specific time period, I normalize the average number of firms selling to Germany over all years and quarters in my data to $\phi \cdot \sum_{c \in C} N_{c,\text{USA}}$.

[20]For example, Helpman, Melitz, and Rubinstein (2008) and Feenstra and Romalis (2014) estimate to which extent fixed costs depend on observables for a wide range of products.

this were not the case, each firm would want to produce an infinitively high level of quality. Finally, the intercept m_{cm}^0 can be backed out via

$$m_{cm}^0 = \ln(mc_{cm}) - m_{cm}^1 q_{cm}.$$

The resulting values for m_{cm}^0 and m_{cm}^1 will guarantee that firms optimally choose the observed prices and qualities in the current equilibrium.

One can be completely agnostic regarding what drives differences in m_{cm}^0 and m_{cm}^1 as long as these coefficients are exogenous. However, this condition may be violated particularly through general equilibrium forces: As wages are likely a determinant especially of the intercept m_{cm}^0, changes in trade costs may result in wage adjustments and hence affect production costs. In my model this is ruled out through the assumption of a freely traded good which pins down wages but it may nevertheless be of empirical significance.

Therefore, in order to assess the importance of this feedback effect, I will first regress m_{cm}^0 on measures of labor costs. As many previous papers have quantified the implied changes in wages if countries were to move to autarky, I can use those to realisitically bound any possible changes in m_{cm}^0 through changes in labor costs.

A potentially not immediately obvious but crucial advantage of being able to directly back out the cost parameters from the structural model is that I am able to completely avoid estimating these parameters. This is important as for many parameter values $(m_{cm}^0 \; m_{cm}^1)$ the optimal price and quality choices may very well be infinitively high which significantly complicates the estimation of the supply side as estimators may easily get stuck or arrive at estimates far from observables in the data. Intuitively, when the cost function for example is not convex enough in quality, firms will find it optimal to always choose a higher quality as the corresponding additional cost increase will never result in lower utility.

In my framework, m_{cm}^0 and m_{cm}^1 rationalize the observed firm behavior, and at the same time still allow inference on how costs vary with wages, distance or in principle any variable of interest. I will show below that for example GDP per capita and distance between countries are strong predictors of these parameters.

5.2.3   Counterfactuals

In order to estimate the consumer gains from trade, I compare the current equilibrium to a counterfactual scenario in which all firms are prohibited from exporting to any market m other than their home country. In practice, I exclude these countries from the choice set of consumers which is effectively equivalent to imposing prohibitively

high trade costs, e.g. by letting $m_{1,d} \to \infty$.

The variables which are being reoptimized are prices p_{cm}, qualities q_{cm}, and the number of firms N_{cm}. In practice, I numerically solve for the optimal price and quality choices using the first-order conditions (13) and (14) for each possible discrete realization of N_{cm}. I then compute profits net of fixed costs f (Equation (7)) at these optimal choices and infer the counterfactual number of firms at the point at which profits are still positive but would turn negative if an additional firm entered.

Restricting the equilibrium number of firms to integer values is not necessary and the model can also handle any non-integer value for the N_{cm}. One may therefore do the above procedure with an arbitrarily fine grid. In practice, this will not make a big difference as the equilibrium number of domestic firms in autarky will usually be a large enough number in the sense that rounding to the nearest integer will not be quantitatively significant.

6   Results

I present my results in two steps: First, I focus on an example category to provide a sense of the data, the estimation procedure, obtained parameter estimates and especially the intuition behind the moving parts of the model. Given that the optimal price and quality choices of firms do not have closed form solutions, this example will shed light on the main mechanisms driving vertical differentiation in the model and its implications for the welfare results. Sections 6.2 and 6.3 will then cover the parameter estimates and counterfactual results for the full sample.

6.1   An Example Category

In order to demonstrate the data, estimation procedure, the obtained parameter estimates as well as the welfare results, I begin with an example category before generalizing in the next section. My example category is *Toilet linen and kitchen linen, of terry towelling or similar terry fabrics of cotton*.[21] I chose this category mainly because it is a representative example for the main results on prices, quality and welfare, which hold for the majority of product categories.

Table 1 shows summary statistics for the example category. The 10 biggest exporters cover over 85% of the European market, with Turkey, China, and Portugal being the leading exporters. The average price differs significantly across exporters with Bangladesh or China selling at less than half the price compared to Portugal or Germany. The pattern that higher-wage countries sell at higher prices is common

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[21]Eurostat classifies this under the Combined Nomenclature category 63026000 in the year 2005.

across the majority of product categories, which makes this example category representative in this regard. Also note that price alone cannot fully explain the variation in market shares: Turkey has a higher market share than Egypt, despite selling at higher prices and being roughly equally close to most European markets.

Table 1: Summary Statistics: Example Category

	Market Share	Avg rel. Export Price	GDP/Capita (2013)	Distance to France (km)
Turkey	0.276	1	10744.70	2255
China	0.137	0.63	6569.35	8225
Portugal	0.114	1.36	20663.23	1452
India	0.092	0.65	1414.11	6594
Belgium	0.083	1.44	45537.46	262
Egypt	0.048	0.68	3113.84	3215
Germany	0.032	1.39	43952.01	439
Brazil	0.027	1.17	10957.61	9408
Netherlands	0.023	1.26	47650.90	427
Bangladesh	0.021	0.56	899.30	7916

Market share describes the overall market share in the EU as a whole. The average export price is the simple average over prices per ton over all EU markets relative to Turkey.

Table 2 summarizes the results of the demand and supply estimation. As for most product categories, α_0 is positive and α_1 negative, which implies a negative price elasticity, particularly for lower-income households.

Out of the 10 biggest exporters, Egypt, Bangladesh and India are found to be lower-quality producers while Belgium, Portugal and Turkey are on the other end of the quality distribution. Hence higher-wage countries tend to produce more expensive higher quality products in this product category, which is also more generally the case across product categories.

Table 3 shows the estimates of the parameters of the cost function. As hypothesized in the previous section, these parameters are strongly correlated with GDP per capita of a country as well as the geographical distance between a country pair. I find that richer countries tend to have a lower value for m_0 and a higher one for m_1 in this product category. A greater shipping distance drives particularly m_1 down.

An important implication of the introduction of consumer heterogeneity within countries, is that it effectively segments a market: Some households will have a higher demand for cheaper lower-quality varieties while others have a stronger preference for higher-quality goods. If these differences in tastes are strong (i.e. if demand is highly non-homothetic), firms have incentives to vertically differentiate, even if they face similar production possibilities. This becomes particularly relevant if a country has a

Table 2: Demand Side Parameters: Example Category

α_0 :	1.9456
α_1 :	-0.9284

Low Quality Producers:

	Quality
Egypt	.3898
Bangladesh	.6049
India	.9254

High Quality Producers:

	Quality
Belgium	2.2371
Portugal	2.6725
Turkey	2.7547

strong comparative advantage in producing, for example, higher-quality varieties. In that case, the market for higher-income consumers will be very competitive, which creates incentives to enter into producing cheaper lower quality varieties.

Table 4 illustrates this point by comparing the impact of a counterfactual move of Poland to autarky which has a comparative advantage in producing lower-quality varieties, versus Belgium, a high-quality producer. I find that Poland responds by quality-upgrading which results in higher prices, while for Belgium, the opposite is true.

The supply side response is particularly important for the extent to which international trade affects consumer welfare asymmetrically across the income distribution. Table 5 summarizes the impact of consumer welfare in this specific product category when EU countries counterfactually shifts to autarky under two scenarios:[22] The left column shows the average welfare consequences over all countries on households below the 15th percentile of the income distribution and those above the 85th percentile distribution when firms do not readjust their products. The right column shows the result under endogenous vertical differentiation. Under the first scenario, poorer consumers would lose 7.7 percentage points more, given that EU countries have a comparative advantage in producing higher-quality varieties and exiting countries such as China, India, or Egypt are predominantly lower-quality producers. This difference is narrowed down to 3.3 percentage points through supply side side responses.

Figure 6 demonstrates this point graphically. In particular it shows the average welfare loss of a move to autarky for different consumers depending on their income under an exogenous as well as an endogenous supply side. In both cases, poorer

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[22]For a derivation of the consumer price index, see Appendix A.3. The counterfactuals were computed by setting the weight ω_k for the example category to 1 and all others to 0.

Table 3: Supply Side Parameters: Example Category

Country	$\mathbf{m}_0$	$\mathbf{m}_1$
Turkey	1.16771	0.518279
China	1.52187	0.443353
Portugal	1.46374	0.577579
India	1.9453	0.551773
Belgium	-5.17872	1.2764342
Egypt	-1.21237	0.7121713
Germany	-1.04375	1.0002715
Brazil	1.99468	0.398083
Netherlands	-2.8223	1.1337148
Bangladesh	-1.2111	0.31186
Correlation with Observables:		
GDP/Capita (in logs)	-1.464033	.2400206
	(-15.71)	(29.73)
GDP/Capita	.0001825	-.0000432
Distance	(2.61)	(-9.47)

t-statistics in brackets. The above cost parameters are for $mc_{cm} = m_{cm}^0 + m_{cm}^1 q_{cm}$.

Table 4: Competition and Vertical Differentiation

	% Change in Quality of domestic firms	% Change in Price of domestic firms
Poland moves to Autarky	23.00	+12.65
Belgium moves to Autarky	-36.21	-18.48

Table 5: Counterfactual move to autarky: Change in consumer price index

	no quality adjustment	quality adjustment
Richer Consumers	-18.7522%	-22.6381%
Poorer Consumers	-26.4409%	-25.9970%

All numbers are 2005. Poorer consumers are defined as being at 15th percentile of the income distribution, rich consumers at the 85th percentile. The numbers describe averages over all EU countries.
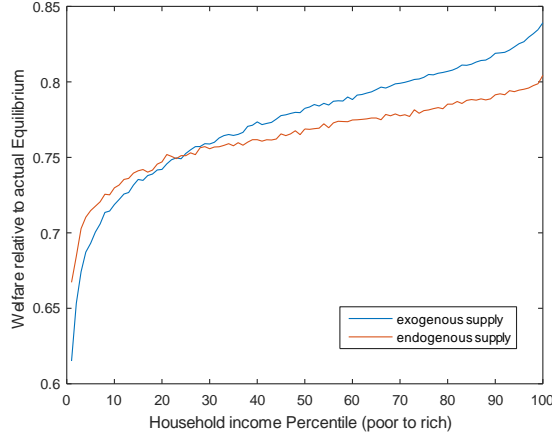
Figure 6: Welfare Losses by Consumer Group

households lose more than rich ones, but this gap is closed to some extent under an endogenous supply side response.

Both curves do not necessarily need to intersect as is the case here. In fact, if one line is above the other varies by product category depending on how strongly markups change in response to a shutdown of trade.

6.2 Full Sample

Caveats   The results presented below are based on a previous estimation procedure for the supply side. This is particularly important in so far as this method had a tendency to generally predict quality downgrading and corresponding price drops of domestic firms when a country moved to autarky. The supply side results below are therefore to be taken with caution and will soon be replaced by those generated by the framework presented above.

Table 6 summarizes the estimates of the demand parameters for the full sample. In most categories, the estimates are consistent with the initial priors: α_0 is positive in 92.6% of the cases which implies a negative price elasticity for the majority of product categories. I also find that α_1, which governs to which degree households differ in terms of their effective demand for quality raltive to price, is negative in well over 80% of the cases. Hence, higher-income consumers behave less price elastically compared to lower income households and will on average demand higher-quality varieties.

Table 6: Summary Statistics: Demand Parameters

Price coefficients:

	Share positive
α_0	92.6%
	Share negative
α_1	82.1%

Own Price Elasticity

25% percentile	-3.8058
50% percentile	-2.3970
75% percentile	-1.1085

The second part of table 6 lists distributions of the implied own price elasticity by the demand side of my model, which can be computed as[23]

$$\frac{\partial x_{jm}}{\partial p_{jm}}\frac{p_{jm}}{x_{jm}} = \sum_{i \in I_m} \frac{E_{im}}{E_m}\left[(\alpha_i + 1)s_{jm}^{(i)} - \alpha_i\left(s_{jm}^{(i)}\right)^2\right]\frac{1}{s_{jm}}$$

I report percentiles of this elasticity over all countries and markets in the year 2005. The median elasticity is -2.40 which is consistent with previous findings in papers which use nested logit frameworks. Handbury (2013) for example finds a median own-price elasticity of -2.09 for a variety of groceries sold in the United States. Berry, Levinsohn and Pakes (1995) find slightly higher price elasticities for cars, ranging from -3.0 to -6.5 depending on the respective car brand. Nevo (2001) estimates elasticities for ready-to-eat cereal brands between -2.3 to -4.3, which is again comparable to my estimates.

Table 7 shows summary statistics of my estimates for product quality for each European exporter. As expected, these estimates are highly correlated with GDP per capita of the respective country.[24] They are further also positively correlated with prices, implying that higher quality-varieties are more costly to produce.

Table 8 shows my estimates for overall marginal costs for the 20 biggest countries in terms of worldwide trade flows (relative to France). Specifically, I regress my estimates for the marginal cost on country dummies as well as market- and product fixed effects and report the coefficients for the respective country.

As described in more detail above, the marginal costs are driven by three key factors: (1) The produced quality level, (2) the overall productivity of a country in a product category, and (3) trade costs. The importance of the latter is evident by

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[23]See Appendix A.5 for the derivation.

[24]This pattern is consistent with the findings of Khandelwal (2010) and Feenstra and Romalis (2014).

Table 7: Quality Estimates of European countries

Country	Quality	Country	Quality
Germany	1.608043	Portugal	-.1304811
Italy	1.596679	Poland	-.1646638
Belgium	1.568292	Romania	-.1707680
Spain	.8608521	Czech Rep.	-.1975584
Luxembourg	.7439827	Lithuania	-.2012076
Netherlands	.6249178	Slovenia	-.2082513
Switzerland	.5867038	Slovakia	-.2913811
Latvia	.4712234	Greece	-.4315810
United Kingdom	.2624893	Bulgaria	-.4935099
Denmark	.2419214	Hungary	-.5438200
Sweden	.2416965	Ukraine	-.6434973
Austria	.2288559	Turkey	-.6458286
Ireland	.2070744	Croatia	-.8617695
Estonia	.0247238	Russia	-.8767532
Finland	-.0695827	Bosnia Herz.	-1.534241
Belarus	-.1020585		

Correlation with GDP per capita:

ln(GDP per capita)	0.3382 (10.45)
ln(price)	0.5182 (5.45)

The graph shows quality estimates for exporting countries when exporting to France. Each value repesents the country fixed effect of a regression of quality on country dummies and market-year controls. In the 2nd part I regress quality on ln(GDP per capita) and (separately) on ln(price). Market-year fixed effects are included, the t-statistic is in brackets.

the fact that 5 out of the 6 most expensive exporters to Europe are from outside the continent. The U.S. and Japan, for example, are additionally among the highest-quality producers in the sample, making them rank among the producers with the highest cost. While the highest quality producers tend to be also the most expensive ones, there are some notable exceptions: Germany specializes in high-quality goods, but has relatively low costs. To a lesser extent this also holds true for Belgium and Spain.

6.3 Counterfactuals

In this part I quantify the consumer gains from trade by computing changes in the household-specific consumer price indexes under the counterfactual scenario of the European Union moving to autarky. As derived in Appendix A.3, the manufacturing

Table 8: Marginal Cost Estimates for Selected Exporters

Country	Marginal Cost	Country	Marginal Cost
United States	1.268552	Spain	-.1705822
United Arabian Emirates	.8829136	Belgium	-.1723616
Switzerland	.8577859	Korea	-.2378967
Japan	.6249939	United Kingdom	-.3154477
Canada	.2491671	Taiwan	-.5361647
Mexico	.1047046	Germany	-.9106106
Netherlands	.0113121	India	-.9696907
France	0	Hongkong	-.9779253
Italy	-.1547871	Russia	-1.083613
Singapore	-.1554336	China	-2.076811

price index for a consumer with service consumption z^* can be computed as

$$\mathbb{P}_{\text{Mfg}}(z^*) = \exp\left(\sum_k \omega_k \left[1 - \ln\frac{\omega_k}{p_k} - \frac{q_k + \varepsilon_{ik}}{\alpha_0 + \alpha_1 \ln z^*}\right]\right)$$

$\mathbb{P}_{\text{Mfg}}(z^*)$ is individual-specific solely through the variety choices that a household makes, i.e. through q_k and p_k of the chosen varieties of each product k. Hence, consumer welfare ultimately depends on the price-quality combination of each available variety in market m. As $\alpha_0 + \alpha_1 \ln z^* > 0$, it is easy to see that price increases raise the overall price index while an increase in the quality of a variety, all else equal, lowers $\mathbb{P}_{\text{Mfg}}(z^*)$. Also notice that the price index depends on ε_{ik}, i.e. the idiosyncratic utility draw of household i. It is through this idiosyncratic term, that households benefit from more variety: Each additional available variety comes with a new draw ε_{ijk}, which if high enough, increases consumer utility, even if it is otherwise equal to other available varieties. Hence, the model captures standard love-for-variety effects as for example present in a CES framework.[25] In order to compute the counterfactuals, I simulate $1,000$ draws of the type 1 extreme value distribution for each consumer and variety and hold these draws constant before and after the policy change.

Table 9 summarizes the effect of international trade on welfare of households at the top and the bottom of the income distribution. On average, richer consumers gain 4.93% from non-EU varieties in the case of exogenous quality. As the EU has a comparative advantage at producing higher-quality varieties, poorer consumers benefit more than richer ones: The difference is on average 4.62 percentage points big. As explicitly seen for the example category, endogenizing quality matters for this

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[25] In fact, when firms are equal in terms of p_{jkm} and q_{jkm} and there is a representative consumer, a discrete choice framework implies the same expenditure function as the CES. See Anderson, De Palma, and Thisse (1987).

Table 9: Change in consumer price index: Full sample

	Without quality adjustment	With quality adjustment
All Consumers (avg)	-7.30%	-6.82%
Richer Consumers	-4.93%	-5.37%
Poorer Consumers	-9.55%	-8.22%
Difference	-4.62%	-2.87%

All numbers are averages over all EU countries. Poorer consumers are defined as being between the 1st and the 15th percentile of the income distribution, rich consumers between the 85th and 100th percentile in the respective country. The numbers describe averages over the respective groups

difference: It shrinks to roughly 2 percentage points, i.e. by 38%. The gains from trade are also on average lower in the case of an exogenous supply side: Averaging over all households implies a 7.30% loss from moving to autarky compared to 6.82% in the endogenous quality case, a difference of about 7%.

The intuition behind these results is similar to the one explained above for the example category: Exporters have incentives to vertically differentiate and the exit of predominantly low-quality producers creates new profit opportunities for EU firms. In this case, EU countries will on average downgrade the quality of their products which partially mitigates the welfare losses to consumers, especially on the lower end of the income distribution. Higher-income consumers will even lose slightly more from a move to autarky when supply side responses are taken into account, as EU countries shift away from their preferred varieties.

Table 10 shows the differences in welfare gains from trade for poor and rich consumers distinguished by country. On average, trade is the most pro-poor in richer countries, which tend to have a comparative advantage in higher-quality varieties. A regression of the difference in welfare gains on log GDP per capita gives a regression coefficient of 0.054 with a t–statistic of 3.28 and an R-squared of 37%. In autarky, poor consumers in these richer economies would particularly lose access to cheaper lower-quality products, which is the main source of cross-country differences. Also notice that for most EU countries, trade is pro-poor, which is due to most EU countries having a comparative advantage in higher-quality products. The exceptions are Hungary, Lithuania, and Slovakia. Generally, trade has a relatively homogenous effect for Eastern Europe but stronger pro-poor effects in the other countries.

Table 10: Welfare Changes by Country

Country	Gains from Trade$_{poor}$ - Gains from Trade$_{rich}$	Country	Gains from Trade$_{poor}$ - Gains from Trade$_{rich}$
Luxembourg	.185550	Poland	.041531
Greece	.107240	Czech Republic	.039381
Ireland	.088684	Spain	.037628
Denmark	.088379	Estonia	.018999
Belgium	.086511	Bulgaria	.011159
Sweden	.083863	Cyprus	.010925
Finland	.079866	Slovenia	.005334
Italy	.078186	Latvia	.004689
Austria	.076887	Romania	.003536
Netherlands	.067052	United Kingdom	.001772
France	.057163	Hungary	-.001923
Portugal	.056933	Lithuania	-.022841
Germany	.048831	Slovakia	-.236680

Gains from Trade$_{poor}$ describe the average percentage welfare change of the bottom 15 % of the income distribution in the respective country. Gains from Trade$_{rich}$ denotes the welfare change for the top 15%.

7 Conclusions

In this paper, I have developed a framework to study the unequal consumer gains from international trade under endogenous quality specialization. I have shown that in the short run, international trade can have highly unequal effects on consumer welfare. In the long run however, when domestic firms can adjust which type of products they offer, consumer gains become much more equal. These results are important given the common claim that international trade increases inequality within countries, which has been frequently used as an argument for more protection. While I still find that trade favors poorer consumers in developed countries, supply side adjustments and competition appear to significantly mitigate the impact of trade on inequality in consumer welfare.

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Appendices

A   Derivations

A.1   Household Decision

A.1.1   Variety Choice

In this part, I show that when household utility for variety j is given by

$$u_{jk}^{(i)} = x_{ijk}e^{\frac{q_{jk}+\varepsilon_{ijk}}{\alpha(z_i)}},$$

the resulting probability that a household with serice consumption z_i will buy variety j^* will be

$$\Pr(i \mapsto j^*) = \frac{\exp[q_{j^*k} - \alpha(z_i)\ln p_{j^*k}]}{\sum_{j \in J_k} \exp[q_{jk} - \alpha(z_i)\ln p_{jk}]}$$

when ε_{ijk} follows a type 1 extreme value distribution. Generally, consumers will choose variety j^* if

$$
\begin{aligned}
u_{j^*k}^{(i)} &\geq u_{jk}^{(i)} \\
x_{j^*k}e^{\frac{q_{j^*k}+\varepsilon_{ij^*k}}{\alpha(z_i)}} &\geq x_{jk}e^{\frac{q_{jk}+\varepsilon_{ijk}}{\alpha(z_i)}} \\
E_{ij^*k}\frac{e^{\frac{q_{j^*k}+\varepsilon_{ij^*k}}{\alpha(z_i)}}}{p_{j^*k}} &\geq E_{ijk}\frac{e^{\frac{q_{jk}+\varepsilon_{ijk}}{\alpha(z_i)}}}{p_{jk}}
\end{aligned}
$$

where E_{ijk} denotes the expenditure which a consumer spends on variety j. The term $\exp[q_{jk} + \varepsilon_{ijk}/\alpha(z_i)]/p_{jk}$ represents the utility per dollar a household receives when he chooses variety j. Ultimately households will want to choose the variety which maximizes this expression andit will be unnecessary to explicitly need to keep track of expenditures E_{ijk}.[26] Hence, taking logs, consumers will optimally choose variety j^* if

$$
\begin{aligned}
\frac{q_{j^*k}+\varepsilon_{ij^*k}}{\alpha(z_i)} - \ln p_{j^*k} &\geq \max_{j \in J_k}\left(\frac{q_{jk}+\varepsilon_{ijk}}{\alpha(z_i)} - \ln p_{jk}\right) \\
\Leftrightarrow q_{j^*k} + \varepsilon_{ij^*k} - \alpha(z_i)\ln p_{j^*k} &\geq \max_{j \in J_k}\left(q_{jk} + \varepsilon_{ijk} - \alpha(z_i)\ln p_{jk}\right).
\end{aligned}
$$

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[26]Given that utility over different products is of Cobb-Douglas form, the optimal expenditure on a product will in any case be independent of the optimal variety and hence $E_{ijk} = E_{ik}, \forall j \in J_k$.

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In order to derive the optimal decision rule, first note that if ε_{ijk} follows a type 1 extreme value distribution, then

$$\varepsilon_{ijk} + q_{jk} - \alpha(z_i) \ln p_{jk}$$

follows the same distribution with location parameter $q_{jk} - \alpha(z_i) \ln p_{jk}$. More importantly, the maximum over N T1EV distributed variables u_j with location parameters v_j is again T1EV distributed, as

$$\Pr(\max\{u_j\} < x) = \prod_{j=1}^{N} \Pr(u_j < x)$$

$$= \prod_{j=1}^{N} e^{-e^{-(x-v_j)}} = e^{-\sum_{j=1}^{N} e^{-(x-v_j)}} = e^{-\sum_{j=1}^{N} e^{-x+v_j}}$$

$$= e^{-e^{-x} \sum_{j=1}^{N} e^{v_j}} = e^{-e^{-x} e^{\left[\log\left(\sum_{j=1}^{N} e^{v_j}\right)\right]}}$$

$$= e^{-e^{-x} e^{v}} = e^{-e^{-(x-v)}}.$$

with location parameter

$$v \equiv \log\left(\sum_{j=1}^{N} e^{v_j}\right).$$

Finally, the difference between two T1EV distributed random variables follows a logisitic distribution with $\mu = 0$ and $\sigma = 1$.[27] Using these results we can derive the household's choice probability:

$$\Pr\left(\varepsilon_{ij*k} + q_{j*k} - \alpha(z_i) \ln p_{j*k} \geq \max\{\varepsilon_{ijk} + q_{jk} - \alpha(z_i) \ln p_{jk}\}\right)$$
$$= \Pr\left(\varepsilon_{ij*k} + q_{j*k} - \alpha(z_i) \ln p_{j*k} \geq \varepsilon_{ijk} + \log\left(\sum_{j=1}^{J_k} e^{q_{jk} - \alpha(z_i) \ln p_{jk}}\right)\right)$$
$$= \Pr\left(\varepsilon_{ij*k} + q_{j*k} - \alpha(z_i) \ln p_{j*k} \geq \varepsilon_{ijk} + \log\left(\sum_{j=1}^{J_k} e^{q_{jk} - \alpha(z_i) \ln p_{jk}}\right)\right)$$
$$= \Pr\left(\varepsilon_{ijk} - \varepsilon_{ij*k} \leq q_{j*k} - \alpha(z_i) \ln p_{j*k} - \log\left(\sum_{j=1}^{J_k} e^{q_{jk} - \alpha(z_i) \ln p_{jk}}\right)\right)$$
$$= \frac{1}{1 + \exp\left[q_{j*k} - \alpha(z_i) \ln p_{j*k} - \log\left(\sum_{j=1}^{J_k} e^{q_{jk} - \alpha(z_i) \ln p_{jk}}\right)\right]}$$
$$= \frac{\exp[q_{j*k} - \alpha(z_i) \ln p_{j*k}]}{\sum_{j \in J_k} \exp[q_{jk} - \alpha(z_i) \ln p_{jk}]}$$

which is the familiar logit expression.

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[27]The cdf of the logistic distribution is $\dfrac{1}{1 + e^{\frac{x-\mu}{\sigma}}}$

A.2 Firm Choices

A.2.1 Prices

Firm profits are given by

$$
\begin{aligned}
\pi_{jm} &= [p_{jm} - mc_{jm}(q_{jm})]\frac{s_{jm}}{p_{jm}}E_m + \varepsilon_{jml} - f \\
&= [p_{jm} - mc_{jm}(q_{jm})]\sum_{i \in I_m}\frac{E_{im}}{E_m}s_{jm}^{(i)}\frac{E_m}{p_{jm}} + \varepsilon_{jml} - f \\
&= [p_{jm} - mc_{jm}(q_{jm})]\sum_{i \in I_m}\frac{E_{im}}{E_m}\frac{\exp[q_{jm} - \alpha(z_i)\ln p_{jm}]}{\sum_{j' \in J_k}\exp[q_{j'm} - \alpha(z_i)\ln p_{j'm}]}\frac{E_m}{p_{jm}} + \varepsilon_{jml} - f \\
&= \frac{p_{jm} - mc_{jm}(q_{jm})}{p_{jm}}\sum_{i \in I_m}E_{im}\frac{\exp[q_{jm} - \alpha(z_i)\ln p_{jm}]}{\sum_{j' \in J_k}\exp[q_{j'm} - \alpha(z_i)\ln p_{j'm}]} + \varepsilon_{jml} - f.
\end{aligned}
$$

The partial derivative of profits with respect to price p_{jm} is

$$
\begin{aligned}
\frac{\partial \pi_{jm}}{\partial p_{jm}} &= \frac{mc_{jm}(q_{jm})}{p_{jm}^2}\sum_{i \in I_m}E_{im}\frac{\exp[q_{jm} - \alpha(z_i)\ln p_{jm}]}{\sum_{j' \in J_k}\exp[q_{j'm} - \alpha(z_i)\ln p_{j'm}]} \\
&+ \frac{p_{jm} - mc_{jm}(q_{jm})}{p_{jm}}\sum_{i \in I_m}E_{im}\frac{\frac{\alpha(z_i)}{p_{jm}}\exp[q_{jm} - \alpha_i \ln p_{jm}]\sum_{j' \in J_k}\exp[q_{j'm} - \alpha_i \ln p_{j'm}] - \frac{\alpha_i}{p_{jm}}\exp[q_{jm} - \alpha_i \ln p_{jm}]^2}{\left(\sum_{j' \in J_k}\exp[q_{j'm} - \alpha_i \ln p_{j'm}]\right)^2} \\
&= \frac{mc_{jm}(q_{jm})}{p_{jm}^2}\sum_{i \in I_m}E_{im}s_{jm}^{(i)} \\
&+ \frac{p_{jm} - mc_{jm}(q_{jm})}{p_{jm}}\sum_{i \in I_m}E_{im}\frac{\alpha(z_i)}{p_{jm}}\left[s_{jm}^{(i)} - \left(s_{jm}^{(i)}\right)^2\right] = 0
\end{aligned}
$$

where I have used the definition for the probability that household i chooses variety j which is equal to

$$
s_{jm}^{(i)} = \frac{\exp[q_{jm} - \alpha(z_i)\ln p_{jm}]}{\sum_{j' \in J_k}\exp[q_{j'm} - \alpha(z_i)\ln p_{j'm}]}.
$$

We can then solve for the percentage markup through

$$\frac{\partial \pi_{jm}}{\partial p_{jm}} = 0$$

$$\Leftrightarrow \frac{mc_{jm}(q_{jm})}{p_{jm}^2} \sum_{i \in I_m} E_{im} s_{jm}^{(i)} = -\frac{p_{jm} - mc_{jm}(q_{jm})}{p_{jm}} \sum_{i \in I_m} E_{im} \frac{\alpha_i}{p_{jm}} \left[s_{jm}^{(i)} - \left(s_{jm}^{(i)} \right)^2 \right]$$

$$\Leftrightarrow mc_{jm}(q_{jm}) \sum_{i \in I_m} E_{im} s_{jm}^{(i)} = -(p_{jm} - mc_{jm}(q_{jm})) \sum_{i \in I_m} E_{im} \alpha_i \left[s_{jm}^{(i)} - \left(s_{jm}^{(i)} \right)^2 \right]$$

$$\Leftrightarrow \frac{p_{jm} - mc_{jm}(q_{jm})}{mc_{jm}(q_{jm})} = -\frac{\sum\limits_{i \in I_m} E_{im} s_{jm}^{(i)}}{\sum\limits_{i \in I_m} E_{im} \alpha_i \left[s_{jm}^{(i)} - \left(s_{jm}^{(i)} \right)^2 \right]}$$

$$\Leftrightarrow \frac{p_{jm} - mc_{jm}(q_{jm})}{mc_{jm}(q_{jm})} = \frac{\sum\limits_{i \in I_m} E_{im} s_{jm}^{(i)}}{\sum\limits_{i \in I_m} E_{im} (-\alpha_i) s_{jm}^{(i)} \left(1 - s_{jm}^{(i)} \right)}.$$

Under the assumption that firms from the same country c make the same choices when selling to market c, it will then be true that

$$\frac{p_{cm} - mc_{cm}(q_{cm})}{mc_{cm}(q_{cm})} = \frac{\sum\limits_{i \in I_m} E_{im} s_{cm}^{(i)} / N_{cm}}{\sum\limits_{i \in I_m} E_{im} (-\alpha_i) s_{cm}^{(i)} / N_{cm} \left(1 - s_{cm}^{(i)} / N_{cm} \right)}$$

$$= \frac{N_{cm} \sum\limits_{i \in I_m} E_{im} s_{cm}^{(i)}}{\sum\limits_{i \in I_m} E_{im} (-\alpha_i) s_{cm}^{(i)} \left(N_{cm} - s_{cm}^{(i)} \right)}$$

with N_{cm} being the equilibrium number of firms selling to market m.

As for example in Cournot frameworks, the markup will be decreasing in the number of firms as

$$\frac{\partial}{\partial N_{cm}} \frac{p_{cm} - mc_{cm}(q_{cm})}{mc_{cm}(q_{cm})}$$

$$= \frac{\sum\limits_{i \in I_m} E_{im} s_{jm}^{(i)} \sum\limits_{i \in I_m} E_{im} (-\alpha_i) s_{cm}^{(i)} \left(N_{cm} - s_{cm}^{(i)} \right) - N_{cm} \sum\limits_{i \in I_m} E_{im} s_{jm}^{(i)} \sum\limits_{i \in I_m} E_{im} (-\alpha_i) s_{cm}^{(i)}}{\left[\sum\limits_{i \in I_m} E_{im} (-\alpha_i) s_{cm}^{(i)} \left(N_{cm} - s_{cm}^{(i)} \right) \right]^2}$$

$$= -\frac{\sum\limits_{i \in I_m} E_{im} s_{jm}^{(i)} \sum\limits_{i \in I_m} E_{im} (-\alpha_i) s_{cm}^{(i)} s_{cm}^{(i)}}{\left[\sum\limits_{i \in I_m} E_{im} (-\alpha_i) s_{cm}^{(i)} \left(N_{cm} - s_{cm}^{(i)} \right) \right]^2} < 0$$

Also notice that if a firm is a monopolist, it will charge an infinitively high markup as in this case

$$\frac{p_{cm} - mc_{cm}(q_{cm})}{mc_{cm}(q_{cm})} = \frac{\sum\limits_{i \in I_m} E_{im}}{\sum\limits_{i \in I_m} E_{im}(-\alpha_i)(1-1)} \longrightarrow \infty.$$

This result is mainly due to the Cobb-Douglas assumption that households spend a constant fraction of their income on a product k. In this case, expenditures E_{im} will be independent of prices and as the monopolist is the only seller, its expenditure share has to be equal to 1. Hence profits will be biggest if $[p_{jm} - mc_{jm}(q_{jm})]/p_{jm}$ is largest, which implies $p_{jm} \longrightarrow \infty$.

A.2.2 Quality

The first-order condition with respect to quality is

$$\begin{aligned}
\frac{\partial \pi_{jm}}{\partial q_{jm}} &= -\frac{1}{p_{jm}} \frac{\partial mc_{jm}(q_{jm})}{\partial q_{jm}} \sum_{i \in I_m} E_{im} \frac{\exp[q_{jm} - \alpha_i \ln p_{jm}]}{\sum_{j' \in J_k} \exp[q_{j'm} - \alpha_i \ln p_{j'm}]} \\
&+ \frac{p_{jm} - mc_{jm}(q_{jm})}{p_{jm}} \sum_{i \in I_m} E_{im} \frac{\exp[q_{jm} - \alpha_i \ln p_{jm}] \sum_{j' \in J_k} \exp[q_{j'm} - \alpha_i \ln p_{j'm}] - (\exp[q_{jm} - \alpha_i \ln p_{jm}])^2}{\left(\sum_{j' \in J_k} \exp[q_{j'm} - \alpha_i \ln p_{j'm}]\right)^2} \\
&= -\frac{1}{p_{jm}} \frac{\partial mc_{jm}(q_{jm})}{\partial q_{jm}} \sum_{i \in I_m} E_{im} s_{jm}^{(i)} \\
&+ \frac{p_{jm} - mc_{jm}(q_{jm})}{p_{jm}} \sum_{i \in I_m} E_{im} \left[s_{jm}^{(i)} - \left(s_{jm}^{(i)} \right)^2 \right] = 0
\end{aligned}$$

and so

$$\begin{aligned}
& \frac{\partial mc_{jm}(q_{jm})}{\partial q_{jm}} \sum_{i \in I_m} E_{im} s_{jm}^{(i)} = (p_{jm} - mc_{jm}(q_{jm})) \sum_{i \in I_m} E_{im} \left[s_{jm}^{(i)} - \left(s_{jm}^{(i)} \right)^2 \right] \\
\Leftrightarrow & \frac{\partial mc_{jm}(q_{jm})}{\partial q_{jm}} \sum_{i \in I_m} \frac{E_{im}}{E_m} s_{jm}^{(i)} = (p_{jm} - mc_{jm}(q_{jm})) \sum_{i \in I_m} \frac{E_{im}}{E_m} \left[s_{jm}^{(i)} - \left(s_{jm}^{(i)} \right)^2 \right] \\
\Leftrightarrow & \frac{\partial mc_{jm}(q_{jm})}{\partial q_{jm}} s_{jm} = (p_{jm} - mc_{jm}(q_{jm})) \sum_{i \in I_m} \frac{E_{im}}{E_m} \left[s_{jm}^{(i)} - \left(s_{jm}^{(i)} \right)^2 \right].
\end{aligned}$$

Intuitively, the left-hand side describes the additional cost of increasing quality and the right-hand side the additional profit through a greater number of units sold. Under the assumption of a representative firm in country c, this expression can be

written as

$$\frac{\partial mc_{cm}(q_{cm})}{\partial q_{cm}} \frac{s_{cm}}{N_{cm}} = (p_{cm} - mc_{cm}(q_{cm})) \sum_{i \in I_m} \frac{E_{im}}{E_m} \left[\frac{s_{cm}^{(i)}}{N_{cm}} - \left(\frac{s_{cm}^{(i)}}{N_{cm}} \right)^2 \right]$$

$$\Leftrightarrow \frac{\partial mc_{cm}(q_{cm})}{\partial q_{cm}} N_{cm} s_{cm} = (p_{cm} - mc_{cm}(q_{cm})) \sum_{i \in I_m} \frac{E_{im}}{E_m} \left[N_{cm} s_{cm}^{(i)} - \left(s_{cm}^{(i)} \right)^2 \right]$$

A.3 Price Index

In this section, I derive price indexes for each consumer i with income y_i, living in country m. First, the indirect utility of a consumer i can be written as

$$
\begin{aligned}
V^{(i)} &= U_{\text{Mfg}} + u(z^*) \\
&= \sum_k \omega_k \ln x_k^* e^{\frac{q_k + \varepsilon_{ik}}{\alpha_0 + \alpha_1 \ln z^*}} + u(z^*)
\end{aligned}
$$

where x_k^* and z^* denote the optimal choices of a household. Replacing those by (5) gives us an expression for the indirect utility as function of income y_i, prices p_{jk}, and characteristics, q_k and ε_{ik}:

$$V^{(i)} = \sum_k \omega_k \ln \omega_k \frac{y_i - z^*}{p_k} e^{\frac{q_k + \varepsilon_{ik}}{\alpha_0 + \alpha_1 \ln z^*}} + u(z^*)$$

I focus on the utility derived from manufacturing goods, U_{Mfg}. To create a price index, I set $U_{\text{Mfg}} = 1$ and solve for $y_i - z^*$:

$$1 = \sum_k \omega_k \ln \left(\omega_k \frac{y_i - z^*}{p_k} e^{\frac{q_k + \varepsilon_{ik}}{\alpha_0 + \alpha_1 \ln z^*}} \right)$$

$$1 = \sum_k \omega_k \ln \frac{\omega_k}{p_k} + \sum_k \omega_k \ln(y_i - z^*) + \sum_k \omega_k \frac{q_k + \varepsilon_{ik}}{\alpha_0 + \alpha_1 \ln z^*}$$

$$\ln(y_i - z^*) = 1 - \sum_k \omega_k \ln \frac{\omega_k}{p_k} - \sum_k \omega_k \frac{q_k + \varepsilon_{ik}}{\alpha_0 + \alpha_1 \ln z^*}$$

$$\mathbb{P}_{\text{Mfg}}(z^*) \quad \exp \left(\sum_k \omega_k \left[1 - \ln \frac{\omega_k}{p_k} - \frac{q_k + \varepsilon_{ik}}{\alpha_0 + \alpha_1 \ln z^*} \right] \right)$$

As $\alpha_0 + \alpha_1 \ln z^*$ will be positive (since the price coefficient will be negative), it can be easily shown that

$$\frac{\partial \mathbb{P}_{\text{Mfg}}}{\partial p_k} > 0$$

$$\frac{\partial \mathbb{P}_{\text{Mfg}}}{\partial q_k} < 0$$

$$\frac{\partial \mathbb{P}_{\text{Mfg}}}{\partial \varepsilon_k} < 0.$$

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The optimal price index will hence be increasing in the price of the optimal variety and decreasing in their respective characteristics. Notice that the price index captures both changes along the intensive as well as the extensive margin: As new varieties become available, the chosen variety k^* may change and with it the respective p_{k^*}, q_{k^*}, and ε_{k^*}.

A.4   Hidden Varieties

The expenditure share in market m of exporters from origin c can be approximated through first-order Taylor expansions as

$$
\begin{aligned}
s_{cm} &= \sum_{i \in I_m} \frac{E_{im}}{E_m} \frac{\sum_{j \in J_c} \exp(q_{jm} - \alpha_i \ln p_{jm})}{\sum_{j'} \exp(q_{j'm} - \alpha_i \ln p_{j'm})} \\
&\approx \sum_{i \in I_m} \frac{E_{im}}{E_m} \frac{\exp(\bar{q}_{cm} - \alpha_i \ln \bar{p}_{cm}) \sum_{j \in J_c} \left[1 + (q_{jm} - \bar{q}_{cm}) - \frac{\alpha_i}{\bar{p}_{jm}}(p_{jm} - \bar{p}_{cm})\right]}{\sum_{c'} \exp(\bar{q}_{c'm} - \alpha_i \ln \bar{p}_{c'm}) \sum_{j' \in J_{c'}} \left[1 + (q_{j'm} - \bar{q}_{c'm}) - \frac{\alpha_i}{\bar{p}_{j'm}}(p_{j'm} - \bar{p}_{c'm})\right]} \\
&= \sum_{i \in I_m} \frac{E_{im}}{E_m} \frac{N_{cm} \exp(\bar{q}_{cm} - \alpha_i \ln \bar{p}_{cm})}{\sum_{c'} N_{c'm} \exp(\bar{q}_{c'm} - \alpha_i \ln \bar{p}_{c'm})} \\
&= \sum_{i \in I_m} \frac{E_{im}}{E_m} \frac{\exp(\bar{q}_{cm} + N_{cm} - \alpha_i \ln \bar{p}_{cm})}{\sum_{c'} \exp(\bar{q}_{c'm} + N_{c'm} - \alpha_i \ln \bar{p}_{c'm})}.
\end{aligned}
$$

The average price $\bar{p}_{cm}$ is hence sufficient to identify α_i up to a first-order approximation.

A.5   Own-Price Elasticities

The elasticity of firm $j's$ sold quantity in market m, x_{jm}, with respect to its own price is

$$\frac{\partial x_{jm}}{\partial p_{jm}}\frac{p_{jm}}{x_{jm}} = \frac{\partial(s_{jm}E_m/p_{jm})}{\partial p_{jm}}\frac{p_{jm}}{s_{jm}E_m/p_{jm}}$$

$$= \frac{\partial}{\partial p_{jm}}\left(\sum_{i\in I_m}\frac{E_{im}}{E_m}\frac{\exp(q_{jm}-\alpha_i\ln p_{jm})}{\sum_{j'}\exp(q_{j'm}-\alpha_i\ln p_{j'm})}\frac{E_m}{p_{jm}}\right)\frac{p_{jm}^2}{s_{jm}E_m}$$

$$= \frac{\partial}{\partial p_{jm}}\left(\sum_{i\in I_m}\frac{E_{im}}{E_m}\frac{\exp(q_{jm}-(\alpha_i+1)\ln p_{jm})}{\sum_{j'}\exp(q_{j'm}-\alpha_i\ln p_{j'm})}\right)\frac{p_{jm}^2}{s_{jm}}$$

$$= \sum_{i\in I_m}\frac{E_{im}}{E_m}\frac{\frac{\alpha_i+1}{p_{jm}}\exp(q_{jm}-(\alpha_i+1)\ln p_{jm})\sum_{j'}\exp(q_{j'm}-\alpha_i\ln p_{j'm})}{\left(\sum_{j'}\exp(q_{j'm}-\alpha_i\ln p_{j'm})\right)^2}\frac{p_{jm}^2}{s_{jm}}$$

$$- \sum_{i\in I_m}\frac{E_{im}}{E_m}\frac{\frac{\alpha_i}{p_{jm}}\exp(q_{jm}-\alpha_i\ln p_{jm})\exp(q_{jm}-(\alpha_i+1)\ln p_{jm})}{\left(\sum_{j'}\exp(q_{j'm}-\alpha_i\ln p_{j'm})\right)^2}\frac{p_{jm}^2}{s_{jm}}$$

$$= \sum_{i\in I_m}\frac{E_{im}}{E_m}\frac{\frac{\alpha_i+1}{p_{jm}^2}\exp(q_{jm}-\alpha_i\ln p_{jm})\sum_{j'}\exp(q_{j'm}-\alpha_i\ln p_{j'm})}{\left(\sum_{j'}\exp(q_{j'm}-\alpha_i\ln p_{j'm})\right)^2}\frac{p_{jm}^2}{s_{jm}}$$

$$- \sum_{i\in I_m}\frac{E_{im}}{E_m}\frac{\frac{\alpha_i}{p_{jm}^2}\exp(q_{jm}-\alpha_i\ln p_{jm})\exp(q_{jm}-\alpha_i\ln p_{jm})}{\left(\sum_{j'}\exp(q_{j'm}-\alpha_i\ln p_{j'm})\right)^2}\frac{p_{jm}^2}{s_{jm}}$$

$$= \sum_{i\in I_m}\frac{E_{im}}{E_m}\left[(\alpha_i+1)s_{jm}^{(i)}-\alpha_i\left(s_{jm}^{(i)}\right)^2\right]\frac{1}{s_{jm}}$$

B Data and Reduced Form Evidence

B.1 Motivation

Table 11: Regression Results - Avg (Log) Import Price by country

	Mean	Percentiles (25%, 50%, 75%)		
Luxembourg	0.3857	[-0.2358;	0.3257;	1.0383]
France	0.3150	[-0.1388;	0.2031;	0.6679]
Ireland	0.2815	[-0.2540;	0.1698;	0.7271]
Austria	0.2684	[-0.2218;	0.1708;	0.7205]
Germany	0.2424	[-0.1603;	0.1148;	0.5322]
Sweden	0.2366	[-0.1826;	0.1520;	0.5925]
United Kingdom	0.2203	[-0.2044;	0.0946;	0.5186]
Finland	0.2115	[-0.2202;	0.1442;	0.6055]
Denmark	0.1320	[-0.2821;	0.0768;	0.5081]
Italy	0.1108	[-0.3027;	0.0217;	0.4460]
Netherlands	0.0546	[-0.3576;	-0.0032;	0.3956]
Hungary	0.0480	[-0.4435;	-0.0246;	0.4789]
Czech Republic	0.0320	[-0.4058;	-0.0321;	0.4344]
Portugal	0.0067	[-0.4276;	-0.0242;	0.4435]
Belgium	-0.0250	[-0.4135;	-0.0566;	0.3109]
Spain	-0.0584	[-0.4100;	-0.0958;	0.2427]
Greece	-0.0823	[-0.5466;	-0.1053;	0.3237]
Estonia	-0.1031	[-0.5449;	-0.0957;	0.3525]
Slovenia	-0.1082	[-0.5433;	-0.1191;	0.3508]
Poland	-0.1137	[-0.5284;	-0.1533;	0.2384]
Lithuania	-0.2611	[-0.6937;	-0.2243;	0.1590]
Latvia	-0.2892	[-0.7341;	-0.2530;	0.1552]
Malta	-0.3130	[-0.7914;	-0.2375;	0.2083]
Romania	-0.3322	[-0.8430;	-0.3218;	0.1598]
Slovakia	-0.3555	[-0.8755;	-0.3115;	0.1584]
Cyprus	-0.5634	[-1.0193;	-0.3948;	0.0284]
Bulgaria	-0.6021	[-1.1227;	-0.5512;	-0.0894]

Table shows average (log) import prices across products after subtracting out product fixed effects. A unit of observation is a weighted average of import prices of a country in a product category.

Table 12: Regression - Average Import Price and GDP per capita

Dependent Variable: Mean weighted import price (in logs)

log(GDP/Capita)	0.3105***	(8.6006)
Product FE	Yes	
N	112,469	

Regression includes product fixed effects. Standard Errors are clustered by importer. t-statistics in brackets.

B.1.1 Prices of the same Exporter when selling to different markets

B.2 Fit - Income Distributions
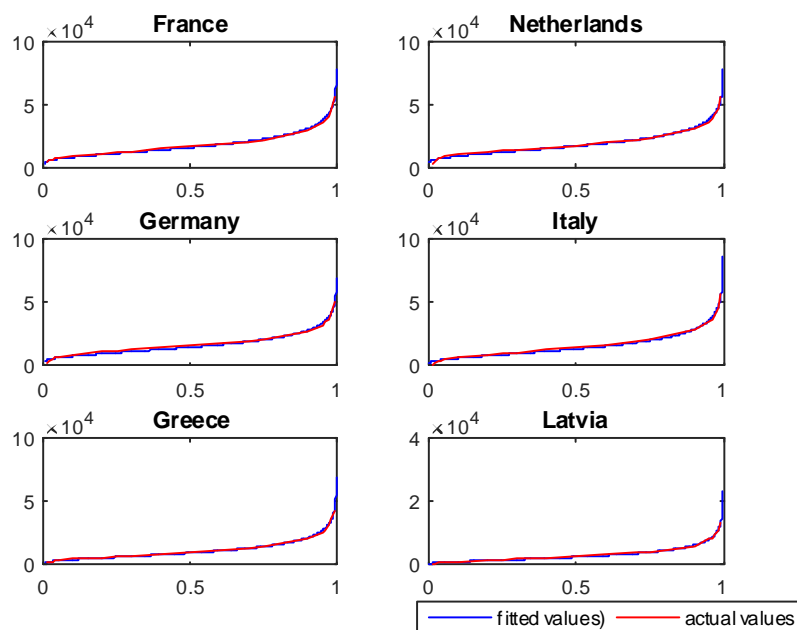
Figure 7: Fitted versus actual income distribution (2006)

B.3 Instruments

B.3.1 Shipping Costs

The Eurostat data does not provide information on shipping cost. The comparable source for the U.S. however provides data on cost, insurance and freight (cif) charges at the HS10 level of disaggregation. I use this data to compute the average charge per unit shipped over one kilometer for each product category and deflate it using the CPI. I compute approximate cif charges per unit shipped for trade flows in the EU data using

$$\text{per unit cif charges}^k_{c_1,c_2,t} = \frac{\sum_c \text{cif charges}^k_{c,US,t}}{\sum_c \text{Units shipped}^k_{c,US,t} \times \text{Distance}_{c,US}} \times \text{Distance}_{c_1,c_2}$$

Table 13: Regression - Average Export Price by Country (2007)

Japan	0.52	Taiwan	-0.44	Kazakhstan	-0.66	Cameroon	-0.91
Switzerland	0.37	Iceland	-0.47	Sri Lanka	-0.66	Lebanon	-0.91
USA	0.27	Peru	-0.47	Rwanda	-0.66	Jordan	-0.94
Canada	0.07	Tunisia	-0.47	El Salvador	-0.67	Mali	-0.94
Australia	0.05	Slovenia	-0.48	Bulgaria	-0.71	Turkmenistan	-0.94
Utd Kingdom	0.02	Estonia	-0.49	Dom. Rep.	-0.71	Egypt	-0.94
Germany	-0.01	Azerbaijan	-0.49	P. N. Guinea	-0.72	Vietnam	-0.95
New Zealand	-0.01	Jamaica	-0.49	Uzbekistan	-0.72	Laos	-0.95
Italy	-0.03	Colombia	-0.50	Zimbabwe	-0.72	Cambodia	-0.96
Sweden	-0.05	Argentina	-0.51	Turkey	-0.72	Sierra Leone	-0.97
Denmark	-0.13	Poland	-0.51	U.A. Emirates	-0.73	Dominica	-0.98
Ireland	-0.14	Thailand	-0.52	Ecuador	-0.74	Iran	-0.98
Finland	-0.15	Greece	-0.56	Bahamas	-0.75	Malawi	-0.99
Austria	-0.15	Morocco	-0.56	Trinidad, Tob.	-0.75	Ukraine	-0.99
Israel	-0.15	Kyrghyzstan	-0.56	Senegal	-0.77	Armenia	-1.00
Norway	-0.17	Costa Rica	-0.57	Ethiopia	-0.77	Macedonia	-1.00
Belgium	-0.22	Angola	-0.57	Libya	-0.78	Guinea	-1.01
South Korea	-0.22	Oman	-0.58	Ant., Barbuda	-0.78	Seychelles	-1.03
Singapore	-0.22	Namibia	-0.58	Brunei	-0.80	Haiti	-1.03
Swaziland	-0.24	Bolivia	-0.60	Mauritania	-0.81	Ghana	-1.03
Netherlands	-0.24	Croatia	-0.60	Guatemala	-0.81	Belarus	-1.04
Luxembourg	-0.26	India	-0.60	Benin	-0.82	Guyana	-1.05
Mexico	-0.28	Gabon	-0.60	Georgia	-0.82	Moldova	-1.07
Malta	-0.30	Nepal	-0.61	Algeria	-0.83	Gambia	-1.07
Cyprus	-0.30	Romania	-0.61	Honduras	-0.84	Equ. Guinea	-1.09
Qatar	-0.34	Latvia	-0.61	Indonesia	-0.85	Mongolia	-1.09
Czech Rep.	-0.35	Niger	-0.61	Nigeria	-0.86	Mozambique	-1.11
South Africa	-0.36	Kenya	-0.61	China	-0.86	Nicaragua	-1.12
Madagascar	-0.38	Congo	-0.61	Surinam	-0.87	Sudan	-1.14
Spain	-0.39	Slovakia	-0.62	Tanzania	-0.87	Botswana	-1.15
Fiji	-0.39	Saudi Arabia	-0.62	Venezuela	-0.88	Bangladesh	-1.16
Mauritius	-0.40	Russia	-0.63	Burkina Faso	-0.88	Iraq	-1.16
Hungary	-0.40	Barbados	-0.63	Togo	-0.88	Albania	-1.22
Bahrain	-0.40	Zambia	-0.63	Tonga	-0.88	Tadjikistan	-1.24
Brazil	-0.41	Lithuania	-0.64	Paraguay	-0.89	Cape Verde	-1.28
Philippines	-0.42	Uganda	-0.64	Bosnia Herz.	-0.90	Belize	-1.35
Hong Kong	-0.42	Uruguay	-0.64	Afghanistan	-0.90	Liberia	-1.44
Portugal	-0.43	Kuwait	-0.65	Panama	-0.91	Djibouti	-1.67
Chile	-0.43	Malaysia	-0.65	Ivory Coast	-0.91	Syria	-1.67

Table shows the results of regression (2), i.e. $log(\text{Avg Export Price}_{jk}) = \beta_k + \beta_j I\{Exporter = j\} + \varepsilon_{jk}$. Avg Export Price$_{jk}$ denotes the average price at which an exporter j sells a product k weighted by trade volume. Regression includes product dummies and all values are relative to France. Countries which sell in less than 50 product categories are excluded.

Table 14: Regression Results - Avg Export Price and GDP per capita

Dependent Variable: Mean weighted export price (in logs)		
log(GDP/Capita)	0.2134***	(10.06)
Product FE	Yes	
N	288,653	

Regression includes product fixed effects. Standard Errors are clustered by exporter. t-statistics in brackets.

Table 15: Prices of exporters when selling to differently rich countries

Log(Export Price of Country)		Log(GDP per capita of Partner country)	
	(1)		(2)
Greece	0.1410***	(5.2400)	0.1237
Slovakia	0.1403***	(7.7095)	0.1326
Malta	0.1259***	(3.4048)	0.1253
Denmark	0.1092***	(5.4158)	0.1346
Spain	0.1035***	(9.7763)	0.1183
Austria	0.0966***	(4.6372)	0.1106
Estonia	0.0893***	(3.4970)	0.0859
Sweden	0.0844***	(4.1759)	0.1186
Cyprus	0.0816***	(2.8518)	0.0833
Belgium	0.0803***	(8.8326)	0.0991
Poland	0.0769***	(8.4563)	0.0791
France	0.0721***	(7.0212)	0.1065
Portugal	0.0721***	(5.4102)	0.0904
Netherlands	0.0677***	(6.2537)	0.1086
Italy	0.0658***	(4.6011)	0.0862
Bulgaria	0.0630***	(4.1283)	0.0562
Czech Rep	0.0613***	(3.7634)	0.0823
Lithuania	0.0600**	(2.1669)	0.0615
Hungary	0.0598***	(4.1538)	0.0631
Latvia	0.0569**	(2.0908)	0.0543
Finland	0.0569***	(3.8466)	0.0734
UK	0.0557***	(3.7369)	0.0949
Slovenia	0.0458*	(1.9141)	0.0490
Romania	0.0387***	(2.7918)	0.0314
Ireland	0.0267	(1.5646)	0.0643
Germany	-0.0117	(1.2095)	0.0380
Luxembourg	-0.1615***	(-3.0683)	-0.0218

***significant at 1%, **significant at 5%, *significantat 10%. (2) includes
log(distance) between exporter and importer as control in each regression.
Standard Errors are clustered by importing country. t-statistics in brackets.

Table 16: Income Distributions: Parameter Estimates 2012

	μ	σ		μ	σ
Luxembourg	10.382	0.49408	Slovenia	9.3564	0.42771
Denmark	10.081	0.52397	Malta	9.3155	0.48757
Sweden	10.038	0.46140	Portugal	8.9922	0.67242
Finland	9.9988	0.47899	Greece	8.9895	0.66251
Austria	9.9390	0.52734	Czech Republic	8.9524	0.49123
Netherlands	9.9181	0.47627	Slovakia	8.8086	0.45726
France	9.8768	0.63231	Estonia	8.6808	0.58832
Belgium	9.8573	0.48121	Poland	8.4881	0.59494
Germany	9.8495	0.50918	Hungary	8.4302	0.52409
Ireland	9.8270	0.55799	Latvia	8.3695	0.66965
United Kingdom	9.8266	0.57945	Lithuania	8.3618	0.57727
Cyprus	9.7163	0.57485	Bulgaria	7.8616	0.63318
Italy	9.5944	0.59886	Romania	7.6037	0.55936
Spain	9.4695	0.60913			

The graph shows estimates of the parameters of the log-normal distribution which approximates the income distribution in each country in 2012.

Table 17: Import prices and cif charges for U.S. trade flows

	1990 log(price)	2000 log(price)	2010 log(price)
log(unit cif charges)	0.702***	0.646***	0.564***
	(0.01)	(0.01)	(0.01)
Constant	3.194***	3.307***	3.569***
	(0.00)	(0.00)	(0.00)
Product Fixed Effects	yes	yes	yes

Trade Flows are at the HS10 level of aggregation. Standard Errors are clustered at the product level.

where c_1 and c_2 are exporting and importing countries in the EU data, respectively and c denotes an exporter to the U.S. An additional issue arrises as the classification of products into categories in the U.S. and the EU is only equal up to the 6 digit level of aggregation. I therefore aggregate the U.S. data up to the six digit level and compute charges per unit and km. For each 8 digit product in the EU data, I set charges equal to their 6 digit counterparts in the U.S. data which is valid if shipping costs are similar for each 8 digit product within a 6 digit category.

Table Ax shows the strength of the instrument in explaining unit values of product shipped to the U.S. for various years.

As the first table shows, cif charges significantly drive up prices. On average a one percent increase in charges raises prices by 0.7% in 1990 and 0.56% in 2010. As expected, the impact of shipping costs is somewhat declining over time (also shown in figure Ax) but remains significant throughout all years.

Table 18: Import prices and cif charges for EU trade flows 1989 - 2012

	log(price)	log(price)	log(price)
log(unit cif charges)	0.032***	0.046***	
	(0.00)	(0.00)	
log(distance)			0.048***
			(0.00)
log(importer GDP per capita)		0.130***	0.133***
		(0.00)	(0.00)
Constant	1.785***	0.449***	0.512***
	(0.01)	(0.01)	(0.01)
Product fixed effects	yes	yes	yes
Exporter fixed effects	yes	yes	yes

Trade Flows are at the CN8 level of aggregation. Standard Errors are clustered at the product-exporter level.
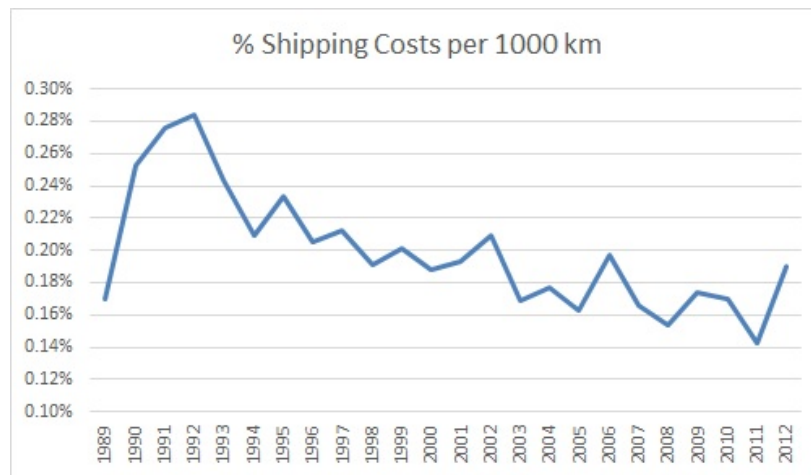

Figure 8: Cif charges as share of trade volume (U.S. 1989 - 2012)

The instrument for the observed unit values in the EU is also significant and has the expected sign. The effect on prices however is smaller, which is partially due to many shipments to EU countries being from other EU countries and therefore over shorter distances. In turn, charges are less important on average than in the U.S.. Also note that the above regressions contain exporter fixed effects. This is important given that EU countries typically produce varieties with higher prices which would imply a negative correlation between distance and prices. The above regressions hence show to which degree export charges affect prices of the same exporter shipping to different destinations.