

Income Differences and Prices of Tradables*

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Abstract

Empirical studies find a strong positive relationship between a country's per-capita income and price level of tradable goods. Among alternative explanations of this observation, I focus on variable mark-ups by firms. Mark-ups that vary with destinations' incomes are evident from a clothing manufacturer's online catalogue featuring unit prices of identical goods sold in 24 countries. Such price discrimination on the basis of income suggests that firms exploit lower price elasticity of demand for identical goods in richer countries. In order to capture that, I introduce non-homothetic preferences in a model of trade with product differentiation and heterogeneity in firm productivity. The model helps bring theory and data closer along a key dimension: it generates positively related prices and incomes, while preserving desirable features of firm behavior and trade flows of existing frameworks. Quantitatively, the model suggests that variable mark-ups can account for as much as a third of the observed positive relationship between prices of tradables and income across a large sample of countries.

JEL Classification: E31, F12, F15, L11

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1 Introduction

A large empirical literature has established a strong positive relationship between countries' per-capita incomes and price levels of tradable goods. Although alternative explanations of this observation exist, I argue that pricing-to-market is a viable one. I present evidence from a clothing manufacturer that sells identical goods online to 24 countries and charges higher prices in richer markets. Such price discrimination on the basis of income suggests that firms exploit different price elasticity of demand across countries that differ in income. In particular, if rich consumers are less responsive to price changes than poor ones, firms find it optimal to price identical products higher in more affluent markets.

In order to capture this mechanism, I introduce non-homothetic preferences in a model of trade with product differentiation and heterogeneity in firm productivity à la Melitz (2003) and Chaney (2008). These models successfully explain firm exporting behavior and bilateral trade flows. However, they assume that consumers value a continuum of varieties in a symmetric CES fashion, resulting in firms following a simple pricing rule of a constant mark-up over marginal cost of production and delivery. In the absence of trade barriers, the models predict that identical goods sell at equal prices across countries. But, in order to match observed bilateral trade patterns, the models require poor countries to face systematically high trade barriers and low productivity levels. The latter yield high marginal costs of production, which coupled with high trade barriers, keep the trade shares of poor countries low and prices of tradable goods high.

To retain the desirable features of these models regarding firm exporting behavior and trade flows, but also generate positively related incomes and prices, I model consumers to have non-homothetic preferences¹. In particular, the utility specification I propose has the property that the marginal satisfaction agents derive from consuming each good is bounded at any level of consumption. Since a tiny amount of consumption of a good does not give infinite increase in utility, a consumer spends her limited income on the subset of potentially produced items whose prices do not exceed marginal valuations. An increase in income spurs consumers, who value variety, to buy a greater pool of goods. For a monopolistic competitor selling a particular item, the presence of more goods in the market raises competition, forcing it to reduce the good's price. However, an increase in income also drives consumers to buy

¹The assumption of non-homothetic preferences is supported by recent empirical literature. In particular, Hunter (1991), Hunter and Markusen (1988), and Movshuk (2004) use cross-country expenditure data on groups of commodities and find that consumption shares of different classes of goods vary considerably across the sample, thus rejecting the assumption of homothetic preferences.

more of each good, allowing the firm to raise the good’s price. In equilibrium, the latter effect dominates, resulting in higher prices of identical goods in more affluent markets.

Moreover, since firms differ in productivity levels, only certain manufacturers can cover production and shipping costs in order to place their good in the market. The marginal firm sells its product at a price that barely covers its production and delivery cost, while maintaining positive demand, thus realizing zero sales. Trade barriers keep exporters in the minority and more productive firms sell more in each market. Facing higher demand in richer countries, firms realize higher sales there, and more firms serve the affluent markets. Moreover, if firm productivities are Pareto-distributed, the distribution of their sales in a market is Pareto in the tail. These predictions are in line with the behavior of French exporters in 1986 reported by Eaton et al. (2004), Eaton et al. (2005) and Arkolakis (2008)².

The model yields a standard gravity equation of trade relating bilateral trade flows and trade barriers. Similarly to previous frameworks, the model matches observed trade flows when its calibrated trade barriers are high and productivity levels are low for poor countries. However, since price elasticities of demand are high in poor countries, exporters sell their products at low prices there. The calibrated model suggests that the elasticity of the price level of tradable goods with respect to per-capita income for a set of 100 countries that comprised 91% of world output in 1996 is 0.05. The corresponding estimate arising from 1996 income and price data for the same set of countries is 0.21, as can be seen in figure 1 below. Since the model can account for a quarter of observed cross-country price differences, it is reasonable to conclude that variable mark-ups are quantitatively important.

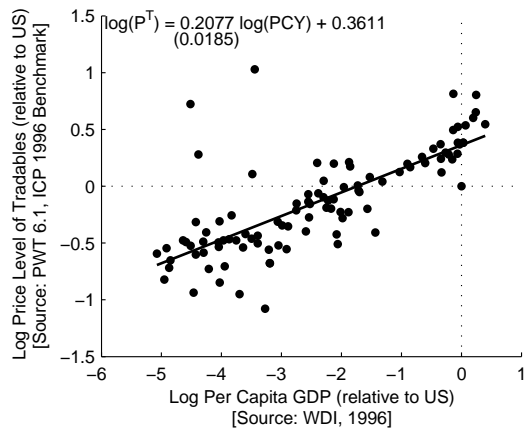


Figure 1: Price Level of Tradable Goods and Per-Capita GDP for 100 Countries

²Arkolakis (2008) proposes a model that is not only qualitatively, but also quantitatively in line with firm exporting behavior, however, it relies on a CES framework that cannot capture the price-income relationship.

The price indices plotted in figure 1 are computed at the retail level and necessarily account for non-tradable components and trade barriers³. To correct for such components, the empirical literature has analyzed unit values from data collected at the port of shipping. Using Harmonized System (HS) 10-digit-level commodity classification data, the most highly disaggregated US commodities trade data publicly available, Schott (2004) finds that “unit values of US imports are higher for varieties originating in capital- and skill-abundant countries than they are for varieties sourced from labor-abundant countries.” A large subsequent literature interprets this finding to indicate that imports from richer countries are of higher quality. Yet, Alessandria and Kaboski (2007) use the same data set and find that unit values of US exports to richer markets are higher, interpreting this as evidence of pricing-to-market: the decision of firms to set higher mark-ups on identical goods in richer markets.

Given the alternative interpretations of the same data, an empirical literature attempting to directly measure variable mark-ups has emerged. These studies track the prices of identical goods across countries. Goldberg and Verboven (2001) and Goldberg and Verboven (2005) analyze the car market in five European countries over time and find persistent deviations from the law of one price. Haskel and Wolf (2001) collect prices of items sold in IKEA stores across countries and find typical deviations in prices of identical products of twenty to fifty percent. Finally, Ghosh and Wolf (1994) study the listed price of the Economist magazine across markets and find it considerably differs.

These experiments convey convincing evidence that goods of identical qualities are sold at different prices across countries. But, they employ retail prices, which necessarily contain non-tradable components and trade barriers⁴. Instead, I collect prices of identical items featured in the clothing manufacturer Mango’s online catalogues across 24 countries, allowing me to overcome the problems posed by both varying product quality and non-tradable price components. In addition, the prices I analyze are adjusted for tariffs and sales taxes. However, they account for transportation costs, since products sold above a minimum price ship at no fee. After controlling for transportation costs and good-specific characteristics, I find that the estimated elasticity of an item’s price with respect to per-capita income of a destination is 0.1221. Thus, countries that are twice as rich in per capita terms pay 12% more for the same good.

³Indeed, in a series of studies, Crucini et al. (2005a), Crucini et al. (2005b) and Crucini and Shintani (2008) document large and persistent deviations from the law of one price using disaggregated unit price data at the retail level for a large sample of countries.

⁴Goldberg and Verboven (2001) and Goldberg and Verboven (2005) control for such components and conclude that deviations from the law of one price persist.

Complementary to the empirical findings of variable mark-ups, a theoretical literature studying pricing-to-market within an international trade framework exists, building on the seminal work of Krugman (1986). Recently, Atkeson and Burstein (2005) explore the implications of pricing-to-market on the fluctuations of relative producers' and consumers' prices of tradable and traded goods. Moreover, Bergin and Feenstra (2001) propose an explanation of real exchange rate persistence by introducing a symmetric translog expenditure function in a monopolistic competition framework with a fixed number of producers. Feenstra (2003) further allows for firm free entry, but does not account for consumer income differences. In such environment, monopolistic competitors set lower mark-ups when the number of available varieties is larger⁵. However, Jackson (1984) presents evidence that the pool of consumed goods varies positively with consumer income and indeed suggests that non-homothetic preferences may be an underlying reason.

Melitz and Ottaviano (2008) introduce non-homothetic preferences, represented by a quadratic utility function, in a model of trade with product differentiation and firm productivity heterogeneity. However, their focus lies on the interaction between mark-ups and market size, measured by the population of each destination. In fact, income effects are absent from their analysis due to the presence of a homogenous commodity that is freely traded, thus ensuring (per-capita) income equalization across countries⁶. Finally, Alessandria and Kaboski (2007) explore the implications of pricing-to-market on prices of tradables across countries in a very different setting from the one analyzed in this paper. In their model, pricing-to-market arises due to costly search frictions between consumers and retailers in countries that differ in their wage levels.

To summarize, the present paper contributes toward the understanding of the positive relationship between two key macroeconomic variables: income and price level. First, it provides direct evidence of variable mark-ups from a unique database, thus enriching the empirical pricing-to-market literature. Second, it proposes a theoretical framework that is consistent with firm exporting behavior, bilateral trade patterns and prices of tradable goods. Finally, it carries out a quantitative exercise, whose results suggests that variable mark-ups by firms play an important role in explaining cross-country price differences. As multinational firms receive an increasing attention in policy circles, theoretical frameworks

⁵It would be interesting to extend the model of Feenstra (2003) to a multi-country general equilibrium setting that allows for income heterogeneity and to study the cross-country prices of tradables arising from that framework both qualitatively and quantitatively.

⁶In an online appendix, Arkolakis (2008) analyzes the model of Melitz and Ottaviano (2008) in the absence of a homogenous good, thus allowing for heterogeneous incomes across countries. I am currently studying the quantitative predictions of such model.

that are consistent with firms' pricing and exporting behavior are needed in order to better understand the role such firms play in shaping countries' trade and growth patterns.

The remainder of the paper is organized as follows: section 2 discusses evidence of pricing-to-market extracted from a new database featuring prices of items sold online by the Spanish clothing manufacturer Mango; section 3 describes the model and its qualitative predictions; section 4 discusses the calibration and quantitative predictions of the model; and section 5 concludes. Finally, the appendices are organized as follows: appendix A describes a model with consumers represented by CES preferences; appendix B outlines the price-accounting procedure; and the remaining appendices support data findings and provide algebraic expressions used throughout the paper.

2 Pricing-to-Market: Evidence from Mango

In this section, I present direct evidence of variable mark-ups from a data set that has not been used in previous empirical studies. I find that the Spanish clothing manufacturer Mango systematically price-discriminates according to the per-capita income level of the market to which it sells.

2.1 Data Description

I collect price data from the clothing manufacturer Mango, a producer based in Barcelona, Spain, that offers a line of clothing targeted at middle-income female consumers.

Mango produces its items in Spain and sells them both online and in stores around the world. To facilitate data collection, I only consider Mango's online store. I use data from 24 countries in Europe as well as Canada. Each country has a website and customers from one country cannot buy products from another country's website due to shipping restrictions. Thus, a customer with a physical shipping address in Germany can only have items delivered to her when purchased from the German Mango website. A list of countries I study is given in Table 3 located in appendix E.

I collect data on all items featured in the Summer 2008 online catalogue, which became available in March of 2008. In each country, the catalogue lists item prices in the local currency. I use average monthly exchange rates for February of 2008 to convert all values into Euro, the currency used in the home country, Spain⁷.

⁷I choose to work with February data because the catalogue became available in March and the company would have had to set the price before placing the catalogue into circulation. I repeat the analysis with

Each item in the catalogue has a distinct name and an 8-digit code reported in every country. This enables me to collect prices of identical products across markets. Prices listed on the website include sales taxes (VAT), which I adjust for accordingly, but exclude tariffs since all countries are members of the European Union⁸. Thus, once I remove the sales tax, prices include production costs, mark-ups and transportation costs.

The shipping and handling policy of Mango is such that no fee is incurred for purchases above a minimum value, which differs across countries. Thus, not only does a single product, whose price is above this minimum, incur no shipping charge, but also any bundle of goods with value above the minimum satisfies the free-shipping requirement. All other purchases incur a shipping and handling fee. Table 4 in appendix E lists the free-shipping minimum requirement for every country in Euros, using February 2008 exchange rates.

Many items sold by Mango classify for free shipping. However, it is not always the case that the same product ships at no fee to different destinations, since the minimum price requirement as well as the actual Euro-denominated price of the product often differ. Thus, it is necessary to control for shipping costs in the analysis⁹.

Out of potentially 124 products, I reduce the sample to 93 items. The 31 items I drop are not available in every country in my sample, so I exclude them from my study as the objective is to compare the prices of identical items in every destination. Finally, I use 2006 PPP-adjusted per-capita income from the World Bank in my analysis of the relationship between prices and incomes.¹⁰

2.2 Data Analysis

The data set I analyze displays large heterogeneity in per-capita incomes and prices across countries. In my sample of 24 countries, the richest country in per-capita terms, Luxembourg, is over 4 times richer than the poorest one, Slovakia. Similarly, the average price of identical

exchange rate data for the months of January and March of 2008 and although the coefficients differ, the results remain unchanged. I do not perform robustness checks with data from 2007 (for ex. December of 2007) because three of my sample countries, Cyprus, Malta and Slovenia, used their respective national currencies at the time, which were replaced with the Euro starting January 1, 2008.

⁸Canada applies sales taxes and import duties at checkout, so no price adjustment is necessary.

⁹Mango uses a third-party international courier to ship its products. Mango's website lists the shipping fee charged on items priced below the free-shipping minimum. The fee does not generally vary with the weight and type of the item shipped. Table 4 in appendix E summarizes the per-item shipping and handling fee for each country in Euro, using February 2008 exchange rates.

¹⁰I conduct the same analysis with nominal per-capita income, real per-capita income (base year 2000) and for a subset of the countries (for which data is available), I repeat the analysis using wages since this statistic corresponds to the measure of per-capita income in the model. Although estimated elasticities change, the nature of the results remains unaltered. Results are available upon request.

goods is almost 1.6 times as much in the most expensive country, Switzerland, as it is in the cheapest, Portugal¹¹. In fact, when looking at all items sold to the 24 markets, the elasticity of the average priced item with respect to the per-capita income of the destination is 0.12¹².

Equation (1) below summarizes the regression framework used to analyze the pricing practices of Mango:

$$\log p_{ij} = \alpha_i + \beta_y \log y_j + \epsilon_{ij}, \quad (1)$$

where p_{ij} is the pre-tax price of good i in country j in Euros and y_j is the PPP-adjusted per-capita income of country j . The coefficient β_y is the estimated elasticity of price with respect to per-capita income, while α_i is a good i -specific fixed effect¹³.

I use the “within” (fixed-effects) estimator and report White robust standard errors for the income coefficient as well as the t-statistic in table 6 found in appendix E. The regression yields an estimate of β_y of 0.1185 with standard error 0.0065.

The prices used in the above estimation, however, implicitly include transportation costs due to Mango’s pricing policy discussed earlier. Since many items satisfy the minimum-price requirement for free shipping, their final price contains (a fraction of) the shipping cost Mango incurs. Hence, I modify (1) to account for shipping costs as follows:

$$\log p_{ij} = \alpha_i + \beta_y \log y_j + \beta_\tau \log \tau_j + \epsilon_{ij}, \quad (2)$$

where τ_j is the distance between Barcelona and the capital city of the destination country¹⁴.

The regression yields estimates for β_y and β_τ of 0.1221 (0.0051) and 0.0331 (0.0008), respectively. Thus, controlling for transportation costs and good-specific characteristics, countries that are twice as rich in per-capita terms pay 12% more for identical items¹⁵.

Table 7 in appendix E repeats all exercises for a subset of countries that belong to the Euro zone as of January 1, 2008, allowing to exclude exchange rates from the analysis. The

¹¹Table 5 in appendix E lists the average price of items sold in every destination and the per-capita income of each country, relative to Spain.

¹²Figure 4 in appendix E summarizes this discussion graphically.

¹³I employ good-specific fixed effects to capture good-specific observable and unobservable characteristics that affect item prices.

¹⁴Using the most populated city instead of the capital does not change the results.

¹⁵I am currently performing a robustness check using quoted shipping fees of the international courier Mango uses. Although these fees are not entirely representative of Mango’s shipping costs, as the firm likely receives preferential rates, they may capture the relationship between the shipping cost and the destination served. It may also be of interest to jointly estimate price elasticities of income and parameters determining the shipping fee Mango charges its customers, in order to better understand the firm’s pricing practices.

estimated elasticity of prices with respect to income rises to 0.1565 (0.0086), after controlling for transportation costs and good-specific characteristics. Thus, per-capita income remains a strong candidate that potentially poses a wedge in prices of identical goods across countries¹⁶.

3 Model

In this section, I propose a model in which firms practice pricing-to-market. The model incorporates the assumptions of product differentiation and firm productivity heterogeneity using the monopolistic framework proposed by Melitz (2003) and extended by Chaney (2008). It departs, however, from the existing literature in that consumers' preferences are non-homothetic, rather than being represented by a symmetric CES utility function. This novel framework yields a new set of predictions regarding exporter behavior, trade flows and price levels of tradable goods across rich and poor countries.

3.1 Consumers' Problem

I consider a world of I countries engaged in trade of final goods¹⁷, where I is finite. Let i represent an exporter and j an importer, that is, i is the source country, while j is the destination country.

I assume each country is populated by identical consumers of measure L , whose utility function is given by:

$$U^c = \int_{\omega \in \Omega} \log(q^c(\omega) + \bar{q}) d\omega, \quad (3)$$

where $q^c(\omega)$ is individual consumption of variety ω and $\bar{q} > 0$ is a (non-country-specific) constant¹⁸. To ensure that the utility function is well defined, I assume $\Omega \subseteq \bar{\Omega}$, where $\bar{\Omega}$ is a compact set containing all potentially produced varieties in the world.

¹⁶I am currently repeating the analysis using winter catalogue data to ensure that seasonal effects are not driving the above relationships. Preliminary results confirm the findings in this paper.

¹⁷Throughout the paper I use the terms good and variety interchangeably.

¹⁸This function is the limiting case of the following generalized function:

$$U^g = \left(\int_{\omega \in \Omega} (q^c(\omega) + \bar{q})^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}},$$

where $\sigma \rightarrow 1$. Throughout the paper, I exploit the analytical tractability of the limiting case, but I am currently exploring the quantitative implications of the general function.

Each variety is produced by a single firm, where firms are differentiated by their productivity, ϕ , and country of origin, i . Any two firms originating from country i and producing with productivity level ϕ choose identical optimal pricing rules¹⁹. In every country i , there exists a pool of potential entrants who pay a fixed cost, $f_e > 0$, and subsequently draw a productivity from a distribution, $G_i(\phi)$, with support $[b_i, \infty)$. Only a measure J_i of them produce in equilibrium. Firm entry and exit drives average profits to zero. In addition, only a subset of producers, N_{ij} , sell to a particular market j . Hence, N_{ij} is the measure of goods of i -origin consumed in j . Finally, I denote the density of firms originating from i conditional on selling to j by $\mu_{ij}(\phi)$.

A representative consumer in country j has a unit labor endowment, which, when supplied (inelastically) to the labor market, earns her a wage rate of w_j . Since free entry of firms drives average profits to zero, the per-capita income of country j , y_j , corresponds to the wage rate, w_j .

The demand for variety of type ϕ originating from country i consumed in a positive amount in country j , $q_{ij}(\phi) > 0$, is given by²⁰:

$$q_{ij}(\phi) = L_j \left\{ \frac{w_j + P_j}{N_j p_{ij}(\phi)} - \bar{q} \right\}, \quad (4)$$

where N_j is the total measure of varieties consumed in country j given by:

$$N_j = \sum_{v=1}^I N_{vj}, \quad (5)$$

and P_j is an aggregate price statistic summarized by:

$$P_j = \bar{q} \sum_{v=1}^I N_{vj} \int_{\phi_{vj}^*}^{\infty} p_{vj}(\phi) \mu_{vj}(\phi) d\phi. \quad (6)$$

3.2 Firms' Problem

An operating firm must choose the price of its good p , accounting for the demand for its product q . A firm with productivity draw ϕ faces a constant returns to scale production function, $x(\phi) = \phi l$, where l represents the amount of labor used toward the production of final output. Furthermore, each firm from country i wishing to sell to destination j faces an

¹⁹Thus, I can index each variety by the productivity of its producer.

²⁰The consumers' problem and derivations of demand can be found in appendix C.1.

iceberg transportation cost incurred in terms of labor units, $\tau_{ij} > 1$, with $\tau_{ii} = 1$ ($\forall i$).

Substituting for the demand function using expression (4), the profit maximization problem of a firm with productivity draw ϕ originating in country i and contemplating selling to country j is:

$$\pi_{ij}(\phi) = \max_{p_{ij} \geq 0} p_{ij} L_j \left\{ \frac{w_j + P_j}{N_j p_{ij}} - \bar{q} \right\} - \frac{\tau_{ij} w_i}{\phi} L_j \left\{ \frac{w_j + P_j}{N_j p_{ij}} - \bar{q} \right\} \quad (7)$$

The total profits of the firm are simply the summation of profits flowing from all destinations it sells to. The resulting optimal price a firm charges for its variety supplied in a positive amount is given by²¹:

$$p_{ij}(\phi) = \left(\frac{\tau_{ij} w_i}{\phi} \frac{w_j + P_j}{N_j \bar{q}} \right)^{\frac{1}{2}}. \quad (8)$$

3.3 Productivity Thresholds and Firms' Mark-Ups

In this model, not all firms serve all destinations. In particular, for any source and destination pair of countries, i, j , only firms originating from country i with productivity draws $\phi \geq \phi_{ij}^*$ sell to market j , where ϕ_{ij}^* is a productivity threshold defined by²²:

$$\phi_{ij}^* = \sup_{\phi \geq b_i} \{\pi_{ij}(\phi) = 0\}.$$

Thus, a productivity threshold is the productivity draw of a firm that is indifferent between serving a market or not, namely one whose good's price barely covers the firm's marginal cost of production,

$$p_{ij}(\phi_{ij}^*) = \frac{\tau_{ij} w_i}{\phi_{ij}^*}. \quad (9)$$

The price a firm would charge for its variety, however, is limited by the variety's demand, which diminishes as the variety's price rises. In particular, it is the case that consumers in destination j are indifferent between buying the variety of type ϕ_{ij}^* or not. To see this, from (4), notice that consumers' demand is exactly zero for the variety whose price satisfies:

²¹The firm's problem is solved in appendix C.2.

²²I restrict the model's parameters to ensure that $b_i \leq \phi_{ij}^*$, $\forall i, j$.

$$p_{ij}(\phi_{ij}^*) = \frac{w_j + P_j}{N_j \bar{q}}. \quad (10)$$

Combining expressions (9) and (10) yields a simple characterization of the threshold:

$$\phi_{ij}^* = \frac{\tau_{ij} w_i N_j \bar{q}}{w_j + P_j}. \quad (11)$$

Using (11), the optimal pricing rule of a firm with productivity draw $\phi \geq \phi_{ij}^*$ becomes:

$$p_{ij}(\phi) = \underbrace{\left(\frac{\phi}{\phi_{ij}^*}\right)^{\frac{1}{2}}}_{\text{mark-up}} \underbrace{\frac{\tau_{ij} w_i}{\phi}}_{\text{marginal cost}}$$

Appendix A describes a typical model with symmetric CES preferences. The optimal pricing rule of a firm with productivity draw $\phi \geq \phi_{ij}^*$ in such model is given by²³:

$$p_{ij}(\phi) = \underbrace{\frac{\sigma}{\sigma - 1}}_{\text{mark-up}} \underbrace{\frac{\tau_{ij} w_i}{\phi}}_{\text{marginal cost}}$$

where $\sigma > 0$ is the constant elasticity of substitution between two varieties in this model.

Clearly, the optimal mark-up rules of firms differ in the two frameworks. The CES model predicts that every firm charges an identical constant mark-up over its marginal cost of production and delivery. The non-homothetic model suggests that mark-ups are not only firm-specific, but are also determined by the local conditions of the destination market, summarized by the threshold firms must surpass in order to serve a destination. I proceed to characterize these thresholds in the following section.

3.4 Equilibrium of the World Economy

In this model, a potential entrant from country i pays a fixed cost $f_e > 0$ in labor units, and subsequently draws a productivity from a cdf, $G_i(\phi)$, with corresponding pdf, $g_i(\phi)$,

²³The two models give different solutions to the firms' problem, so productivity thresholds also differ.

and support $[b_i, \infty)$. A measure J_i of firms produce in equilibrium. Firm entry and exit drives average profits to zero. In addition, only a subset of producers, N_{ij} , sell to market j . These firms, in turn, are productive enough so as to surpass the productivity threshold characterizing destination j , ϕ_{ij}^* . Hence, N_{ij} satisfies:

$$N_{ij} = J_i[1 - G_i(\phi_{ij}^*)]. \quad (12)$$

Furthermore, the conditional density of firms operating in j is:

$$\mu_{ij}(\phi) = \begin{cases} \frac{g_i(\phi)}{1-G_i(\phi_{ij}^*)} & \text{if } \phi \geq \phi_{ij}^* \\ 0 & \text{otherwise.} \end{cases} \quad (13)$$

Using these objects, total sales to country j by firms originating in country i become:

$$T_{ij} = N_{ij} \int_{\phi_{ij}^*}^{\infty} p_{ij}(\phi)x_{ij}(\phi)\mu_{ij}(\phi)d\phi. \quad (14)$$

In addition, the ex-ante average profits of firms originating from country i are:

$$\pi_i = \sum_v^I [1 - G_i(\phi_{iv}^*)] \int_{\phi_{iv}^*}^{\infty} \pi_{iv}(\phi)\mu_{iv}(\phi)d\phi, \quad (15)$$

where potential profits from destination v are weighted by the probability that they are realized, $1 - G_i(\phi_{iv}^*)$. The average profit, in turn, barely covers the fixed cost of entry:

$$w_i f_e = \sum_v^I [1 - G_i(\phi_{iv}^*)] \int_{\phi_{iv}^*}^{\infty} \pi_{iv}(\phi)\mu_{iv}(\phi)d\phi. \quad (16)$$

Finally, the income of consumers from country i , spent on final goods produced domestically and abroad, becomes:

$$w_i L_i = \sum_v^I T_{iv}. \quad (17)$$

I now proceed to define equilibrium in this economy.

Definition 1. *Given trade barriers τ_{ij} and productivity distributions $G_i(\phi)$, an equilibrium for $i, j = 1, \dots, I$ is given by a productivity threshold $\hat{\phi}_{ij}^*$; measure of entrants \hat{J}_i ; measure of firms from country i serving market j \hat{N}_{ij} ; total measure of firms serving market j \hat{N}_j ;*

conditional pdf of serving a market $\hat{\mu}_{ij}(\phi)$; aggregate price statistic \hat{P}_j ; wage rate \hat{w}_j ; per-consumer allocation $\hat{q}_{ij}^c(\phi)$; total consumer allocation $\hat{q}_{ij}(\phi)$; decision rule $\hat{p}_{ij}(\phi)$ for firm ϕ , $\forall \phi \in [b_i, \infty)$, such that:

- Given $\hat{P}_j, \hat{w}_j, \hat{p}_{ij}$, the representative consumer solves her maximization problem by choosing $\hat{q}_{ij}^c(\phi)$ according to (3);
- Total demand function for good of type ϕ originating from country i by consumers in country j , $\hat{q}_{ij}(\phi) = \hat{q}_{ij}(\hat{p}_{ij}(\phi); \hat{P}_j, \hat{N}_j, \hat{w}_j)$ satisfies (4);
- Given \hat{P}_j, \hat{w}_j and the demand function $q_{ij}(\phi) = q_{ij}(p_{ij}(\phi); \hat{P}_j, \hat{N}_j, \hat{w}_j)$ in (4), firm ϕ chooses $\hat{p}_{ij}(\phi)$ to solve its maximization problem in (7) $\forall j = 1, \dots, I$ ²⁴;
- The productivity threshold $\hat{\phi}_{ij}^*$ satisfies (11);
- The measure of firms from country i serving market j , \hat{N}_{ij} , satisfies (12);
- The total measure of firms serving market j , \hat{N}_j , satisfies (5);
- The conditional pdf of serving each market, $\hat{\mu}_{ij}(\phi)$, satisfies (13);
- The aggregate price statistic \hat{P}_j satisfies (6);
- The wage rate \hat{w}_i and the measure of entrants \hat{J}_i together satisfy (16) and (17);
- The individual goods market clears $\hat{q}_{ij}(\phi) = \hat{x}_{ij}(\phi)$.

In order to analytically solve the model and derive predictions at the firm and aggregate levels, I assume that the productivities of firms are drawn from a Pareto²⁵ distribution

²⁴An additional equilibrium restriction for this class of models is that there is no cross-country arbitrage, that is, it must be the case that $p_{ij}(\phi) \leq p_{iv}(\phi)\tau_{vj}$ ($\forall i, v, j$). In the CES model, it is sufficient to assume that the triangle inequality for trade barriers holds, $\tau_{ij} \leq \tau_{iv}\tau_{vj}$ ($\forall i, v, j$). In the non-homothetic model, the inequality involves equilibrium objects, in particular, productivity thresholds, which in turn reflect trade barriers. As I discuss in section 4, once I calibrate the two models, it turns out that arbitrage opportunities arise more frequently in the CES model than in the non-homothetic model. Ideally, restrictions in the calibration procedure are necessary to prevent arbitrage. To my knowledge, previous quantitative studies do not address this issue. For the purpose of this paper, I assume that the cost a consumer faces in order to re-export a final good is arbitrarily large. In the previous section, I show that the clothing manufacturer Mango practices pricing-to-market within the EU, suggesting that costs of re-exporting may be high.

²⁵Kortum (1997), Eaton et al. (2005), Luttmer (2007) and Arkolakis (2007), among others, provide theoretical justifications for the use of the Pareto distribution.

with cdf $G_i(\phi) = 1 - b_i^\theta/\phi^\theta$, pdf $g_i(\phi) = \theta b_i^\theta/\phi^{\theta+1}$ and shape parameter $\theta > 0$ ²⁶. I retain the support of the distribution as $[b_i, \infty)$ and let b_i summarize the level of technology in country i . This parameter, in turn, is the source of per-capita income differences across countries. In particular, a relatively high b_i represents a more technologically-advanced country. Such a country is characterized by relatively more productive firms, whose marginal cost of production is low, and by richer consumers, who enjoy higher wages. The upcoming sections study how exporters respond to such market conditions.

With this parametrization in mind, it is straightforward to prove that a unique equilibrium exists in the model. The following proposition states this result. The proof can be found in appendix C.4.

Proposition 1. *Suppose there is a finite number of countries $i = 1, \dots, I$. Let $w = (w_1, \dots, w_I)$, $\Theta = (\theta, \{b_i\}_{i=1}^I, \{L_i\}_{i=1}^I, \{\tau_{ij}\}_{i,j=1}^I)$. Assume $\Theta \in [\underline{\Theta}, \overline{\Theta}]$. Consider the following system of I equations, $\{\Psi_i(w, \Theta)\}_{i=1}^I = 0$, where Ψ_i is given by:*

$$\Psi_i(w_i, w_{-i}, \Theta) = -\frac{w_i^{\theta+1}}{(b_i)^\theta} + \sum_j \left(\frac{L_j w_j}{\tau_{ij}^\theta \sum_v L_v \frac{(b_v)^\theta}{(\tau_{vj} w_v)^\theta}} \right) \quad (18)$$

Then $\forall \Theta \in [\underline{\Theta}, \overline{\Theta}]$, $\exists! w^*$, $w_i^* \in (0, \infty) \forall i$, s.th. $\{\Psi_i(w^*, \Theta)\}_{i=1}^I = 0$.

3.5 Firms' Prices and Mark-Ups

The different optimal mark-ups that arise from the two frameworks play a key role in delivering a relationship between price levels of tradables and per-capita incomes across countries. In particular, consider two firms with productivity draws ϕ_1 and ϕ_2 originating from countries 1 and 2, respectively, and selling to market j . Expression (8) shows that, in the non-homothetic model, the relative prices of the goods these firms sell are determined by the firms' relative marginal costs of production and delivery. The CES model obtains a similar prediction. In particular, the two models deliver the following relative prices:

²⁶This parameter restriction is sufficient to solve the non-homothetic model. See the proof of existence and uniqueness of equilibrium in appendix C.4. Throughout the quantitative analysis, I restrict $\theta > \sigma - 1$ to ensure a solution to the CES model exists.

$$\begin{aligned} \text{NH} : \frac{p_{1j}(\phi_1)}{p_{2j}(\phi_2)} &= \left(\frac{\tau_{1j} w_1 \phi_2}{\tau_{2j} w_2 \phi_1} \right)^{\frac{1}{2}} \\ \text{CES} : \frac{p_{1j}(\phi_1)}{p_{2j}(\phi_2)} &= \left(\frac{\tau_{1j} w_1 \phi_2}{\tau_{2j} w_2 \phi_1} \right). \end{aligned}$$

Thus, both models predict that, within a country, relative prices of goods are determined entirely by marginal costs of production and delivery firms face. These costs, by affecting relative demands for goods originating from different source countries, ultimately guide bilateral trade patterns across countries. Hence, the two models do not differ in their predictions on bilateral trade flows and result in identical gravity equations of trade.

Now, consider a firm with productivity draw ϕ , originating from country i and selling an identical variety to markets j and k , that is, $\phi \geq \max[\phi_{ij}^*, \phi_{ik}^*]$. The relative price this firm charges across the two markets in the two models is:

$$\begin{aligned} \text{NH} : \frac{p_{ij}(\phi)}{p_{ik}(\phi)} &= \frac{\tau_{ij}}{\tau_{ik}} \left(\frac{\phi_{ik}^*}{\phi_{ij}^*} \right)^{\frac{1}{2}} \\ \text{CES} : \frac{p_{ij}(\phi)}{p_{ik}(\phi)} &= \frac{\tau_{ij}}{\tau_{ik}}. \end{aligned} \tag{19}$$

The CES model predicts that the relative prices this firm charges across countries purely reflect the transportation cost incurred to ship the good to each destination. Expression (8) for the non-homothetic model, on the other hand, suggests that the firm not only accounts for shipping costs, but it also responds to local conditions, such as the destination's wage, aggregate price statistic, and the presence of competition, described by the total number of firms selling there. All of these characteristics are reflected in the productivity threshold the firm must surpass in order to sell to the particular market as seen in expression (19).

Consider for a moment the scenario of costless trade, namely, $\tau_{ij} = 1 \forall i, j$. Then, the productivity threshold in the non-homothetic model becomes²⁷:

$$\phi_{ij}^* = \left[\frac{b_i^\theta \bar{q}}{f_e(\theta + 1)(1 + 2\theta)} \left(L_j + \sum_{v \neq j} \frac{w_v L_v}{w_j} \right) \right]^{\frac{1}{\theta+1}}. \tag{20}$$

Looking at comparative statics, expression (20) clearly shows that productivity thresholds

²⁷ I refer the reader to appendix C.3 for a characterization of all equilibrium objects.

respond positively to the population and negatively to the per-capita income of the destination market. Thus, richer markets are more easily accessible for firms in this model, in that the productivity threshold they need to surpass is lower there. Hence, rich countries consume a larger pool of varieties than poor ones. Since consumers enjoy buying varieties, as their income increases, they buy not only more of each good, but also more goods.

Revisiting the mark-ups arising in the two models described in expression (19), costless trade leads to price equalization across countries in the CES model. However, since thresholds fall in destination per-capita income in the non-homothetic model, mark-ups, which are inversely related to thresholds, necessarily rise, thus yielding higher prices.

In order to better understand why, in the non-homothetic model, firms charge higher prices for identical products in richer markets, it is useful to examine the (absolute value of the) price-elasticity of demand for variety of type (ϕ, i, j) , given by:

$$\epsilon_{ij}(\phi) = \left[1 - \left(\frac{\phi}{\phi_{ij}^*} \right)^{-\frac{1}{2}} \right]^{-1}. \quad (21)$$

Using (21), the relative price of a variety across two markets becomes:

$$\frac{p_{ij}(\phi)}{p_{ik}(\phi)} = \frac{1 - [\epsilon_{ik}(\phi)]^{-1} \tau_{ij}}{1 - [\epsilon_{ij}(\phi)]^{-1} \tau_{ik}}.$$

Thus, prices reflect trade barriers and price elasticities of demand in this model. Moreover, in the absence of trade barriers, price equalization across markets does not occur. Since productivity thresholds fall with per-capita incomes of destinations, so do the price elasticities of demand as seen from (21). Thus, consumers in rich countries find their demand for an identical good less responsive to price changes than those in poor ones. Firms exploit this opportunity and charge a high mark-up in the more affluent market.

3.6 Firms' Sales and Their Distribution

This section argues that the non-homothetic model's qualitative predictions regarding exporters' sales and their distribution within a country are in line with the behavior of French exporters in 1986, as reported by Eaton et al. (2004) and Eaton et al. (2005)²⁸.

Letting $m_{ij}(\phi)$ represent the mark-up a firm from country i with productivity ϕ selling

²⁸I refer the reader to Eaton et al. (2005) for a detailed discussion of the CES model's predictions regarding firms' sales and their distribution.

to destination j charges, the sales this firm realizes in market j , relative to the average firm sales in market j , are given by:

$$s_{ij}(\phi) \equiv \frac{r_{ij}(\phi)}{t_{ij}} = \begin{cases} (1 + 2\theta) \left(1 - \frac{1}{m_{ij}(\phi)}\right) & \text{if } \phi \geq \phi_{ij}^* \\ 0 & \text{otherwise,} \end{cases}$$

where $t_{ij} = T_{ij}/N_{ij}$ represents average sales of firms from country i in destination j .

Notice that a firm with productivity equivalent to the threshold, ϕ_{ij}^* , sets a mark-up of unity and realizes zero sales. When looking at the optimal pricing rule, a more productive firm sells its variety at a lower price. This naturally raises its sales. However, notice that the price of a variety contains two components: the firm's marginal cost and its mark-up. While a more productive firm faces lower marginal cost, it is also able to charge a higher mark-up. Thus, a more productive firm enjoys higher mark-ups and higher sales. However, while the mark-up increases with firm productivity, it does so in a concave fashion. This translates into firm sales that are also concave in firm productivity. Figure 5 in appendix E graphically summarizes the relationship between firms sales' and their productivities.

Since the marginal firm in a market realizes zero sales, and sales are increasing in firms' productivities, this model generates a distribution of firms' sales that is qualitatively in line with the findings for French exporters reported by Eaton et al. (2005)²⁹.

Appendix C.5 derives the following distribution of firms' sales, relative to average sales in a market, predicted by the model:

$$F_{ij}(s) = 1 - \left[1 - \frac{s}{2\theta + 1}\right]^{2\theta}.$$

It also shows that the above distribution exhibits Pareto tails. Arkolakis (2008), in turn, finds that the distribution of French exporters' sales in Portugal in 1986 has the same feature. Finally, recall that, in this model, richer countries consume a larger pool of varieties. Since each variety is produced by a single firm, the relationship between the number of firms that serve each destination and the destination's per-capita income is a positive one. Thus, the non-homothetic model's qualitative predictions regarding firms' sales are in line with the

²⁹Eaton et al. (2005) identify the failure of the CES model to deliver small sales of exporters, if they face fixed costs of reaching a market. Arkolakis (2008) proposes a model in which exporters sell tiny amounts because they optimally reach only a portion of a destination's population. His model explains the behavior of exporters qualitatively as well as quantitatively, but it relies on CES preferences, thus delivering predictions regarding prices of tradables that are in contrast with the data.

behavior of French exporters reported in Eaton et al. (2004) and Eaton et al. (2005)³⁰.

4 Quantitative Analysis

In this section, I calibrate the non-homothetic and CES models to match bilateral trade flows and proceed to study the resulting price levels of tradables for two sets of countries.

4.1 Calibration

In this subsection, I discuss the choice of parameters used to study the quantitative predictions of the models. To begin the exposition, it is useful to analyze the gravity equation suggested by the two models.

I define λ_{ij} to be the share of goods originating from country i in the total expenditure on final goods by consumers in country j , or simply j 's import share of i -goods:

$$\begin{aligned}\lambda_{ij} &= \frac{T_{ij}}{\sum_v T_{vj}} \\ &= \frac{L_i \frac{b_i^\theta}{(\tau_{ij} w_i)^\theta}}{\sum_v L_v \frac{b_v^\theta}{(\tau_{vj} w_v)^\theta}}.\end{aligned}\tag{22}$$

Recall that T_{ij} corresponds to total sales of firms from country i in market j , which are in turn the product of the number of firms and their average sales there, $T_{ij} = N_{ij} t_{ij}$. The average sales of firms are given by:

$$\begin{aligned}t_{ij} &= \int_{\phi_{ij}^*}^{\infty} r_{ij}(\phi) \mu_{ij}(\phi) d\phi \\ &= \frac{(y_j + P_j) L_j}{2N_j(\theta + 0.5)}.\end{aligned}\tag{23}$$

³⁰ While the model qualitatively captures the behavior of exporters reported in the French data, it fails to quantitatively reproduce the elasticity of the number of firms that serve at least k markets with respect to their domestic sales. In this model, the distribution of firms' sales is summarized by the Pareto shape parameter, θ , which also governs bilateral trade flows through a standard gravity equation. When $\theta = 8$, the model matches bilateral trade flows very well, but the above elasticity is 0.61, which is well above the value of 0.35 for French exporters reported by Eaton et al. (2005). However, using the generalized utility function introduced earlier would allow me to quantitatively match the distribution of firms' sales by choosing an appropriate value for the curvature parameter, σ .

Notice that average sales of firms in destination j are entirely determined by local market conditions. Thus, bilateral trade shares solely reflect the number of firms serving particular destinations. Using (23), I arrive at (22), which defines the trade share components that constitute a standard gravity equation of trade.

Following the methodology of Eaton and Kortum (2002), and letting $\tau_{jj} = 1$, the gravity equation is³¹:

$$\log \left(\frac{\lambda_{ij}}{\lambda_{jj}} \right) = S_j - S_i - \theta \log \tau_{ij}, \quad (24)$$

where S_j and S_i represent importer- j and exporter- i fixed effects, with $S_j = \theta \log(w_j) - \log(L_j) - \theta \log(b_j)(\forall j)$. I assume the following functional form for trade barriers:

$$\log \tau_{ij} = d_k + b + e_h + x_i + \delta_{ij}, \quad (25)$$

where the dummy variable associated with each effect has been suppressed for notational simplicity. In the above expression, d_k , $k = 1, \dots, 6$, quantifies the effect of the distance between i and j lying in the k -th interval, b captures the importance of sharing a border and e_h is the effect of i and j both belonging to the European Union (in 1996) and the NAFTA (North American Free Trade Agreement), respectively³². Finally, following Waugh (2007), I let x_i capture additional hurdles exporters face in order to place their products abroad³³.

As discussed in appendix A, with the help of two assumptions about the CES model, its gravity equation collapses to (24). First, I assume that the amount of labor necessary to cover the fixed cost of selling domestically and abroad is equivalent, an assumption used

³¹Import shares, λ_{ij} 's, are straightforward to compute from the bilateral trade flows data in Feenstra et al. (2005). I take total bilateral trade flows, which include Standard International Trade Classification (SITC) 1-digit codes ranging between 0-9. Thus, my data includes agricultural goods. I compute the domestic share of total expenditure, λ_{jj} , by subtracting total exports from gross output and adding back the imports from all the countries in the respective sample. I define gross output to be the value added of manufacturing and agriculture, collected from WDI. Since my framework models trade in final goods, and given that the PWT 6.1 price data puts a large emphasis on food items, I find it appropriate to account for agricultural goods in addition to manufacturing items.

³²I obtain distance and border data from Nicita and Olarreaga (2006), better known as World Bank's Trade, Production and Protection Database.

³³In Appendix O.1 available on my website www.econ.umn.edu/~ina, I repeat the analysis with trade barriers estimated according to Eaton and Kortum (2002), namely using importer-specific fixed effects. I report all summary statistics and reproduce figure 1 using prices generated from the CES and non-homothetic models. Since trade barriers are systematically lower in richer destinations, they diminish the effect low price elasticities of demand have on the price level of tradables. But, the reader can verify that, while estimated elasticities are lower, the nature of the results remains unaltered.

by Arkolakis (2008) when calibrating a similar model. Second, I assume that fixed costs are incurred in destination-specific wages. This assumption can be rationalized if one takes fixed costs to represent the costs of establishing a retail network in the destination country.

A quick glance at the gravity equation indicates that a value for the Pareto shape parameter θ is necessary in order to calibrate the trade barriers in the model. I take a value of 8 for θ , a parameter choice used by Eaton and Kortum (2002) in their study of OECD economies, and retain the value for the larger sample of countries³⁴. The (restricted) linear regression relating bilateral trade flows and trade barriers results in an R^2 of 0.88 for the OECD countries, and 0.73 for the sample of 100 countries. These findings are in line with those reported by Eaton and Kortum (2002) and Waugh (2007).

In order to derive the technology parameters of each country, b_i , I solve the model using the calibrated trade barriers and Pareto shape parameter, together with per-capita income and population data for 1996³⁵. The technology parameters thus satisfy all equilibrium conditions of the model³⁶.

Finally, for the purpose of price-comparisons across countries, the fixed cost of market entry f_e , the non-homotheticity parameter \bar{q} , the fixed cost of selling to a market f , and the constant elasticity of substitution σ , (where the last two parameters are found in the CES model only) need not be calibrated. This is because they are country-invariant and cancel out in relative-price comparisons³⁷.

³⁴Eaton and Kortum (2002) choose a value of θ so that their model matches prices in OECD countries. Although their model differs from mine, the two frameworks yield gravity equations that are alike, which allows me to take their parameter choice for the OECD sample. Ideally, I would calibrate θ to match price data for the sample of 100 countries, but the PWT 6.1 price data is not disaggregated enough. Once I obtain data from the latest ICP round, I can carry out such estimation. Waugh (2007) estimates the parameter for a large sample of countries using 1985 price data and finds a lower value is appropriate. Fieler (2007) uses a value of 8 for θ in her analysis of a sample of countries comparable to mine. Finally, Arkolakis (2008) makes the same parameter choice in his model, which has a comparable market structure to mine.

³⁵Per-capita and population data are obtained from WDI.

³⁶In appendix C.3, I show that all equilibrium objects can be expressed as functions of wage rates of all the countries. Since the CES and the non-homothetic models deliver identical gravity equations, the system of equations that characterizes the unique vector of wages that solves the two models is also identical. Hence, technology parameters, calibrated to generate per-capita incomes observed in the data, are equivalent in the two models.

³⁷Since both models are limiting cases of the general utility function introduced earlier, there is an apparent discontinuity in both models. For values of $\bar{q} = 0$ and $\sigma = 1$, both models collapse into a simple framework in which products are perfect substitutes. This case is of no interest because exporter behavior is trivial. The most interesting case is the general one, in which both parameters are chosen to match observed features of firms. I am currently working on this case. While quantitative results differ, the qualitative relationships derived in this paper remain unaltered.

4.2 Income Differences and Prices of Tradables

In this section, I evaluate the ability of the two models to explain the observed differences in prices of tradable goods across countries. As discussed in section 1, tradable goods are systematically more expensive in richer (per-capita) countries. For the OECD³⁸ member countries, the estimated elasticity of the price level of tradables with respect to per-capita income is 0.32, while for a sample of 100 countries, the same statistic is 0.21. In order to evaluate the ability of the two models to reconcile these observations, I solve the calibrated models and calculate the price levels of tradable goods³⁹.

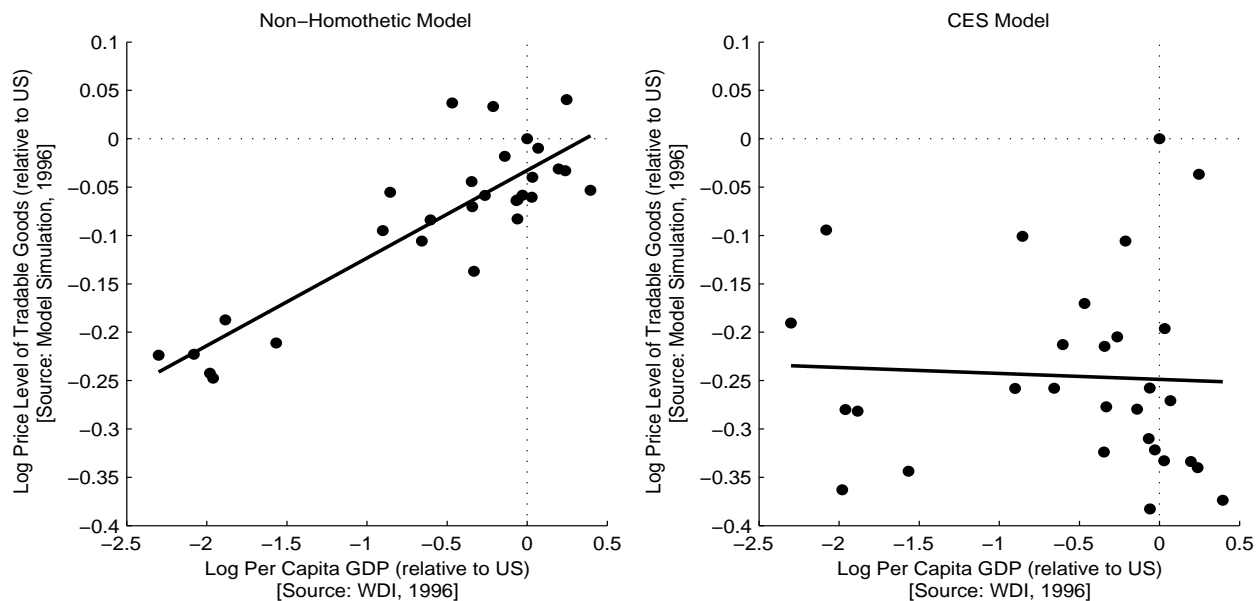


Figure 2: Price Level of Tradable Goods and Per-Capita GDP for OECD Countries

Figure 2 reproduces figure 1 for OECD economies, using the price levels of tradables

³⁸The sample of OECD countries contains 29 price and income observations. I drop Taiwan from the sample because price data is unavailable. I compute a weighted average of the price observations for Belgium and Luxembourg, using GDP as weights, because bilateral trade flows data are only available for the two countries together.

³⁹I take the price level data from the Penn World Table 6.1, 1996 ICP Benchmark Studies. The price levels in the PWT 6.1 are computed following the Elteto-Koves-Schultz (EKS) method up to a basic-heading level and further combined to disaggregate-category level using the Geary-Khamis (GK) method. The latter constitutes publicly available data. Since the models can only differentiate products up to the basic-heading level, I apply the EKS method throughout to derive price levels of tradables in the models. Data at the basic-heading level for 1996 is unavailable. However, I am requesting data at the basic-heading level from the 2005 International Comparison Program (ICP) from the World Bank in order to verify the relationship between prices of tradables and per-capita income reported earlier. Appendix B describes the accounting procedure for the data and the two models in detail.

resulting from the optimal decisions of firms in the two models, whose parameters have been calibrated to match 1996 bilateral trade flows of OECD countries⁴⁰.

While the models match OECD bilateral trade shares well, they depart in their predictions regarding price levels. The CES model is unable to produce a relationship between the price level of tradables and per-capita income for OECD countries. The model's estimated elasticity of the price level of tradables with respect to per-capita income is -0.0061, which is not statistically different from 0, as the t-statistic is -0.25. The non-homothetic model, on the other hand, not only qualitatively predicts a positive relationship between the two variables, but can also explain almost a third of the price differentials since its estimated elasticity is 0.09, with standard error 0.0098.

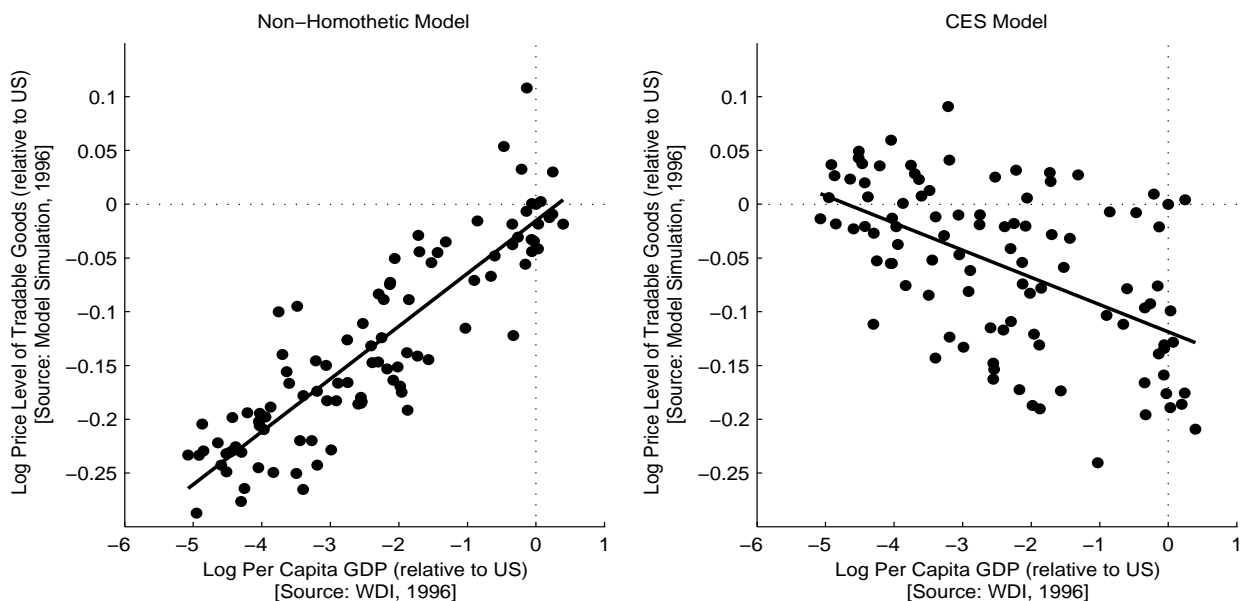


Figure 3: Price Level of Tradable Goods and Per-Capita GDP for 100 Countries

Figure 3 reproduces figure 1 using the price levels of tradables resulting from the optimal decisions of firms in the two models, whose parameters have been calibrated to best match 1996 bilateral trade flows of 100 countries⁴¹. While the non-homothetic model predicts a positive correlation between prices of tradables and per-capita income levels, the CES model

⁴⁰Figure 6 in appendix E plots the relationship between prices of tradables and per-capita incomes for OECD countries in the data and the two models. Figure 7 compares the prices of tradables observed in the data and those arising from the non-homothetic model for OECD countries.

⁴¹Figure 8 in appendix E plots the relationship between prices of tradables and per-capita incomes for 100 countries in the data and the two models. Figure 9 compares the prices of tradables observed in the data and those arising from the non-homothetic model for 100 countries.

obtains a counterfactual prediction. Indeed, the estimated price elasticity of tradables with respect to per capita income implied by the CES model is $-0.02(0.0040)$, while that generated by the non-homothetic model is $0.05(0.0026)$. Thus, the non-homothetic model can explain a quarter of the observed cross-country price differences for a large sample of countries.

To understand the CES model's different predictions regarding the two samples of countries, it suffices to examine the optimal pricing rule of any firm with productivity ϕ , originating in country i and selling to country j , $p_{ij} = \sigma/(\sigma - 1)\tau_{ij}w_i/\phi$. The price of a tradable good captures the productivity of the exporting firm, reflected in its marginal cost of production, trade barriers and a constant mark-up. Moreover, the relative price of a good that is actually exported to two different destinations departs from unity only to the extent that its producer faces country-specific trade barriers. Should trade barriers be uncorrelated with per-capita income, no relationship between prices and incomes is to be expected. Indeed, this is the case for OECD economies. These countries have bilateral trade flows that are characterized by virtually no zero-entries, suggesting low trade barriers. Hence, for these economies, the CES model predicts no relationship between prices of tradables and income levels.

Once the sample is extended to 100 countries, the per-capita income heterogeneity rises dramatically. However, in this case, trade barriers also diverge in order to deliver the many zero bilateral trade observations found in the data. These are in turn more prominent among poor countries. In fact, rich countries are both more productive and trade more among themselves. Their high productivity levels in turn imply low marginal costs of production. Hence, the varieties they produce and trade with each other are cheaper. From the point of view of a poor economy, it only benefits from low prices if its trade barriers are low enough. Otherwise, the low levels of productivity, which result in high marginal costs of production for its domestic producers, not only prevent it from placing its products internationally, but also hurt its consumers by raising the price of domestically produced goods. Thus, a negative relationship between prices of tradable goods and per-capita income levels arises.

The non-homothetic model, on the other hand, introduces a pricing-to-market channel in addition to the trade barrier effect outlined above. While trade barriers are an important determinant of the price of imports, so is the responsiveness of consumers to price changes. The pricing rule a firm ϕ follows is $p_{ij}(\phi) = \tau_{ij}/(1 - [\epsilon_{ij}(\phi)]^{-1})$, which reflects trade barriers and the price elasticity of demand. High income levels result in low price elasticity of demand, allowing firms to extract high mark-ups in more affluent markets. Although domestically-produced varieties are relatively cheap in rich markets due to the countries' high productivity levels, imports are not. To the extent that rich economies enjoy lower trade barriers, their

import-penetration ratios are higher, and so are their price levels of tradable goods.

5 Conclusion

This paper builds on the success of the existing trade literature that aims to explain the behavior of exporters and bilateral trade flows. It further contributes to the literature by capturing the observed positive relationship between prices of tradable goods and income. It does so by introducing non-homothetic preferences in a model of trade with product differentiation and heterogeneity in firm productivity. In an analytically tractable framework, the model predicts that not only are exporters in the minority, but that they also sell tiny amounts per market. Moreover, these exporters exploit low price elasticities of demand in rich countries by charging high mark-ups for identical products relative to poor destinations.

The pricing-to-market channel is not only key for qualitatively matching the relationship between prices of tradables and countries' incomes, but it also appears to be quantitatively important. In particular, variable mark-ups can account for a third of price differences across OECD economies and for over a quarter of world price differences.

Since a simple model of non-homothetic preferences appears to both qualitatively and quantitatively match trade flows and price levels across countries, it may be reasonable to build on such a framework in future studies. In particular, quantifying the general framework that nests the CES and non-homothetic models is of particular interest. Such model would be able to quantitatively explain both firm behavior and aggregate observations such as trade flows and prices. The model can further be extended to a dynamic framework in which real exchange rate fluctuations can be explored.

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Appendix

A CES Model

Throughout this paper, I compare the predictions of the model with non-homothetic preferences to those arising from one with symmetric CES preferences. This is a variant of the model proposed by Melitz (2003) and extended by Chaney (2008)⁴².

The maximization problem of a consumer in country j buying goods from (potentially) all countries $v = 1, \dots, I$ is:

$$\begin{aligned} \max_{\{q_{vj}^c\}_{v=1}^I \geq 0} & \left(\sum_{v=1}^I \int_{\Omega_{vj}} (q_{vj}^c(\omega))^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \\ \text{s.t.} & \sum_{v=1}^I \int_{\Omega_{vj}} p_{vj}(\omega) q_{vj}^c(\omega) d\omega \leq w_j. \end{aligned}$$

I assume that the market structure is identical to that of the model with non-homothetic preferences. Then, the demand for variety of type ϕ originating from country i consumed in a positive amount in country j , $q_{ij}(\phi) > 0$, is given by⁴³:

$$q_{ij}(\phi) = w_j L_j \frac{p_{ij}(\phi)^{-\sigma}}{P_j^{1-\sigma}}, \quad (26)$$

where

$$P_j^{1-\sigma} = \sum_{v=1}^I N_{vj} \int_{\phi_{vj}^*}^{\infty} p_{vj}(\phi)^{1-\sigma} \mu_{vj}(\phi) d\phi, \quad \sigma > 1. \quad (27)$$

From (26), notice that the productivity threshold in this economy cannot be determined using the demand for the cutoff variety. Instead, it is necessary to introduce fixed costs at the firm level to bound the number of firms that serve each market.

Using (26), the profit maximization problem of a firm with productivity draw ϕ originat-

⁴²It can also be seen as the limiting case of the general utility function outlined earlier, where $\bar{q} \rightarrow 0$.

⁴³I refer the reader to Melitz (2003) for detailed derivations of optimal rules in this economy. Arkolakis (2008) describes a procedure for computing equilibrium objects in this economy. The procedure is virtually identical to the one I apply to the non-homothetic model, so I refrain from the details in this paper.

ing in country i and considering to sell to country j is:

$$\max_{p_{ij} \geq 0} p_{ij} w_j L_j \frac{p_{ij}^{-\sigma}}{P_j^{1-\sigma}} - \frac{\tau_{ij} w_i}{\phi} w_j L_j \frac{p_{ij}^{-\sigma}}{P_j^{1-\sigma}} - w_j f.$$

In the above problem, I assume that each firm incurs a fixed cost, $f > 0$, in order to sell to a particular market. Moreover, the fixed cost is paid in terms of labor units of the destination country⁴⁴.

The optimal pricing rule of a firm with productivity draw $\phi \geq \phi_{ij}^*$ is given by:

$$p_{ij}(\phi) = \underbrace{\frac{\sigma}{\sigma - 1}}_{\text{mark-up}} \underbrace{\frac{\tau_{ij} w_i}{\phi}}_{\text{marginal cost}}.$$

B Computing Price Levels of Tradables

In this section, I describe the procedure used to derive the price levels of tradable goods in the data and the two models.

To begin, I use data from the 1996 round of the International Comparison Program (ICP) reported by Heston et al. (2002), better known as the 1996 Benchmark Study used to calculate the purchasing power parities in the Penn World Table Version 6.1. According to the ICP Handbooks⁴⁵, unit price data on identical goods is collected across retail locations in the participating countries. The lowest level of aggregation is the basic heading (BH), which represents a group of goods for which expenditure data is available. There are a total of 150 BHs in the data set. The BHs are then combined to form Disaggregate Categories, which constitute the lowest level of aggregation for which data is made publicly available.

Each BH contains a certain number of products. Hence, the reported price of a BH is

⁴⁴These two assumptions do not change the predictions of the model with respect to price levels, however, they result in a gravity equation for the model that is equivalent to the one with non-homothetic preferences. This allows me to use the same parameter estimates for the two models in the quantitative analysis of price levels.

⁴⁵The ICP Handbook for the 1996 Benchmark study provided by the United Nations Statistic Division is available at <http://unstats.un.org/unsd/methods/icp/ipcohtm.htm>. A more detailed and updated handbook, the ICP Handbook for the latest ICP round of 2003-2006 prepared by the World Bank, is available at <http://go.worldbank.org/LGVPTQ6YJ0>.

an aggregate price. In order to derive at that price, the ICP uses the Elteto-Koves-Schultz (EKS) method. For all N countries and I products within the basic heading, the ICP collects unit prices. The goal is to find the equivalent product in every country, thus washing away any quality differences. If an identical product is not found, the price entry is either left blank, resulting in missing observations, or a comparable product is found, ensuring that its specifications are carefully recorded so that quality adjustments can be made to the price entry.

A subset $R \subseteq I$ of goods is deemed representative in every country. An item is representative in country j relative to k if it is consumed relatively more in j . The representativeness is in turn determined from surveys of households and retailers.

A numeraire country is chosen, USA, and prices are expressed in 1996 US dollars. The EKS method for computing a price level at the BH-level can be described as follows:

Step 1: Relative price between countries j and k based on j 's representative goods is:

$$P_{jk}^j = \left(\prod_{i=1}^{R_j} \frac{p_{ij}}{p_{ik}} \right)^{\frac{1}{R_j}}$$

Step 2: Relative price between countries j and k based on k 's representative goods is:

$$P_{jk}^k = \left(\prod_{i=1}^{R_k} \frac{p_{ij}}{p_{ik}} \right)^{\frac{1}{R_k}}$$

Step 3: Relative price between countries j and k based on both j 's and k 's representative goods is:

$$P_{jk}^{j,k} = (P_{jk}^j P_{jk}^k)^{\frac{1}{2}}$$

Step 4: Relative price of BH between j and k is:

$$P_{jk} = \left[\left(P_{jk}^{j,k} \right)^2 \prod_{l \neq j,k} \frac{P_{lk}^{l,k}}{P_{lj}^{l,j}} \right]^{\frac{1}{N}}$$

Thus, the relative price between two countries does not only represent the geometric average of relative prices of the two countries' representative goods, but also accounts for the implied

cross price levels using all participating countries. This method makes price levels transitive.

Basic headings are then combined into Disaggregate Categories using the Geary-Khamis (GK) method. The reported data features expenditures on Disaggregate Categories by different countries in domestic currency. Dividing expenditures by those reported for the US and adjusting them by annual exchange rates allows to arrive at the price level of a category of goods, relative to the US. Using this data, I compute the price level of tradable goods as an average of the price levels of the disaggregate categories that correspond to tradable goods only. I use three different methods to combine the disaggregate category prices into a price level of tradables:

1. Arithmetic Average
2. Geometric Average
3. Weighted arithmetic average, with weights corresponding to the expenditure weights for each disaggregate category.

All three methods give very similar estimates of the price elasticity with respect to per-capita income. Since my model cannot distinguish past a BH-level⁴⁶, I report all results with estimates obtained using the first method in the above list.

I now describe the EKS method using the model variables. The procedure is equivalent for the two models, but the price entries differ, since the optimal pricing rules of firms under the two models are different.

Following the definition of representativeness, I can rank goods by ranking the per-consumer sales of the firms in a destination, since this statistic represents the per-consumer expenditure on a good. Now, consider two destinations, j and k , and a common source country i . If $\phi_{ij}^* \neq \phi_{ik}^*$, then not all firms from country i serve both destinations. Hence, only prices of firms with productivity draws $\phi \geq \max[\phi_{ij}^*, \phi_{ik}^*]$ are relevant in my comparison. Moreover, for any $\phi_1 > \phi_2 \geq \max(\phi_{ij}^*, \phi_{ik}^*)$, $r_{iv}^c(\phi_1) > r_{iv}^c(\phi_2) \geq r_{iv}^c(\max[\phi_{ij}^*, \phi_{ik}^*])$, $v = j, k$, where $r_{iv}^c = r_{iv}/L_v$ is per-consumer sales of firm ϕ originating from country i . Hence, if two goods from the same source country are sold in both destinations, the relative rank (within all goods from that source country) is the same in both destinations. Thus, comparing the relative prices of two goods that originate from country i and are being sold in destinations

⁴⁶Ideally, data at the BH level would allow me to simply take an average of BH prices and compare this statistic to the price level of the BH implied by the model. Unfortunately, such data is not publicly available, and I am in the process of applying for the archive files.

j and k does not require keeping track of their representativeness in each country, which allows to merge steps 1 – 3 outlined above into a single step.

It is however important to keep track of the country of origin of the goods, since two countries i, i' do not necessarily have the same export-penetration ratio in two destinations j, k . However, the share of the number of exporters from country i selling to destination j , N_{ij} , in the total number of firms selling to country j , N_j , measures the export-penetration ratio of country i in country j ⁴⁷.

Finally, in order to compute the relative price between countries j and k (based on either country's representative goods), I need to compute a geometric average of the relative prices of goods within the BH. Since the model contains a continuum of varieties, the geometric mean formula,

$$\bar{x}_g = \left(\prod_K x_k \right)^{\frac{1}{K}}$$

simply becomes

$$\bar{x}_g = \exp \left(\int_K \log[x(k)]f(k)dk \right),$$

where $f(k)$ is the appropriate pdf.

Hence, the price of the BH between countries j and k (based on both j 's and k 's representative goods) is:

$$P_{jk}^{j,k} = \exp \left\{ \frac{\sum_v \frac{J_v b_v^\theta}{[\max(\phi_{vj}^*, \phi_{vk}^*)]^\theta} \int_{\max(\phi_{vj}^*, \phi_{vk}^*)}^\infty \log \left[\frac{p_{vj}(\phi)}{p_{vk}(\phi)} \right] \frac{\theta [\max(\phi_{vj}^*, \phi_{vk}^*)]^\theta}{\phi^{\theta+1}} d\phi}{\sum_v \frac{J_v b_v^\theta}{[\max(\phi_{vj}^*, \phi_{vk}^*)]^\theta}} \right\}, \quad (28)$$

having substituted in for the equilibrium number of firms serving each market.

However, the relative prices a single firm charges in two destinations is independent of its productivity and depends only on relative trade barriers in the CES model, and on trade barriers, per-capita incomes and populations of the destinations in the non-homothetic

⁴⁷In this model, $N_{ij}/N_j = T_{ij}/T_j$, where T_{ij} represents total sales of firms from country i in country j , the statistic used by the ICP to define representativeness.

model. Thus, (28) for the CES and non-homothetic model, respectively, becomes:

$$\begin{aligned} \text{CES: } P_{jk}^{j,k} &= \exp \left\{ \frac{\sum_v \frac{J_v b_v^\theta}{[\max(\phi_{vj}^*, \phi_{vk}^*)]^\theta} \log \left[\frac{\tau_{vj}}{\tau_{vk}} \right]}{\sum_v \frac{J_v b_v^\theta}{[\max(\phi_{vj}^*, \phi_{vk}^*)]^\theta}} \right\} \\ \text{NH: } P_{jk}^{j,k} &= \exp \left\{ \frac{\sum_v \frac{J_v b_v^\theta}{[\max(\phi_{vj}^*, \phi_{vk}^*)]^\theta} \log \left[\frac{\tau_{vj}}{\tau_{vk}} \left(\frac{\phi_{vk}^*}{\phi_{vj}^*} \right)^{\frac{1}{2}} \right]}{\sum_v \frac{J_v b_v^\theta}{[\max(\phi_{vj}^*, \phi_{vk}^*)]^\theta}} \right\}. \end{aligned}$$

Using these expressions in step 4 allows to compute the price levels of tradables across countries.

It is important to make a final note regarding the computational procedure. Since the models are calibrated to match bilateral trade flows, bilateral trade barriers are set to arbitrarily high values for entries of zero in the bilateral trade flows matrix. For these pairs of countries, the productivity thresholds become arbitrarily large, thus preventing firms from surpassing them. Hence, all such observations are given zero-weight in the price computation procedure for the models, which is in line with ICP computational procedures. Thus, any varieties that are only sold domestically are excluded from relative price comparisons. So, in order to apply the ICP procedure to the models, computing price levels of tradable goods amounts to computing price levels of traded goods.

C Algebraic Derivations

C.1 Deriving Consumer's Demand

The maximization problem of a consumer in country j buying goods from (potentially) all countries $v = 1, \dots, I$ is:

$$\begin{aligned} \max_{\{q_{vj}^c\}_{v=1}^I \geq 0} & \sum_{v=1}^I \int_{\Omega_{vj}} \log(q_{vj}^c(\omega) + \bar{q}) d\omega \\ \text{s.t. } & \lambda_j \left[\sum_{v=1}^I \int_{\Omega_{vj}} p_{vj}(\omega) q_{vj}^c(\omega) d\omega \leq w_j \right], \end{aligned}$$

where λ_j is the Lagrange multiplier.

The FOCs of the above problem yield ($\forall q_{ij}^c(\omega) > 0$) :

$$\lambda_j p_{ij}(\omega) = \frac{1}{q_{ij}^c(\omega) + \bar{q}}. \quad (29)$$

Let $\Omega_j^* \equiv \sum_{v=1}^I \Omega_{vj}^*$ be the set of all consumed varieties in country j . Letting N_{vj} be the measure of set Ω_{vj}^* , the measure of Ω_j^* , N_j , is given by $N_j = \sum_{v=1}^I N_{vj}$.

For any pair of goods $\omega_{ij}, \omega'_{vj} \in \Omega_j^*$, (29) gives:

$$p_{ij}(\omega) (q_{ij}^c(\omega) + \bar{q}) = p_{vj}(\omega') q_{vj}^c(\omega') + p_{vj}(\omega') \bar{q}. \quad (30)$$

Integrating over all $\omega'_{vj} \in \Omega_j^*$, keeping in mind that the measure of Ω_{vj}^* is N_{vj} , yields the consumer's demand for any variety $\omega_{ij} \in \Omega_j^*$:

$$\begin{aligned} & \int_{\Omega_j^*} [p_{ij}(\omega) (q_{ij}^c(\omega) + \bar{q})] d\omega' = \int_{\Omega_j^*} [p_{vj}(\omega') q_{vj}^c(\omega') + p_{vj}(\omega') \bar{q}] d\omega' \\ \Rightarrow & \sum_{v=1}^I \int_{\Omega_{vj}^*} [p_{ij}(\omega) (q_{ij}^c(\omega) + \bar{q})] d\omega' = \sum_{v=1}^I \int_{\Omega_{vj}^*} [p_{vj}(\omega') q_{vj}^c(\omega') + p_{vj}(\omega') \bar{q}] d\omega' \\ \Rightarrow & [p_{ij}(\omega) (q_{ij}^c(\omega) + \bar{q})] \sum_{v=1}^I \int_{\Omega_{vj}^*} 1 d\omega' = \sum_{v=1}^I \int_{\Omega_{vj}^*} [p_{vj}(\omega') q_{vj}^c(\omega') + p_{vj}(\omega') \bar{q}] d\omega' \\ \Rightarrow & [p_{ij}(\omega) (q_{ij}^c(\omega) + \bar{q})] \sum_{v=1}^I N_{vj} = w_j + \sum_{v=1}^I \int_{\Omega_{vj}^*} p_{vj}(\omega') \bar{q} d\omega' \\ \Rightarrow & [p_{ij}(\omega) (q_{ij}^c(\omega) + \bar{q})] N_j = w_j + P_j \\ \Rightarrow & q_{ij}^c(\omega) = \frac{w_j + P_j}{N_j p_{ij}(\omega)} - \bar{q} \end{aligned} \quad (31)$$

where $P_j \equiv \bar{q} \sum_{v=1}^I \int_{\Omega_{vj}^*} p_{vj}(\omega') d\omega'$ is an aggregate price statistic and $N_j = \sum_{v=1}^I N_{vj}$ is the number of varieties consumed.

The total demand for variety ω originating from country i by consumers in country j then becomes:

$$q_{ij}(\omega) = L_j \left[\frac{w_j + P_j}{N_j p_{ij}(\omega)} - \bar{q} \right].$$

C.2 Solving the Firm's Problem

Recall (7), which gives the profit maximization problem of a firm with productivity draw ϕ originating in country i and considering to sell to country j :

$$\max_{p_{ij} \geq 0} p_{ij} L_j \left[\frac{w_j + P_j}{N_j p_{ij}} - \bar{q} \right] - \frac{\tau_{ij} w_i}{\phi} L_j \left[\frac{w_j + P_j}{N_j p_{ij}} - \bar{q} \right]$$

Since there is a continuum of firms, an individual monopolistic competitor does not view the aggregate variables, P_j and N_j , as choice variables. Hence, the FOCs of the firm's problem are given by

$$-L_j \bar{q} + \frac{\tau_{ij} w_i}{\phi} L_j \frac{w_j + P_j}{N_j (p_{ij})^2} = 0,$$

which results in the optimal price of:

$$p_{ij}(\phi) = \left(\frac{\tau_{ij} w_i}{\phi} \frac{w_j + P_j}{N_j \bar{q}} \right)^{\frac{1}{2}}.$$

C.3 Solving for Equilibrium Objects

In this section, I characterize the equilibrium objects of the model. I express all objects in terms of wage rates and I derive a set of equations that solve for the wage rates of all countries simultaneously. In the next section, I explore the properties of the system of equations and prove that a unique solution exists.

Straightforward algebraic manipulations allow to obtain the aggregate price statistic P_j , the number of firms serving each destination N_{ij} , and the productivity thresholds ϕ_{ij}^* , in terms of wage rates and number of entrants for each country.

As described in section 3.4, to solve the model, it is necessary to jointly determine wage rates, w_i , and the number of entrants, J_i , $\forall i$. These are in turn found using the free entry condition, (16), and the income/spending equality, (17).

Free entry requires that average profits cover the fixed cost of entry:

$$\begin{aligned} w_i f_e &= (1 - G_i(\phi_{ii}^*)) \pi_i \\ \Rightarrow w_i f_e &= \left(\frac{b_i}{\phi_{ii}^*} \right)^\theta \sum_v \left(\frac{\phi_{ii}^*}{\phi_{iv}^*} \right)^\theta \frac{\bar{q} \tau_{iv} w_i L_v}{2 \phi_{iv}^* (\theta + 1) (\theta + 0.5)} \end{aligned} \quad (32)$$

The income/spending identity requires that country i 's consumers spend their entire income

on imported and domestically-produced final goods:

$$L_i w_i = \sum_v J_i \frac{b_i^\theta}{\phi_{iv}^*} \frac{\bar{q} \tau_{iv} w_i L_v}{2 \phi_{iv}^* (\theta + 0.5)} \quad (33)$$

Expressions (32) and (33) yield:

$$J_i = \frac{L_i}{(\theta + 1) f_e} \quad (34)$$

In order to characterize wages, I follow the approach of Arkolakis (2008) and Arkolakis et al. (2008). This amounts to using import shares λ_{ij} , and the trade balance $\sum_j T_{ij} = \sum_j T_{ji}$, to arrive at:

$$\frac{w_i^{\theta+1}}{(b_i)^\theta} = \sum_j \left(\frac{L_j w_j}{\tau_{ij}^\theta \sum_v L_v \frac{(b_v)^\theta}{(\tau_{vj} w_v)^\theta}} \right) \quad (35)$$

This equation implicitly solves for the wage rate w_i for each country i , where $w_1 = 1$ can be taken to be the numeraire country.

C.4 Existence and Uniqueness of Equilibrium

Proof. Existence. Assume country $i = 1$ is a numeraire, $(b_1, L_1) = (1, 1)$. Also, let $w_1 = 1$. Hence we will consider a system of $I - 1$ equations and unknowns.

Suppose $\Theta \in [\underline{\Theta}, \bar{\Theta}]$. Let $0 < \epsilon < 1$ be arbitrarily small. Define the lower and upper bounds on parameters by:

$$\begin{aligned} \underline{\Theta} &= \left(\epsilon, (1, \{\epsilon\}^{I-1}), (1, \{\epsilon\}^{I-1}), \{1\}^I \right), \\ \bar{\Theta} &= \left(1/\epsilon, (1, \{\epsilon\}^{I-1}), (1, \{\epsilon\}^{I-1}), \{1/\epsilon\}^I \right). \end{aligned} \quad (36)$$

For $i \neq 1$, rewrite (18) as

$$\begin{aligned} \Psi_i(w_i, w_{-i}, \Theta) &= -1 + \frac{1}{\tau_{ii}^\theta \left[\frac{1}{\tau_{ii}^\theta} + \frac{w_i^\theta}{L_i (b_i)^\theta} \sum_{v \neq i} \frac{L_v (b_v)^\theta}{(\tau_{vi} w_v)^\theta} \right]} \\ &+ \sum_{j \neq i} \left(\frac{L_j w_j}{\tau_{ij}^\theta \left[\frac{w_i L_i}{\tau_{ij}^\theta} + \frac{w_i^{\theta+1}}{(b_i)^\theta} \sum_{v \neq i} \frac{L_v (b_v)^\theta}{(\tau_{vj} w_v)^\theta} \right]} \right) \end{aligned} \quad (37)$$

Notice that $\forall w_j \in (0, \infty)$, $\Psi_i(\cdot, \Theta)$ is continuous and differentiable.

Clearly:

$$\frac{\partial \Psi_i}{\partial w_i} < 0 \quad (\forall j \neq i) \frac{\partial \Psi_i}{\partial w_j} > 0$$

In order to prove the existence of equilibrium, $\forall i \neq 1$ let $0 < \delta_i \leq 1$ be arbitrarily small s.th. $w_i \in [\delta_i, 1/\delta_i], \forall i \neq 1$. Let $\delta = \inf_i \delta_i$. Then, $0 < \delta \leq 1$ and by construction $w_i \in [\delta, 1/\delta], \forall i \neq 1$. Notice $\Psi_i(\cdot, w_{-i}, \Theta) : [\delta, 1/\delta]^{I-2} \rightarrow [\delta, 1/\delta]$. Let $\Psi = X_{i=1}^I \Psi_i$. Then $\Psi : [\delta, 1/\delta]^{I-1} \rightarrow [\delta, 1/\delta]^{I-1}$.

Notice $[\delta, 1/\delta]^{I-1} \in \mathbb{R}_+^{I-1}$ is:

1. Nonempty $\forall \delta, 0 < \delta \leq 1$
2. Compact
3. Convex

Also, $\Psi : [\delta, 1/\delta]^{I-1} \rightarrow [\delta, 1/\delta]^{I-1}$ is continuous function of $w \in [\delta, 1/\delta]^{I-1}$.

Then, by the Brouwer fixed point theorem, $\exists w^* \in [\delta, 1/\delta]^{I-1}$ s.th. $\Psi(w^*) = w^*$.

Uniqueness.

Suppose $w^* \in [\delta, 1/\delta]^{I-1}$ is an equilibrium. From (37), notice:

1. $\Psi_i(\cdot, w_{-i}^*, \Theta)$ is strictly decreasing and continuous on $[\delta, 1/\delta]$.
2. $\Psi_i(0, w_{-i}^*, \Theta) = +\infty$
3. $\Psi_i(+\infty, w_{-i}^*, \Theta) = -1$

Hence, $\exists! w_i^* \in (0, \infty)$ s.th. $\Psi_i(w_i^*, w_{-i}^*, \Theta) = 0$. Thus, the equilibrium is unique. \square

C.5 Distribution of Firms' Sales

Section (3.6) derives the sales of a firm with productivity ϕ from source country i in destination j , relative to average sales there:

$$s_{ij}(\phi) \equiv \frac{r_{ij}(\phi)}{t_{ij}} = \begin{cases} (1 + 2\theta) \left(1 - \left[\frac{\phi_{ij}^*}{\phi} \right]^{\frac{1}{2}} \right) & \text{if } \phi \geq \phi_{ij}^* \\ 0 & \text{otherwise.} \end{cases} \quad (38)$$

Firm sales are increasing, strictly concave in firm productivity, and bounded above:⁴⁸:

$$\lim_{\phi \rightarrow +\infty} s_{ij}(\phi) = 1 + 2\theta$$

Let $s_{ij}^{\min} = s_{ij}(\phi_{ij}^*)$ represent sales of a firm with productivity draw equivalent to the threshold, ϕ_{ij}^* . For the remainder of this subsection, I suppress all i, j -subscripts for ease of exposition. Then,

$$Pr[S \geq s | S \geq s^{\min}] = \frac{Pr[\Phi \geq \phi]}{Pr[\Phi \geq \phi^*]} = \left(\frac{\phi^*}{\phi}\right)^\theta$$

Let F represent the distribution of firms' sales, relative to average sales. This distribution satisfies:

$$Pr[S \geq s | S \geq s^{\min}] = 1 - Pr[S < s | R \geq s^{\min}] = 1 - F(s)$$

The above two expressions yield:

$$1 - F(s) = \left(\frac{\phi^*}{\phi}\right)^\theta \tag{39}$$

Using (38) and (39), the cdf F , and its corresponding pdf f , become:

$$F(s) = 1 - \left[1 - \frac{s}{2\theta + 1}\right]^{2\theta} \quad f(s) = \frac{2\theta}{2\theta + 1} \left[1 - \frac{s}{2\theta + 1}\right]^{2\theta-1}.$$

I now follow Saez (2001) to argue that the distribution of firms' sales is Pareto in the tail.

Let \bar{s}^m be the mean of s , conditional on $s \geq s^m$, for $1 + 2\theta \geq s^m \geq s^{\min}$, where $1 + 2\theta$ is the upper bound on firm sales as shown above. It suffices to show that \bar{s}^m/s^m is constant.

⁴⁸Since the upper bound on firm sales is determined by the Pareto shape parameter, which also governs bilateral trade flows, the model cannot generate a dispersion of firm sales in line with the data. The model with the generalized utility function is potentially capable of capturing this dispersion with an appropriate choice of the non-homotheticity parameter \bar{q} .

Clearly,

$$\begin{aligned} \frac{\bar{s}^m}{s^m} &= \frac{1}{s^m} \int_{s^m}^{2\theta+1} s \frac{\frac{2\theta}{2\theta+1} \left[1 - \frac{s}{2\theta+1}\right]^{2\theta-1}}{\left[1 - \frac{s^m}{2\theta+1}\right]^{2\theta}} ds \\ &= \frac{\left(1 - \frac{s^m}{2\theta+1}\right)^{2\theta} (2\theta(s^m + 1) + 1)}{s^m(2\theta + 1)} \end{aligned}$$

is constant, which allows to conclude that the distribution of firms' sales is Pareto in the tail.

D Gravity Equation Results

In this section, I discuss the results from the gravity equation estimation in more detail.

Tables 1 and 2 report the estimated coefficients from the gravity equation assuming trade barriers reflect exporter-specific hurdles in addition to distance, border and trade area membership, for OECD economies and for a set of 100 countries, respectively. I report the total sum of squares and the sum of squared residuals for every regression at the bottom of each table.

I also check whether estimated trade barriers allow for triangular arbitrage opportunity. In each model, there are potentially N^3 triangular opportunities, where N is the total number of countries in the sample. Using exporter fixed-effects in the trade barrier specification, triangular opportunities arise in 0.13% of the cases in the non-homothetic model, and in 0.32% of the cases in the CES model, for the set of OECD economies. The corresponding number for the set of 100 countries is 11% for both models.

Thus, for the larger set of countries, it may be worth estimating barriers to trade through constrained minimization in order to ensure arbitrage opportunities are non-existent. However, I do not pursue this task in the present paper.

Country		est.	s.e.		est.	s.e.
Hungary	S_{34}	0.16	(0.16)	$-\theta x_{34}$	0.58	(0.16)
Iceland	S_{35}	0.28	(0.24)	$-\theta x_{35}$	-1.20	(0.22)
Indonesia	S_{36}	0.21	(0.16)	$-\theta x_{36}$	2.55	(0.16)
Iran	S_{37}	0.36	(0.21)	$-\theta x_{37}$	0.76	(0.21)
Ireland	S_{38}	0.20	(0.15)	$-\theta x_{38}$	1.75	(0.15)
Italy	S_{39}	-0.04	(0.14)	$-\theta x_{39}$	3.94	(0.14)
Jamaica	S_{40}	-0.43	(0.22)	$-\theta x_{40}$	-1.13	(0.24)
Japan	S_{41}	0.86	(0.15)	$-\theta x_{41}$	4.52	(0.14)
Jordan	S_{42}	-1.37	(0.21)	$-\theta x_{42}$	-1.81	(0.23)
Kazakhstan	S_{43}	-0.33	(0.17)	$-\theta x_{43}$	-0.25	(0.18)
Kenya	S_{44}	0.00	(0.22)	$-\theta x_{44}$	-0.71	(0.23)
Korea, Rep.	S_{45}	0.07	(0.15)	$-\theta x_{45}$	3.68	(0.14)
Kyrgyz Republic	S_{46}	0.21	(0.26)	$-\theta x_{46}$	-3.07	(0.30)
Latvia	S_{47}	-0.19	(0.24)	$-\theta x_{47}$	-1.54	(0.24)
Lebanon	S_{48}	-0.81	(0.21)	$-\theta x_{48}$	-2.33	(0.24)
Lithuania	S_{49}	-0.15	(0.22)	$-\theta x_{49}$	-1.41	(0.23)
Madagascar	S_{50}	0.65	(0.26)	$-\theta x_{50}$	-2.12	(0.24)
Malawi	S_{51}	1.07	(0.28)	$-\theta x_{51}$	-1.54	(0.24)
Mali	S_{52}	1.07	(0.26)	$-\theta x_{52}$	-2.53	(0.30)
Mauritius	S_{53}	-0.94	(0.24)	$-\theta x_{53}$	-1.26	(0.25)
Mexico	S_{54}	0.55	(0.16)	$-\theta x_{54}$	1.77	(0.16)
Mongolia	S_{55}	-0.14	(0.28)	$-\theta x_{55}$	-2.69	(0.34)
Morocco	S_{56}	-0.05	(0.16)	$-\theta x_{56}$	0.17	(0.17)
Nepal	S_{57}	1.16	(0.25)	$-\theta x_{57}$	-3.17	(0.28)
Netherlands	S_{58}	-0.76	(0.15)	$-\theta x_{58}$	3.28	(0.14)
New Zealand	S_{59}	-0.21	(0.18)	$-\theta x_{59}$	1.49	(0.17)
Nigeria	S_{60}	0.65	(0.18)	$-\theta x_{60}$	0.55	(0.19)
Norway	S_{61}	-0.19	(0.16)	$-\theta x_{61}$	1.38	(0.15)
Oman	S_{62}	-1.59	(0.19)	$-\theta x_{62}$	-0.68	(0.20)
Pakistan	S_{63}	0.47	(0.16)	$-\theta x_{63}$	1.06	(0.15)
Panama	S_{64}	-2.06	(0.21)	$-\theta x_{64}$	-0.20	(0.22)
Peru	S_{65}	0.05	(0.19)	$-\theta x_{65}$	0.50	(0.18)
Philippines	S_{66}	-0.03	(0.16)	$-\theta x_{66}$	0.73	(0.18)
Poland	S_{67}	0.29	(0.15)	$-\theta x_{67}$	1.17	(0.15)
Portugal	S_{68}	-0.47	(0.15)	$-\theta x_{68}$	0.64	(0.16)
Rep Moldova	S_{69}	0.38	(0.26)	$-\theta x_{69}$	-3.00	(0.27)
Romania	S_{70}	0.34	(0.16)	$-\theta x_{70}$	0.54	(0.15)
Russian Federation	S_{71}	-0.25	(0.15)	$-\theta x_{71}$	2.87	(0.15)
Senegal	S_{72}	0.08	(0.22)	$-\theta x_{72}$	-1.90	(0.28)
Sierra Leone	S_{73}	0.09	(0.27)	$-\theta x_{73}$	-2.57	(0.30)
Singapore	S_{74}	-1.66	(0.16)	$-\theta x_{74}$	3.00	(0.16)
Slovak Republic	S_{75}	-0.07	(0.16)	$-\theta x_{75}$	-0.34	(0.16)
Slovenia	S_{76}	0.10	(0.16)	$-\theta x_{76}$	-0.63	(0.16)

Country		est.	s.e.		est.	s.e.
Spain	S_{77}	-0.36	(0.14)	$-\theta x_{77}$	2.84	(0.15)
Sri Lanka	S_{78}	-0.20	(0.21)	$-\theta x_{78}$	-0.03	(0.21)
St. Kitts and Nevis	S_{79}	-2.34	(0.23)	$-\theta x_{79}$	-1.85	(0.24)
Sweden	S_{80}	0.36	(0.15)	$-\theta x_{80}$	2.50	(0.15)
Switzerland	S_{81}	0.46	(0.15)	$-\theta x_{81}$	2.50	(0.14)
Syrian Arab Republic	S_{82}	0.16	(0.21)	$-\theta x_{82}$	-1.72	(0.21)
Tajikistan	S_{83}	0.12	(0.27)	$-\theta x_{83}$	-2.12	(0.27)
Tanzania	S_{84}	0.38	(0.23)	$-\theta x_{84}$	-1.36	(0.23)
TFYR Macedonia	S_{85}	0.12	(0.26)	$-\theta x_{85}$	-2.39	(0.26)
Thailand	S_{86}	-0.30	(0.15)	$-\theta x_{86}$	2.45	(0.15)
Trinidad and Tobago	S_{87}	-1.05	(0.23)	$-\theta x_{87}$	-1.81	(0.26)
Tunisia	S_{88}	-0.40	(0.18)	$-\theta x_{88}$	-0.93	(0.18)
Turkey	S_{89}	0.11	(0.15)	$-\theta x_{89}$	1.59	(0.15)
Turkmenistan	S_{90}	-0.14	(0.25)	$-\theta x_{90}$	-2.12	(0.28)
UK	S_{91}	-0.26	(0.14)	$-\theta x_{91}$	4.02	(0.14)
Ukraine	S_{92}	1.13	(0.21)	$-\theta x_{92}$	0.09	(0.21)
Uruguay	S_{93}	-0.07	(0.21)	$-\theta x_{93}$	-0.67	(0.21)
USA	S_{94}	-0.02	(0.14)	$-\theta x_{94}$	5.29	(0.14)
Uzbekistan	S_{95}	0.09	(0.23)	$-\theta x_{95}$	-0.36	(0.25)
Venezuela	S_{96}	0.54	(0.18)	$-\theta x_{96}$	0.37	(0.19)
Vietnam	S_{97}	-0.04	(0.22)	$-\theta x_{97}$	0.54	(0.21)
Yemen	S_{98}	-0.80	(0.22)	$-\theta x_{98}$	-1.84	(0.27)
Zambia	S_{99}	-0.14	(0.27)	$-\theta x_{99}$	-1.89	(0.24)
Zimbabwe	S_{100}	0.41	(0.24)	$-\theta x_{100}$	-0.25	(0.21)

SSR= 11054

TSS= 303030

Note: Estimated by OLS using 1996 data. The specification is given in equations (24) and (25). The parameters are normalized so that $\sum_{j=1}^{100} S_j = 0$ and $\sum_{i=1}^{100} x_i = 0$.

E Tables and Figures

This section provides summary statistics from the Mango database. In addition to regressions (1) and (2), I check whether item prices are related to the size of the destination, measured by the 2006 population of each country. I estimate the following regression:

$$\log p_{ij} = \alpha_i + \beta_y \log y_j + \beta_\tau \log \tau_j + \beta_L \log L_j + \epsilon_{ij}, \quad (40)$$

where L_j is country j 's population.

All tables and figures related to the Mango database can be found below. Finally, the end of the section contains all figures.

Table 3: List of Countries in Sample

Austria	Belgium	Canada
Cyprus (Southern area)	Denmark	Estonia
Finland	France	Germany
Greece	Hungary	Ireland
Italy	Luxembourg	Malta
Netherlands	Norway	Portugal
Slovakia	Slovenia	Spain (Peninsula and Balearic Islands)
Sweden	Switzerland	United Kingdom

Table 4: Minimum Item Cost To Qualify For Free Shipping, Ascending (In Euro) and Per-Unit Shipping Cost, Ascending (In Euro)

Destination	Free Shipping From	Destination	Shipping Cost
Spain	EUR 20.00	Spain	EUR 6.50
United Kingdom	EUR 38.72	United Kingdom	EUR 7.74
Sweden	EUR 38.84	Luxembourg	EUR 8.50
Belgium	EUR 45.00	Portugal	EUR 8.50
Germany	EUR 45.00	Sweden	EUR 8.50
Ireland	EUR 45.00	Austria	EUR 8.60
Luxembourg	EUR 45.00	Denmark	EUR 8.60
Portugal	EUR 45.00	Finland	EUR 8.60
Denmark	EUR 45.63	Greece	EUR 8.60
France	EUR 48.00	France	EUR 8.70
Italy	EUR 48.00	Germany	EUR 8.70
Netherlands	EUR 48.00	Netherlands	EUR 8.70
Austria	EUR 50.00	Italy	EUR 8.75
Finland	EUR 50.00	Belgium	EUR 8.85
Greece	EUR 50.00	Ireland	EUR 8.95
Switzerland	EUR 54.14	Switzerland	EUR 12.74
Norway	EUR 81.64	Norway	EUR 14.93
Estonia	EUR 94.25	Hungary	EUR 15.05
Cyprus	EUR 95.00	Cyprus	EUR 15.50
Hungary	EUR 95.67	Malta	EUR 15.50
Canada	EUR 96.44	Slovenia	EUR 15.50
Slovakia	EUR 99.78	Estonia	EUR 15.52
Malta	EUR 165.00	Slovakia	EUR 16.16
Slovenia	EUR 165.00	Canada	EUR 19.29

Table 5: Average Price of Items in Euro (February 2008 XR) and Per-Capita GDP (PPP 2006), Relative to Spain in Ascending Order

Destination	Relative Price	Destination	Relative PC GDP
Portugal	0.9587	Slovak Republic	0.6211
Spain	1.0000	Hungary	0.6343
Greece	1.0869	Estonia	0.6655
Denmark	1.1422	Portugal	0.7235
Hungary	1.1564	Slovenia	0.8679
France	1.1786	Greece	0.9500
Belgium	1.1870	Spain	1.0000
Slovenia	1.2086	Italy	1.0200
Italy	1.2121	France	1.1085
Malta	1.2327	Germany	1.1272
Estonia	1.2337	Finland	1.1420
Austria	1.2363	United Kingdom	1.1591
Finland	1.2406	Belgium	1.1711
Luxembourg	1.2489	Sweden	1.2118
Germany	1.2501	Denmark	1.2476
Cyprus	1.2568	Austria	1.2587
Netherlands	1.2627	Netherlands	1.2801
Slovak Republic	1.2828	Canada	1.2803
United Kingdom	1.2846	Switzerland	1.3527
Sweden	1.3326	Ireland	1.4135
Norway	1.3468	Cyprus	1.5338
Ireland	1.3625	Norway	1.7449
Canada	1.5125	Malta	1.7567
Switzerland	1.5129	Luxembourg	2.6204

Table 6: Coefficients from Good Fixed-Effects Regression of Log Prices on Logs of PPP-Adjusted Per-Capita Income, Distance from Barcelona (KM) and Population

Included Variables	PCGDP(PPP)	PCGDP(PPP) Distance	PCGDP(PPP) Distance Population
Coefficient (St. Error) *t-stat			
Log PCGDP (PPP)	0.1185 (0.0052) *22.93	0.1221 (0.0051) *24.09	0.1254 (0.0051) *24.79
Log Distance from Barcelona (KM)		0.0331 (0.0008) *41.09	0.0343 (0.0010) *33.52
Log Population			0.0039 (0.0012) *3.30

All prices are converted to Euro using February 2008 average monthly exchange rates. The distance variable contains the distance from Barcelona to the capital city of the destination country. The distance coefficients were minimally altered when distance between Barcelona and the destination country's most populated city was used.

Data Sources: Price data obtained by author from March 2008 online catalogues of clothing manufacturer Mango. PPP-adjusted per-capita income and population data for 2006 was collected from WDI. Exchange rate data was obtained from the IFS. Distance data in kilometers was obtained from Mapcrow.

Table 7: Coefficients from Good Fixed-Effects Regression of Log Prices on Logs of PPP-Adjusted Per-Capita Income, Distance from Barcelona (KM) and Population (Subset of Countries in Euro Zone)

Included Variables	PCGDP(PPP)	PCGDP(PPP) Distance	PCGDP(PPP) Distance Population
Coefficient (St. Error) *t-stat			
Log PCGDP (PPP)	0.1808 (0.0088) *20.54	0.1565 (0.0086) *18.13	0.2076 (0.0112) *18.46
Log Distance from Barcelona (KM)		0.0245 (0.0005) *48.64	0.0281 (0.0005) *60.49
Log Population			0.0156 (0.0014) *11.12

These regressions use countries in the Euro zone as of January 1, 2008 only so no exchange rate data is necessary. The distance variable contains the distance from Barcelona to the capital city of the destination country. The distance coefficients were minimally altered when distance between Barcelona and the destination country's most populated city was used.

Data Sources: Price data obtained by author from March 2008 online catalogues of clothing manufacturer Mango. PPP-adjusted per-capita income and population data for 2006 was collected from WDI. Distance data in kilometers was obtained from Mapcrow.

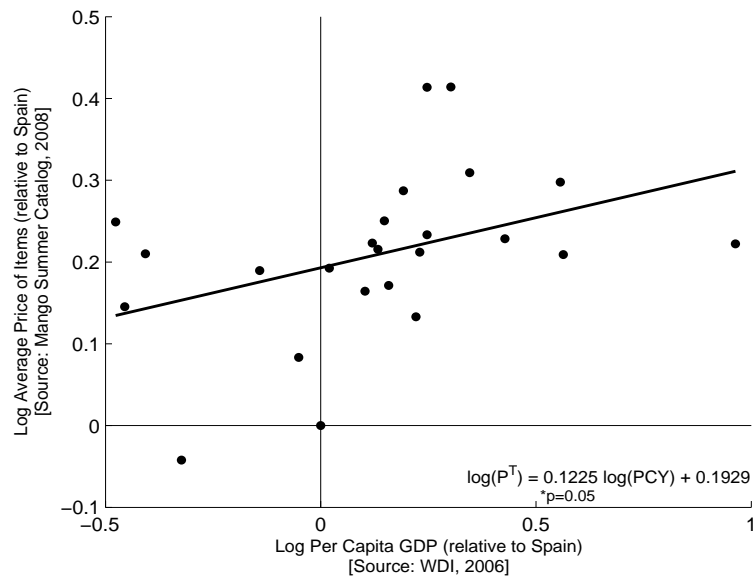


Figure 4: Average Price of Identical Items and Per-Capita GDP for 24 Countries

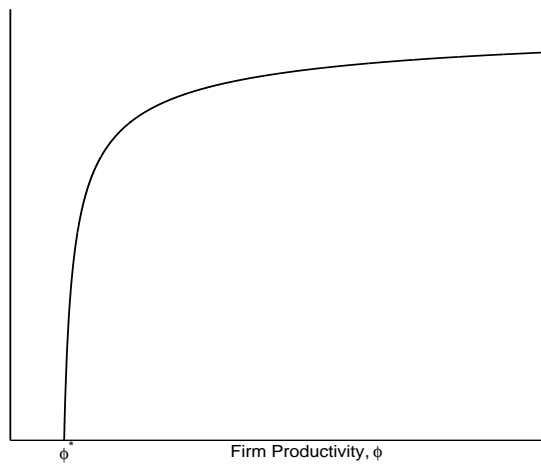


Figure 5: Firms' Sales as Function of Firms' Productivities

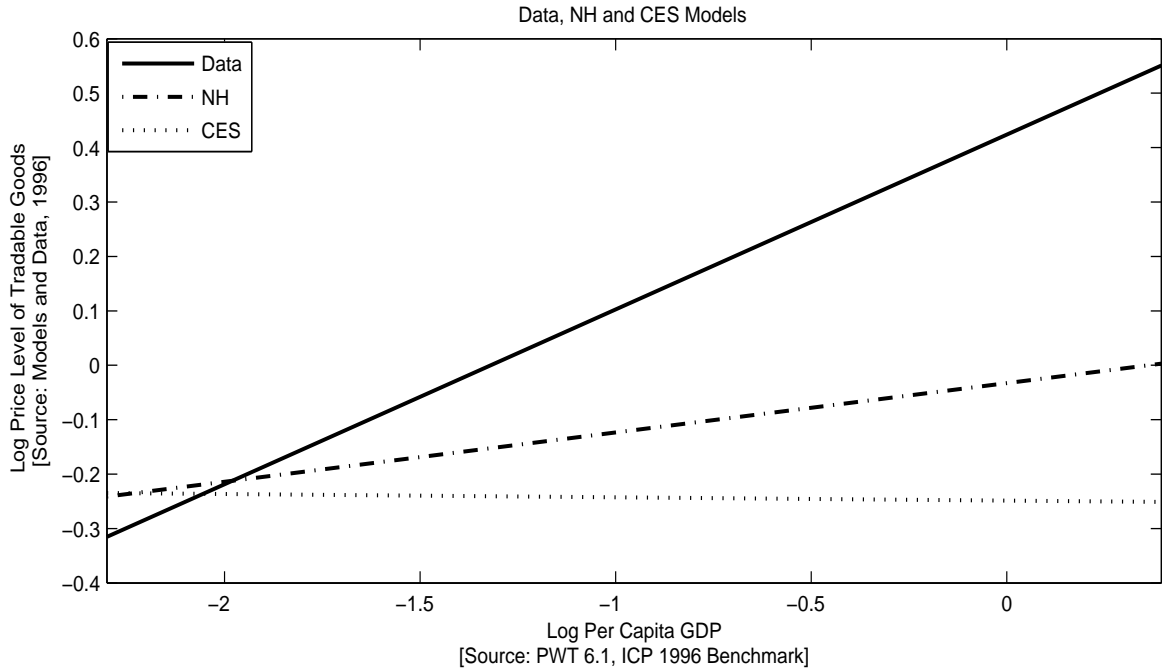


Figure 6: Price Level of Tradable Goods and Per-Capita GDP for OECD Countries

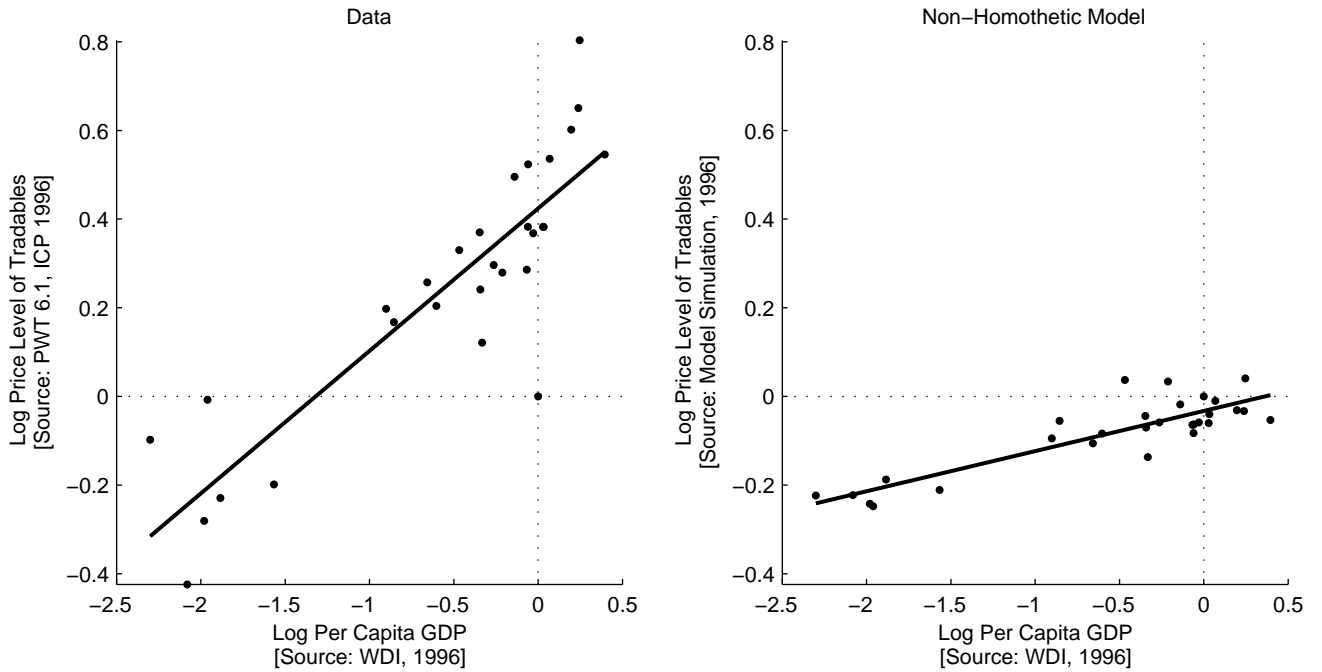


Figure 7: Price Level of Tradable Goods and Per-Capita GDP for OECD Countries

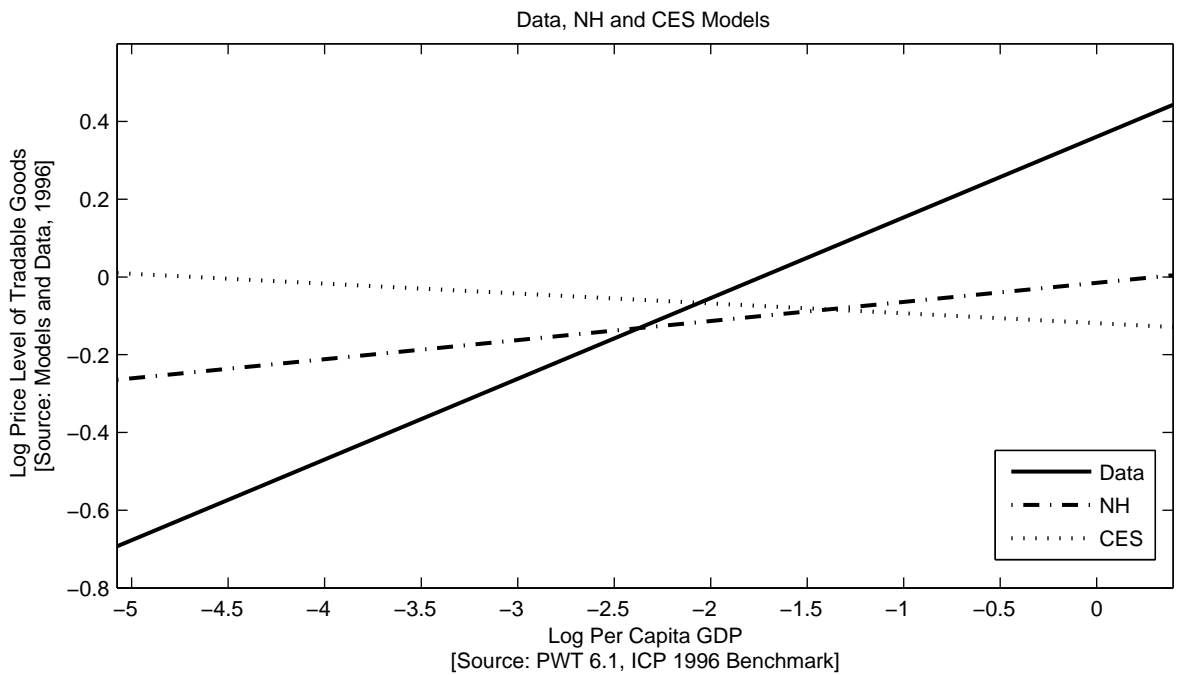


Figure 8: Price Level of Tradable Goods and Per-Capita GDP for 100 Countries

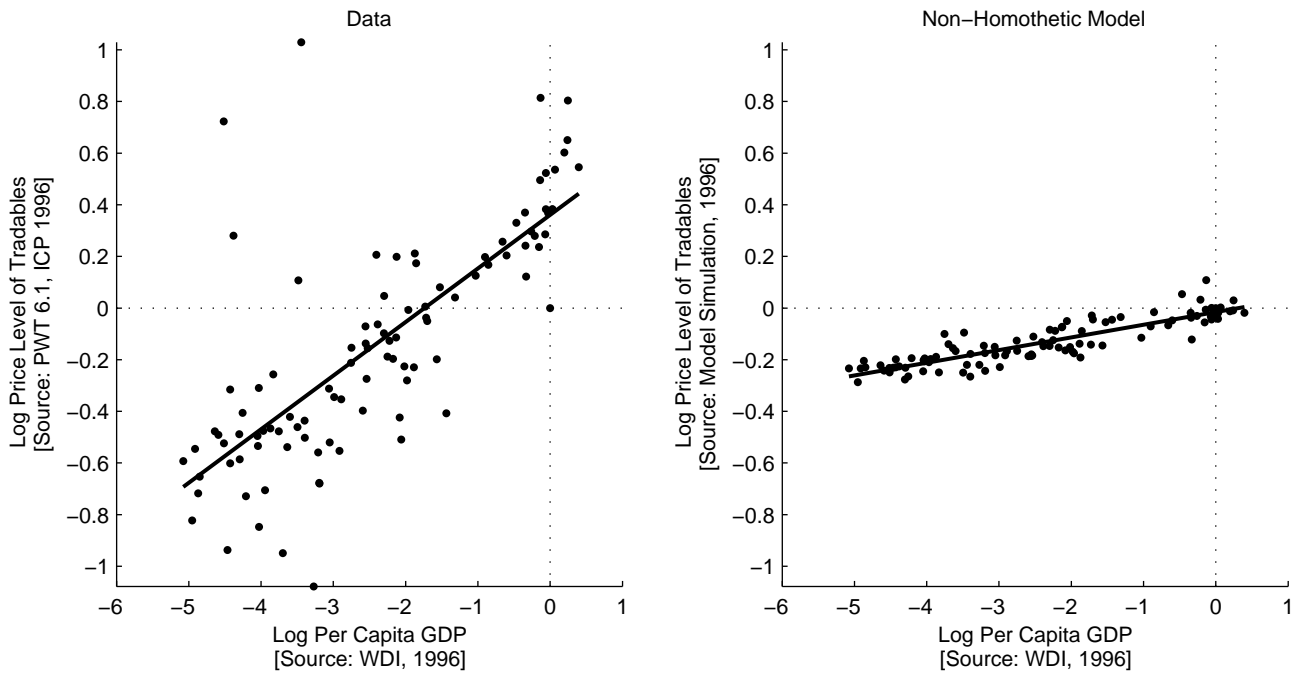


Figure 9: Price Level of Tradable Goods and Per-Capita GDP for 100 Countries