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 final 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 28 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 at least a half of the observed positive relationship between prices of tradables and income across a large sample of countries.

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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. Using 1996 data, Hsieh and Klenow (2007) demonstrate that the relationship is mainly driven by cross-country differences in prices of consumption 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 28 countries and charges higher prices in richer markets. Such price discrimination on the basis of income suggests that firms exploit different price elasticities 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[1].

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 preferences[2]. 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

[1]Waugh (2007) demonstrates this finding for models that rely on the Ricardian structure introduced by Eaton and Kortum (2002).

[2]The 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.

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 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 qualitatively in line with the behavior of French exporters in 1986 reported by Eaton et al. (2004), Eaton et al. (2008) and Arkolakis (2008)[3].

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 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 123 countries that comprised the majority of world output in 2004 varies between 0.05 and 0.10, under alternative calibrations of trade barriers and firm productivity distributions. The corresponding estimate arising from 2004 income and price data for the same set of countries is 0.11, as can be seen in figure 1 below. Since the model can account for at least a half of observed cross-country price differences, it is reasonable to conclude that variable mark-ups are quantitatively important.

[3] Arkolakis (2008) and Eaton et al. (2008) propose models that are not only qualitatively, but also quantitatively in line with firm exporting behavior, however, they rely on a CES framework that cannot capture the price-income relationship. A richer version of the present model that nests the CES framework can also capture firm behavior quantitatively, but only using numerical solution methods.

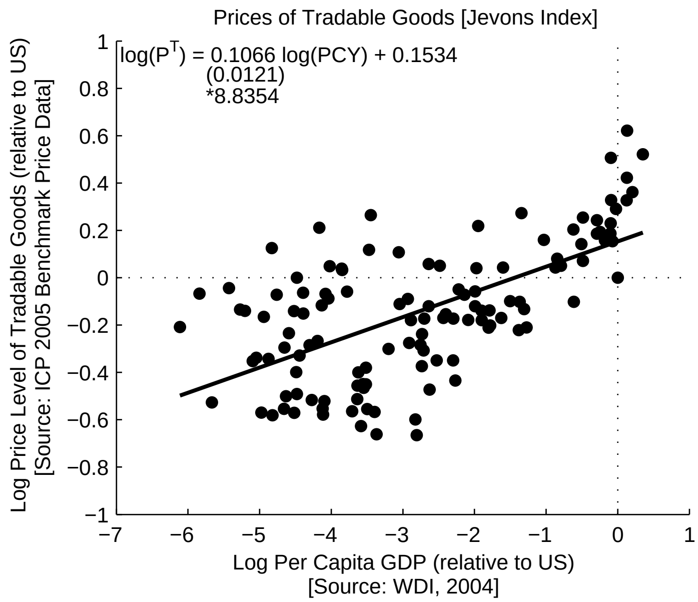

Figure 1: Price Level of Tradable Goods and Per-Capita GDP for 100 Countries

The portion of cross-country price differences that is not captured by the model can be explained by a variety of factors. Indeed, the price indices of tradable goods plotted in figure 1 are computed at the retail level and necessarily reflect non-tradable components, trade barriers and taxes[4]. 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) 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.

Since the latter experiment likely reflects both phenomena, 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

[4]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. Further, Burstein et al. (2003) quantify the effect of large distribution costs on retail prices.

(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 in-store prices, which necessarily reflect non-tradable components, taxes and trade barriers[5]. Instead, I collect prices of identical items featured in the clothing manufacturer Mango's online catalogues across 28 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 0.0761. Thus, countries that are twice as rich in per capita terms pay over 7% more for the same good.

Complementary to the empirical findings of variable mark-ups, there exists theoretical literature studying pricing-to-market within an international trade framework. 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 larger[6]. 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

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

[6] It 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.

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 countries[7]. 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 per-capita income and price level of tradable consumption goods, which Hsieh and Klenow (2007) convincingly argue is central toward the understanding of relative investment and growth patterns across countries. First, the paper 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 suggest that variable mark-ups by firms play an important role in explaining cross-country price differences, but also caution to the importance of careful calibration of trade barriers and firm productivity distributions.

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 that the Spanish clothing manufacturing company Mango systematically price-discriminates according to the per-capita income level of the market to which it sells.

Mango specializes in the production of clothing for middle-income female consumers and

[7]In an online appendix, I analyze the model of Melitz and Ottaviano (2008) in the absence of a homogenous good, thus allowing for heterogeneous incomes across countries. I also outline the quantitative analysis of the model.

sells its items both online and in stores around the world[8]. To facilitate data collection, I only consider Mango's online store. I use data from 28 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.

I collect data on all 190 items featured in the Summer and Winter 2008 online catalogues, which became available in March and September 2008, respectively[9]. In each country, the catalogue lists item prices in the local currency. I use average monthly exchange rates for February and August, 2008, respectively to convert all values into Euro, the currency used in the home country, Spain[10].

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 Union[11]. Thus, once I remove the sales tax, prices include production costs, mark-ups and transportation costs[12].

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. 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 analysis. This task is facilitated by the fact that Mango uses DHL Express to ship its products from a

[8]Often items sold online do not appear in stores and vice verse.

[9]This eliminates seasonal biases in clothing prices in different regions.

[10]I choose to work with February/August data because the catalogue became available in March/September and the company would have had to set the price before placing the catalogue into circulation. In an online appendix, I repeat the analysis with exchange rate data for the months of January/July and March/September of 2008 and find changes in the coefficients that are not statistically significant.

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

[12]I conducted a controlled experiment to ensure that quality differences are not an issue since I verified that identical items are produced in a single location, regardless of the market to which they are sold. Different items (ex. skirt vs. shirt) may be produced in different countries, but the same item (ex. skirt) is sourced from a single location and sold to all destinations. Since I study relative prices, the actual marginal cost of producing a particular good is irrelevant, for it is the same regardless of the market to which an item is sold.

single warehouse located outside of Barcelona, Spain, to every destination[13]. I collect DHL Express shipping quotes from Mango's warehouse address to each destination country and use them as an independent control for transportation costs in my analysis[14]. Finally, I use 2007 nominal per-capita income from the World Bank in my analysis of the relationship between prices and income[15].

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

$$\log p_{ij} = \alpha_i + \beta_y \log y_j + \beta_\tau \log \tau_j + \epsilon_{ij}, \tag{1}$$

where p_{ij} is the pre-tax price of good i in country j in Euros, y_j is per-capita income of country j and τ_j is the DHL Express shipping charge from Barcelona to destination j. The coefficient β_y and β_τ can be interpreted as the estimated elasticities of price with respect to per-capita income and transportation cost, while α_i is a good i-specific fixed effect[16].

I use the "within" (fixed-effects) estimator and report White robust standard errors for the income coefficient as well as the t-statistic in an online appendix. The regression yields estimates for β_y and β_τ of 0.0761 (0.0023) and 0.1577 (0.0030), respectively. Thus, controlling for transportation costs and good-specific characteristics, countries that are twice as rich in per-capita terms pay over 7% more for identical items.

In the same online note, I address the issue of taste heterogeneity by introducing dummies for the Scandinavian, Eastern European and Mediterranean regions. I further control for demographic characteristics of each market such as the size of the adult female population and the Gini income inequality coefficient, which may be important in the pricing practices of firms in a world in which consumers are modeled to have non-homothetic preferences. Moreover, in order to control for the possibility that Mango responds to competitive pressures when pricing its products, I use data on the number of stores its major competitors Zara, Miss Sixty and Bershka have in each destination. Across these scenarios, price elasticities with

[13] I conducted a controlled experiment and collected DHL tracking codes for an identical item sent to all 28 destinations and verified the shipping and production origin are identical across destinations.

[14] I have verified with DHL that regular customers receive a percentage discount, which leaves relative shipping costs across destinations unaltered.

[15] In an online appendix, I conduct the same analysis with PPP-adjusted per-capita income and for a subset of the countries (for which data is available), I repeat the analysis using manufacturing wages since this statistic corresponds to the measure of per-capita income in the model. Estimated elasticities of price with respect to income are even higher than in the benchmark analysis.

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

respect to income range between 0.0396 and 0.0750. Finally, I obtain per-capita television advertising costs for a subsample of Western European countries to control for the possible effects marketing expenditures may have on prices charged across different destinations and find an increase in the price elasticity with respect to income to 0.3701.

I repeat all exercises for a subset of countries that belong to the Euro zone as of January 1, 2008, allowing me to exclude exchange rates from the analysis. The estimated elasticity of price with respect to income rises to 0.1204 (0.0027), after controlling for transportation costs and good-specific characteristics. Thus, per-capita income remains a strong candidate that potentially poses a wedge on prices of identical goods across countries.

3 Model

Motivated by the empirical findings, 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 competition 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 goods[17], 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:

$$U^c = \int_{\omega \in \Omega} \log(q^c(\omega) + \bar{q}) d\omega, \tag{2}$$

where $q^c(\omega)$ is individual consumption of variety ω and $\bar{q} > 0$ is a (non-country-specific)

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

constant[18]. 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.

Each variety is produced by a single firm, where firms are differentiated by their productivity, ϕ, and country of origin, i[19]. Any two firms originating from country i and producing with productivity level ϕ choose identical optimal pricing rules[20]. 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, $G(\phi)$, 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 by[21]:

$$q_{ij}(\phi) = L_j \left\{ \frac{w_j + \bar{q} P_j}{N_j p_{ij}(\phi)} - \bar{q} \right\}, \tag{3}$$

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

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

where $\sigma \to 1$. Notice, $\bar{q} = 0$ yields homothetic CES preferences. Throughout the paper, I exploit the analytical tractability of the limiting case. Sections 4.3.1 and 4.3.2 describe the limitations of this highly tractable framework and explore quantitative predictions of the model using the generalized utility function.

[19]This assumption differentiates the present model from previous frameworks that employ similar preferences. In particular, Young (1991) uses the non-homothetic log-utility function, with the parameter $\bar{q}$ set to 1, in a Ricardian framework to analyze the growth patterns of countries in which firms experience learning-by-doing. Recently, Saure (2009) employs the same parameterization in a monopolistic competition framework featuring firms with homogeneous productivities to study the extensive margin of exporting. As it turns out, assuming firm productivities to be heterogeneous has two distinct advantages: first, the model yields constant average firm mark-ups across destinations that are uniquely determined by the Pareto shape parameter of the firm productivity distribution, allowing me to calibrate it using mark-up data; second, it allows me to calibrate the elasticity parameter in the general utility function in order to match the distribution of sales of French exporting firms reported in Eaton et al. (2004) and Eaton et al. (2008).

[20]Thus, I can index each variety by the productivity of its producer.

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

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

$$N_j = \sum_{\upsilon=1}^{I} N_{\upsilon j}, \tag{4}$$

and P_j is an aggregate price statistic summarized by:

$$P_j = \sum_{\upsilon=1}^{I} N_{\upsilon j} \int_{\phi^*_{\upsilon j}}^{\infty} p_{\upsilon j}(\phi)\mu_{\upsilon j}(\phi)d\phi. \tag{5}$$

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 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 (3), the profit maximization problem of a firm with productivity draw ϕ originating in country i and contemplating selling to country j is:

$$\pi_{ij}(\phi) = \max_{p_{ij}\geq 0} \quad p_{ij}L_j \left\{ \frac{w_j + \bar{q}P_j}{N_j p_{ij}} - \bar{q} \right\} - \frac{\tau_{ij}w_i}{\phi} L_j \left\{ \frac{w_j + \bar{q}P_j}{N_j p_{ij}} - \bar{q} \right\} \tag{6}$$

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 by[22]:

$$p_{ij}(\phi) = \left(\frac{\tau_{ij}w_i}{\phi} \frac{w_j + \bar{q}P_j}{N_j \bar{q}} \right)^{\frac{1}{2}}. \tag{7}$$

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 $\phi \geq \phi^*_{ij}$

[22]The firm's problem is solved in appendix C.2.

sell to market j, where ϕ_{ij}^* is a productivity threshold defined by:

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

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,

$$p_{ij}\left(\phi_{ij}^*\right) = \frac{\tau_{ij} w_i}{\phi_{ij}^*}. \tag{8}$$

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 (3), notice that consumers' demand is exactly zero for the variety whose price satisfies:

$$p_{ij}\left(\phi_{ij}^*\right) = \frac{w_j + \bar{q} P_j}{N_j \bar{q}}. \tag{9}$$

Combining expressions (8) and (9) yields a simple characterization of the threshold[23]:

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

Using (10), 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 by[24]:

[23] The model does not rely on fixed market entry costs in order to pin down the productivity cutoff to serve a market. Rather, consumer income affects the measure of varieties demanded, thus determining the measure of firms serving a market. Hence, the population size of a market plays no role in the entry decision of firms, which is a very different prediction from models relying on CES preferences and fixed costs such as Melitz (2003) and Chaney (2008), or models with quadratic preferences and no fixed costs such as Melitz and Ottaviano (2008), where in the latter, the utility specification gives importance to market size.

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

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

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, $G(\phi)$, with corresponding pdf, $g(\phi)$, 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:

$$N_{ij} = J_i[1 - G(\phi^*_{ij})]. \tag{11}$$

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

$$\mu_{ij}(\phi) = \begin{cases} \frac{g(\phi)}{1-G(\phi^*_{ij})} & \text{if } \phi \geq \phi^*_{ij} \\ 0 & \text{otherwise.} \end{cases} \tag{12}$$

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

$$T_{ij} = N_{ij} \int_{\phi^*_{ij}}^{\infty} p_{ij}(\phi) x_{ij}(\phi) \mu_{ij}(\phi) d\phi. \tag{13}$$

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

$$\pi_i = \sum_{\upsilon=1}^{I} [1 - G(\phi^*_{i\upsilon})] \int_{\phi^*_{i\upsilon}}^{\infty} \pi_{i\upsilon}(\phi)\mu_{i\upsilon}(\phi)d\phi, \tag{14}$$

where potential profits from destination υ are weighted by the probability that they are realized, $1 - G(\phi^*_{i\upsilon})$. The average profit, in turn, barely covers the fixed cost of entry:

$$w_i f_e = \sum_{\upsilon=1}^{I} [1 - G(\phi^*_{i\upsilon})] \int_{\phi^*_{i\upsilon}}^{\infty} \pi_{i\upsilon}(\phi)\mu_{i\upsilon}(\phi)d\phi. \tag{15}$$

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

$$w_i L_i = \sum_{\upsilon=1}^{I} T_{\upsilon i}. \tag{16}$$

I now proceed to define equilibrium in this economy.

Definition 1. *Given trade barriers τ_{ij} and a productivity distribution $G(\phi)$, an equilibrium for $i, j = 1, ..., I$ 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 $\hat{q}^c_{ij}(\phi)$; total consumer allocation $\hat{q}_{ij}(\phi)$; decision rule $\hat{p}_{ij}(\phi)$ for firm ϕ, $\forall \phi \in [b_i, \infty)$, $(\forall i)$, such that:*

- *Given $\hat{P}_j, \hat{w}_j, \hat{p}_{ij}$, the representative consumer solves her maximization problem by choosing $\hat{q}^c_{ij}(\phi)$ according to (2);*

- *Total demand function for good of type ϕ originating from country i by consumers in country j, $\hat{q}_{ij}(\phi) = \hat{q}_{ij}\left(\hat{p}_{ij}(\phi); \hat{P}_j, \hat{N}_j, \hat{w}_j\right)$ satisfies (3);*

- *Given $\hat{P}_j, \hat{w}_j$ and the demand function $q_{ij}(\phi) = q_{ij}\left(p_{ij}(\phi); \hat{P}_j, \hat{N}_j, \hat{w}_j\right)$ in (3), firm ϕ chooses $\hat{p}_{ij}(\phi)$ to solve its maximization problem in (6) $\forall j = 1, ..., I$*[25]*;*

[25] An additional equilibrium restriction for this class of models is that there is no cross-country arbitrage, that is, it must be the case that $p_{ij}(\phi) \leq p_{i\upsilon}(\phi)\tau_{\upsilon j}$ $(\forall i, \upsilon, j)$. In the CES model, it is sufficient to assume that the triangle inequality for trade barriers holds, $\tau_{ij} \leq \tau_{i\upsilon}\tau_{\upsilon j}$ $(\forall i, \upsilon, j)$. 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

- *The productivity threshold* $\hat{\phi}^*_{ij}$ *satisfies (10);*

- *The measure of firms from country* i *serving market* j, $\hat{N}_{ij}$, *satisfies (11);*

- *The total measure of firms serving market* j, $\hat{N}_j$, *satisfies (4);*

- *The conditional pdf of serving each market,* $\hat{\mu}_{ij}(\phi)$, *satisfies (12);*

- *The aggregate price statistic* $\hat{P}_j$ *satisfies (5);*

- *The wage rate* $\hat{w}_i$ *and the measure of entrants* $\hat{J}_i$ *together satisfy (15) and (16);*

- *The individual goods market clears* $\hat{q}_{ij}(\phi) = \hat{x}_{ij}(\phi)$.

In order to analytically solve the model and derive stark predictions at the firm and aggregate levels, as well as facilitate the quantitative analysis, I assume that the productivities of firms are drawn from a Pareto[26] distribution with cdf $G(\phi) = 1 - b_i^\theta/\phi^\theta$, pdf $g(\phi) = \theta b_i^\theta/\phi^{\theta+1}$ and shape parameter $\theta > 0$[27]. 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.

3.5 Firms' Prices and Mark-Ups

The different optimal mark-ups that arise from the two frameworks play a key role in understanding two important relationships: that between price levels of tradables and per-capita incomes, and that between bilateral trade costs and trade barriers. Consider two firms with productivity draws ϕ_1 and ϕ_2 originating from countries 1 and 2, respectively, and selling to

arise more frequently in the CES model than in the non-homothetic model, and depend largely on the estimation method for trade barriers. 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.

[26] Kortum (1997), Eaton et al. (2008), Luttmer (2007) and Arkolakis (2007), among others, provide theoretical justifications for the use of the Pareto distribution.

[27] This parameter restriction is sufficient to solve the non-homothetic model. Throughout the quantitative analysis, I must restrict σ or θ, such that $\theta > \sigma - 1$ to ensure a solution to the CES model exists.

market j. Expression (7) 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:

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

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, aided by the assumption of Pareto-distributed productivities, result in identical gravity equations of trade.

In addition, both models yield constant average firm mark-ups. The average mark-up in the CES model is given by $\sigma/(\sigma-1)$, the mark-up all operating firms charge. In the non-homothetic model, the average mark-up is given by[28]:

$$\bar{m} = \int_{\phi_{ij}^*}^{\infty} \left(\frac{\phi}{\phi_{ij}^*}\right)^{\frac{1}{2}} \frac{\theta(\phi_{ij}^*)^{\theta}}{\phi^{\theta+1}} d\phi = \frac{\theta}{\theta - 0.5},$$

assuming $\theta > 0.5$.

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:

$$\begin{aligned} \text{NH}: \frac{p_{ij}(\phi)}{p_{ik}(\phi)} &= \frac{\tau_{ij}}{\tau_{ik}}\left(\frac{\phi_{ik}^*}{\phi_{ij}^*}\right)^{\frac{1}{2}} \\ \text{CES}: \frac{p_{ij}(\phi)}{p_{ik}(\phi)} &= \frac{\tau_{ij}}{\tau_{ik}}. \end{aligned} \tag{17}$$

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 (7)

[28]This feature of the model allows me to calibrate θ in order to match average mark-ups of manufacturing firms.

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 (17).

The productivity threshold in the non-homothetic model is[29]:

$$\phi_{ij}^* = \frac{\tau_{ij} w_i}{[(\theta+1) f_e (1+2\theta)\frac{w_j}{\bar{q}}]^{\frac{1}{\theta+1}}} \left[\sum_{v} \frac{L_v b_v^\theta}{(\tau_{vj} w_v)^\theta} \right]^{\frac{1}{\theta+1}} \tag{18}$$

Looking at comparative statics, expression (18) clearly shows that productivity thresholds respond only marginally and positively to the population, but strongly 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.

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) sold in j, given by:

$$\epsilon_{ij}(\phi) = \left[1 - \left(\frac{\phi}{\phi_{ij}^*} \right)^{-\frac{1}{2}} \right]^{-1}. \tag{19}$$

Using (19), the relative price of a variety across two markets becomes:

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

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 (19). 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.

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

4 Quantitative Analysis

In this section, I calibrate the non-homothetic and CES models and proceed to study the resulting price levels of tradables. Since the two models result in identical gravity equations of trade, thus yielding identical trade barrier estimates, the calibrated CES model is a useful tool to isolate the role of trade barriers in cross-country price variations.

4.1 Benchmark 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:

$$\begin{aligned}\lambda_{ij} &= \frac{T_{ij}}{\sum_v T_{vj}} \\ &= \frac{L_i b_i^{\theta}(\tau_{ij} w_i)^{-\theta}}{\sum_v L_v b_v^{\theta}(\tau_{vj} w_v)^{-\theta}}.\end{aligned} \tag{20}$$

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:

$$\begin{aligned}t_{ij} &= \int_{\phi_{ij}^*}^{\infty} r_{ij}(\phi)\mu_{ij}(\phi)d\phi \\ &= \frac{(w_j + \bar{q}P_j)L_j}{2N_j(\theta + 0.5)}.\end{aligned} \tag{21}$$

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 (21), I arrive at (20), 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 is[30]:

$$\log\left(\frac{\lambda_{ij}}{\lambda_{jj}}\right) = S_j - S_i - \theta\log\tau_{ij}, \tag{22}$$

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:

$$\log\tau_{ij} = d_k + b + e_h + x_i + \delta_{ij}, \tag{23}$$

where the dummy variable associated with each effect has been suppressed for notational simplicity. In the above expression, d_k, $k = 1, ..., 6$, 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 2004) and the NAFTA (North American Free Trade Agreement), respectively[31]. Finally, following Waugh (2007), I let x_i capture additional hurdles exporters face in order to place their products abroad.

As discussed in appendix A, with the help of two assumptions about the CES model, its gravity equation collapses to (22). First, I assume that the amount of labor necessary to cover the fixed cost of selling domestically and abroad is equivalent, an assumption used 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 for θ of 3.8333, which yields average firm mark-up over marginal cost in the model of 1.15, a midpoint of the estimated mark-up range for the manufacturing sector in OECD countries reported by Martins et al. (1996). This value falls within the $3.5 - 4$ range reported by Simonovska and Waugh (2009), who apply the Simulated Method of Moments to the model of Eaton and Kortum (2002) using disaggregate cross-country price data[32]. Finally, the pa-

[30]Import shares, λ_{ij}'s, are straightforward to compute from the bilateral trade flows data reported by UN Comtrade. I take bilateral trade flows that correspond to ISIC manufacturing categories only, using the concordance proposed by Muendler (2009) and UN Comtrade data at the SITC 4-digit level. Thus, my data excludes agricultural goods. I compute the domestic share of total expenditure, λ_{jj}, as the residual of gross output that is not imported, where I impute gross output for countries with missing data using existing gross output figures for a subsample of countries, together with 2004 WDI manufacturing value added, GDP and population data in a cubic regression framework.

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

[32]Simonovska and Waugh (2009) also demonstrate the equivalence of the estimating equations for θ arising

rameter choice is in line with estimates using firm-level data obtained by Eaton et al. (2008) and those using FDI data obtained by Ramondo and Rodrıguez-Clare (2009).

In order to derive the lower productivity bounds 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 2004[33]. The technology parameters thus satisfy all equilibrium conditions of the model[34]. Moreover, all lower productivity bounds are computed relative to the value corresponding to the US, which is in turn chosen in order match average US firm sales in 2002 of USD 11,161,200, as reported by the Annual Survey of Manufacturers (ASM).

Finally, the fixed cost of market entry, f_e, is chosen to match ASM's reported US average number of workers per firm in 2002 of 41 people, while the non-homotheticity parameter, $\bar{q}$, is chosen to match the US price level of tradable goods, which represents the numeraire for all relative price comparisons[35][36].

4.2 Income Differences and Prices of Tradables

In this section, I evaluate the ability of the non-homothetic model 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 and the estimated price elasticity with respect to income is 0.1066 (0.0121). In order to evaluate the ability of the model to reconcile these observations, I solve its calibrated version and calculate the price levels of tradable goods[37].

from monopolistic competition and Ricardian frameworks, thus justifying the use of the estimates across different trade models.

[33] Per-capita and population data are obtained from WDI.

[34] In 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.

[35] See Appendix (B) for the methodology employed to arrive at the price level of tradables in the ICP data and the model.

[36] The fixed cost of selling to a market f and the constant elasticity of substitution σ present in the CES model only need not be calibrated, since they do not affect incomes, trade barriers and relative mark-ups. Recall the first two are identical to the non-homothetic model, while the last is unity due to mark-up invariance across firms and markets in this model.

[37] I take the price data from the 2005 ICP Benchmark Studies. I use data at the basic-heading level, the lowest level of aggregation possible, and combine it to calculate price indices according to the Jevons method. I repeat the procedure for the two models. Appendix B describes the accounting procedure for the data and the two models in detail.

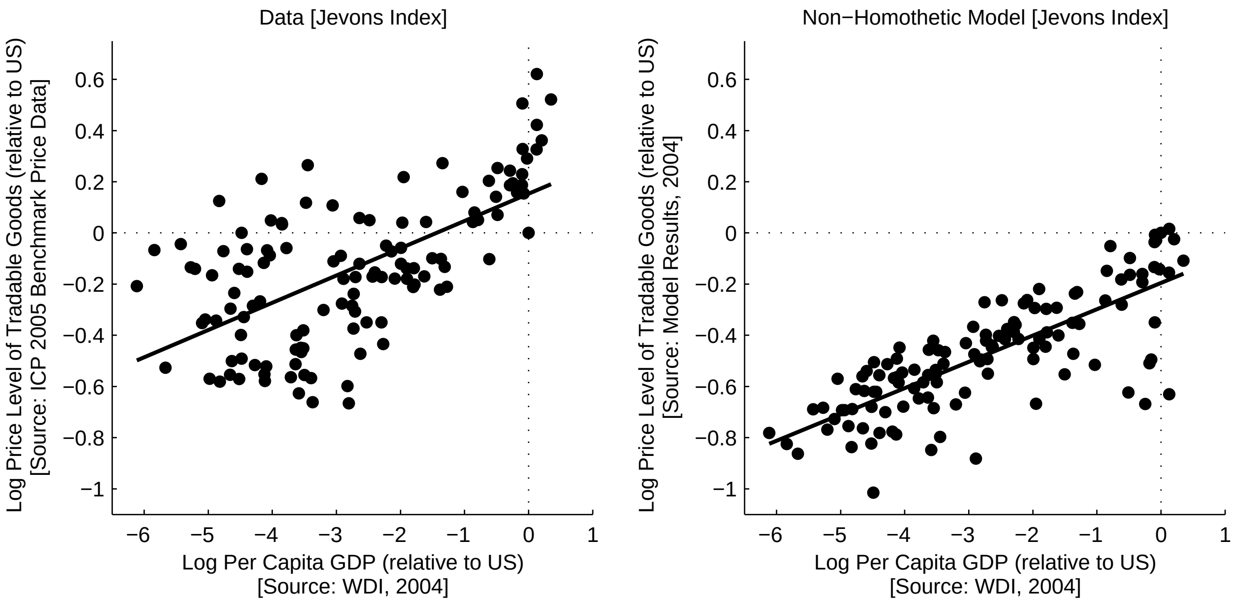

Figure 2: Price Level of Tradable Goods and Per-Capita GDP for 123 Countries

Figure 2 plots the price-income relationship for 123 countries resulting from the data and the non-homothetic model whose parameters have been calibrated to match the moments discussed above[38]. Figure 6 in appendix D plots the relationship between prices of tradables and per-capita incomes for these countries in the non-homothetic and CES models. While the non-homothetic model predicts a positive correlation between prices of tradables and per-capita income levels, the CES model obtains a counterfactual prediction. Indeed, the estimated price elasticity of tradables with respect to per capita income implied by the CES model is -0.0074 (0.0028), while that generated by the non-homothetic model is 0.1029 (0.0075). Thus, under this parameterization, the non-homothetic model can explain most of the observed cross-country price differences for a large sample of countries.

To understand the CES model's predictions about the price-income relationship, 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

[38]I combine 2005-price data with 2004 data on all other income- and trade-related statistics purely due to availability limitations. Moreover, since the ICP round was carried out during the 2003-2005 period, prices likely reflect 2004-levels. An exception is Zimbabwe, which experienced extreme hyperinflation during this period, which is why I exclude it from my analysis.

producer faces country-specific trade barriers. The sample of countries considered demonstrates a large heterogeneity in per-capita income levels. In particular, trade barriers adjust 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. This relationship clearly quantifies the contribution of trade barriers to price variation across countries.

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.

4.2.1 Importance of Trade Barriers

Given the discussion in the previous section, it is obvious that trade barrier estimates have serious quantitative implications on the price-income relationship. Thus, as a sensitivity check to the model, I follow the trade barrier specification originally proposed by Eaton and Kortum (2002) and re-examine the prices resulting from a re-calibrated model. Eaton and Kortum (2002) argue that trade barriers depend on importer- rather than exporter-specific fixed effects, in addition to standard gravity variables such as distance, border and trade area membership. Intuitively, their argument amounts to each importing country facing a particular cost to buy goods from abroad, which can be interpreted as that country's trade policy variable, for example. This differs from the specification proposed by Waugh (2007), where each exporting country is assumed to face a particular barrier to access foreign markets.

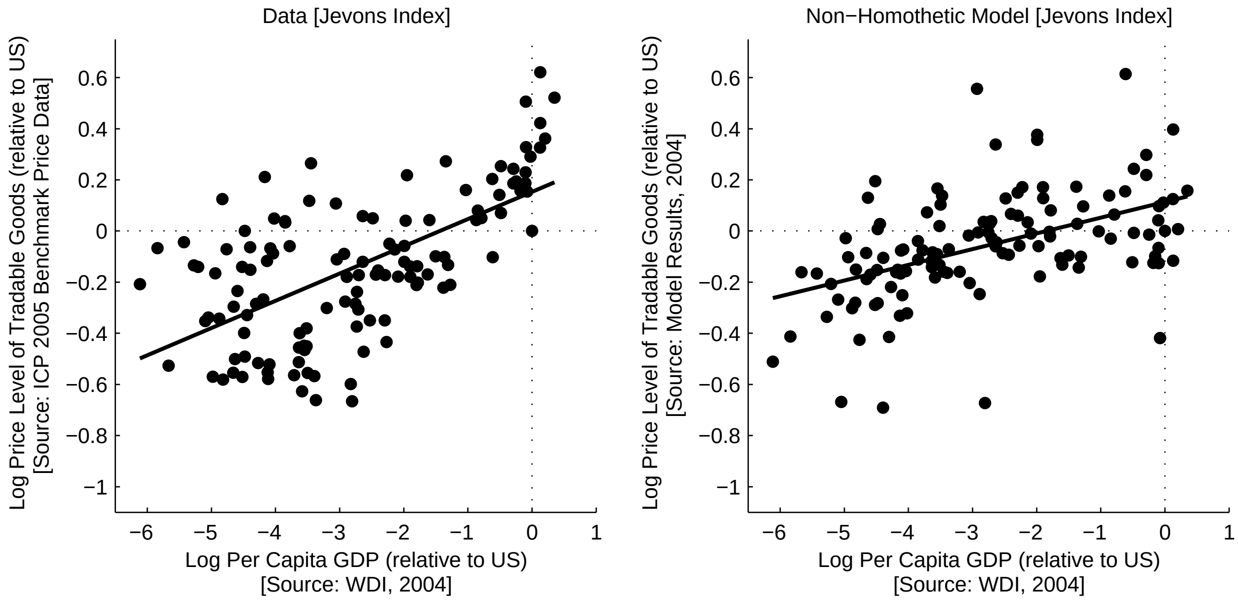

Figure 3: Price Level of Tradable Goods and Per-Capita GDP for 123 Countries

Figure 3 reproduces figure 2 using the specification proposed by Eaton and Kortum (2002). Noticeably, the model can account for a much smaller portion of observed cross-country price differences, as the elasticity of price with respect to per-capita income drops to 0.0615 (0.0100). Clearly, the newly calibrated trade barriers are much more heavily and negatively related to the per-capita income of the importer, as can also be seen from the calibrated CES model in figure 7 in Appendix D. These findings are in line with those reported by Waugh (2007) and signal to the importance of trade barriers to cross-country price differences.

4.2.2 Importance of Firm Productivity Dispersion

In order to understand the importance of the remaining parameters of the model in determining the price-income relationship, it is useful to re-examine the relative price of an identical good produced by a firm with productivity draw ϕ, originating from country i and sold in markets j and k. Substituting the productivity cutoff (18) into the relative price equation in (17) yields:

$$\frac{p_{ij}(\phi)}{p_{ik}(\phi)} = \left(\frac{\tau_{ij}}{\tau_{ik}}\right)^{\frac{1}{2}} \left(\frac{w_j}{w_k}\right)^{\frac{1}{2(\theta+1)}} \left(\frac{\sum_{\upsilon} L_{\upsilon} b_{\upsilon}^{\theta} (\tau_{\upsilon k} w_{\upsilon})^{-\theta}}{\sum_{\upsilon} L_{\upsilon} b_{\upsilon}^{\theta} (\tau_{\upsilon j} w_{\upsilon})^{-\theta}}\right)^{\frac{1}{2(\theta+1)}} \tag{24}$$

Clearly, the choice of parameter values for the entry cost, f_e, and the non-homotheticity parameter, $\bar{q}$, do not alter relative prices, provided that they are chosen subject to the restrictions imposed by the modeling framework. However, the Pareto shape parameter, θ, on the other hand is crucial in determining the extent to which per-capita income differences generate relative price differences across countries. In particular, lower values of θ will magnify the importance of per-capita income on the determination of prices. Intuitively, low values of the Pareto shape parameter suggest lower responsiveness of trade flows with respect to trade frictions, thus increasing the ability of firms to price-discriminate according to the per-capita income of the consumers.

Given the importance of the Pareto shape parameter in determining the extent of the positive relationship between prices and income, I conduct sensitivity analysis with respect to the benchmark calibration. In particular, I calibrate the model's parameters, assuming a value for θ of 8, which is a widely popular parameter choice in the existing literature, due to the estimates provided by Eaton and Kortum (2002). As such, the results below can be easily put into the context of the existing quantitative studies of heterogeneous firm models.

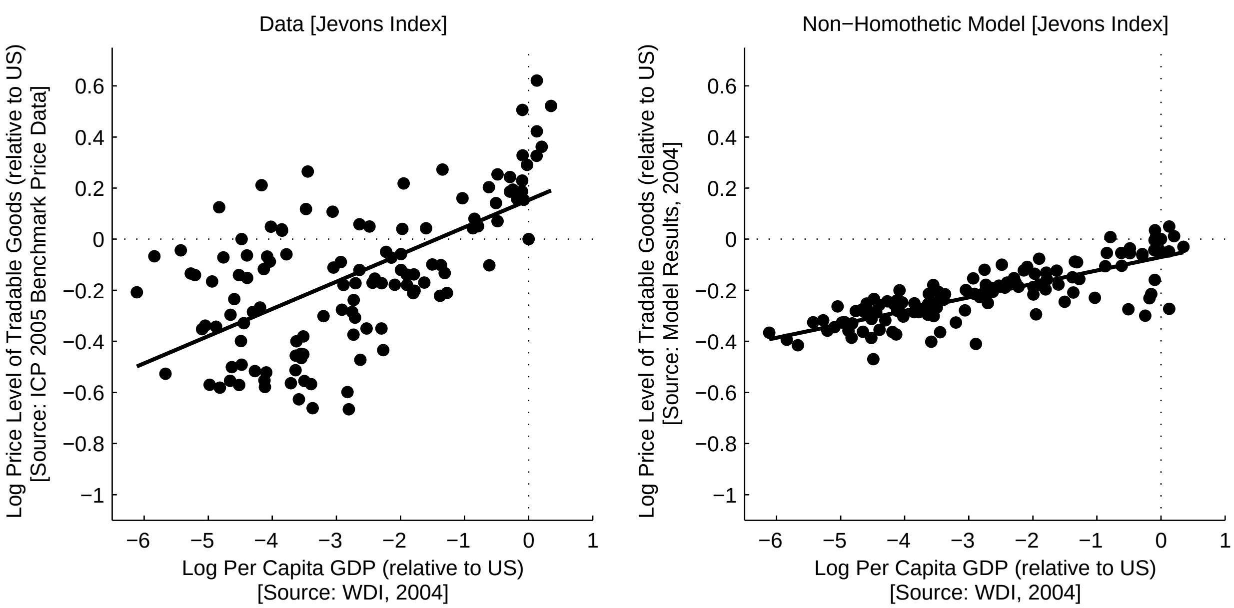

Figure 4: Price Level of Tradable Goods and Per-Capita GDP for 123 Countries

Figure 4 reproduces figure 2 in the re-calibrated model, where trade barriers are estimated using the approach in Waugh (2007). As expected, the model can account for a smaller portion of observed cross-country price differences; indeed, the elasticity of price with respect to per-capita income drops to 0.0526 (0.0036), a mere half of that arising from the benchmark calibration. These findings demonstrate the importance to further study the dispersion parameter and to reconcile its estimates from a wide variety of data and models. Simonovska and Waugh (2009) make an important step in this direction by reconciling estimates for monopolistic competition and Ricardian models using cross-country price and firm-level sales data.

4.3 General Model

In this section, I analyze the quantitative predictions of the model in which consumer preferences take on the following form:

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

where $\sigma \geq 1$ and $\bar{q} \geq 0$. The model nests both the CES and the simple non-homothetic model analyzed in previous sections. Relative to the simple non-homothetic model, its generalized counterpart features an additional parameter, σ, which has important implications about the distribution of firm size in this model. I explore these in the following section.

4.3.1 Firms Size and Market Entry

This section explores how the predictions of the non-homothetic model regarding the size distribution of firms and their decision to enter different markets relate to the behavior of French exporters in 1986, as reported by Eaton et al. (2004) and Eaton et al. (2008)[39].

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

[39] I refer the reader to Eaton et al. (2008) for a detailed discussion of the CES model's predictions regarding firms' sales and their distribution.

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.

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. (2008)[40].

Appendix C.4 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. The opposite is true with respect to the size of the market. However, since the elasticity of the number of firms with respect to per-capita income of a market is much larger than that with respect to the market's size (see equation (18)), more firms serve markets characterized by higher total income. Thus, the non-homothetic model's qualitative predictions regarding firms' sales are in line with the behavior of French exporters reported in Eaton et al. (2004) and Eaton et al. (2008).

While the model qualitatively captures the behavior of exporters reported in the French data, it doesn't do so quantitatively. To see this, notice first that the model predicts a strong hierarchy in the markets firms sell to. Since richer markets are more easily accessible, all firms that sell to destination A necessarily serve all richer destinations $B, C, D, ...$ Hence, we can order the markets in terms of the productivity cutoffs that are necessary in order to reach each destination. Let $\phi_{FF}^{(k)}$ represent the minimum productivity a French firm needs

[40]Eaton et al. (2008) 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.

in order to sell to France and to k additional markets, where $k = 0, 1, 2, ...I - 1$. Then, the model delivers the following equation:

$$\frac{T_{FF}^{(k)}}{t_{FF}^{(0)}} = N_{FF}^{(0)} \left[(2\theta + 1)\frac{N_{FF}^{(k)}}{N_{FF}^{(0)}} - \frac{\theta(2\theta + 1)}{\theta + 0.5} \left(\frac{N_{FF}^{(k)}}{N_{FF}^{(0)}} \right)^{\frac{\theta+0.5}{\theta}} \right],$$

which relates the domestic sales of French firms that serve at least k destinations (normalized by average domestic sales) to their corresponding measure (normalized by the measure of operating French firms).

Notice that this relationship is entirely pinned down by the parameter θ. When $\theta = 8$, the model matches bilateral trade flows very well, but the elasticity of sales with respect to the number of exporters above is 0.61, which is well above the value of 0.35 for French exporters reported by Eaton et al. (2008). While lower values of θ help the model to get closer to the French data, the moment in the data can never be attained. The reason why the model over-predicts the size of firms is the relatively low substitutability across varieties implied by the log-utility function. This hints toward the need of higher elasticities of substitution in the utility function.

4.3.2 Quantitative Predictions of the General Model

For as long as $\bar{q} > 0$, the qualitative predictions of the general model are in line with the limiting log-case studied throughout the paper. However, closed form solutions no longer exist. To see this, the optimal price a firm with productivity ϕ from country i charges to destination j solves the following implicit equation:

$$(1 - \sigma)p_{ij}^{-\sigma} L_j \frac{w_j + \bar{q}P_j}{P_{j\sigma}^{1-\sigma}} - L_j \bar{q} + \sigma \frac{\tau_{ij} w_i}{\phi} p_{ij}^{-\sigma-1} L_j \frac{w_j + \bar{q}P_j}{P_{j\sigma}^{1-\sigma}} = 0, \tag{25}$$

where:

$$P_j = \sum_{\upsilon=1}^{I} \int_{\phi_{\upsilon j}^*}^{\infty} p_{\upsilon j}(\phi) \frac{\theta J_\upsilon b_\upsilon^\theta}{\phi^{\theta+1}} d\phi, \quad P_{\sigma i}^{1-\sigma} = \sum_{\upsilon=1}^{I} \int_{\phi_{\upsilon j}^*}^{\infty} (p_{\upsilon j}(\phi))^{1-\sigma} \frac{\theta J_\upsilon b_\upsilon^\theta}{\phi^{\theta+1}} d\phi. \tag{26}$$

(25) suggests that integer values of σ are necessary in order to obtain numerical solutions to the firm's problem. Moreover, what makes the model computationally difficult is the numerical integration required in order to characterize all equilibrium objects which contain the price indices in (26).

In an online appendix, I characterize the solution to this model and outline the numerical algorithm used in order to deliver the results reported below. Two key changes take place with respect to the calibration procedure for the simple non-homothetic model: first, for a given θ, σ is chosen to deliver the observed size distribution of French firms, and second, the gravity equation no longer holds, which requires an alternative method to estimate trade barriers. I use a value of 8 for θ, which in the calibrated model requires a value of 6 for σ in order to match the size distribution of French firms. These values are in line with those proposed by Arkolakis (2008). In addition, I use the calibrated trade barriers from the simple non-homothetic model[41].

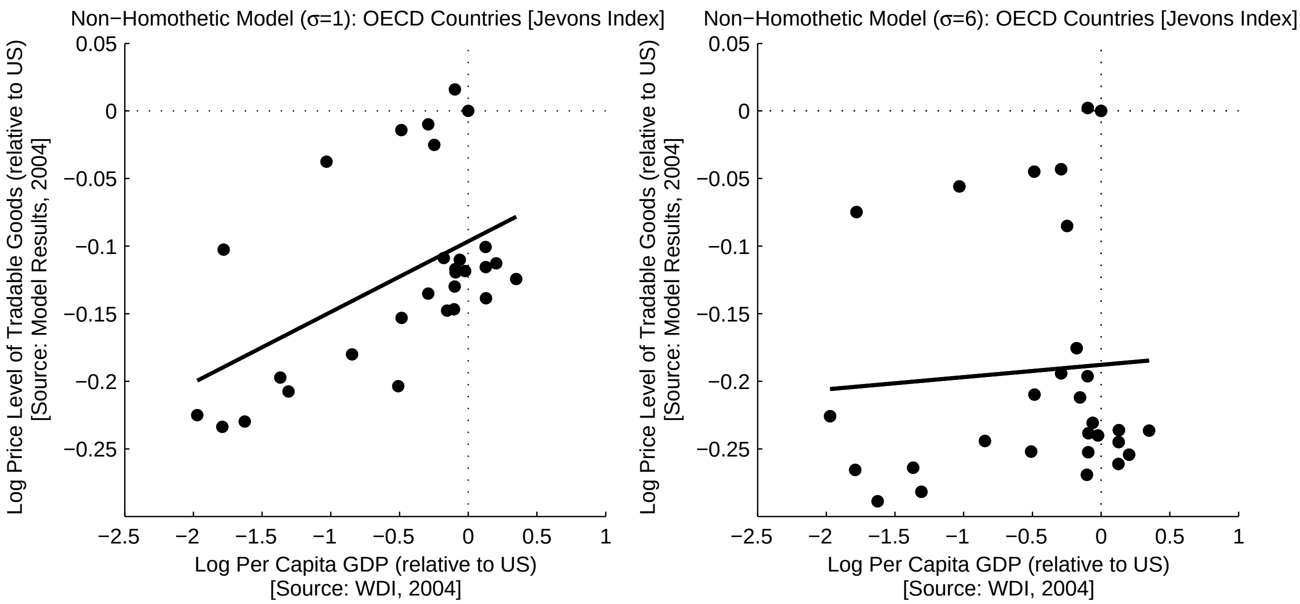

Figure 5: Price Level of Tradable Goods and Per-Capita GDP for OECD Countries

Figure (5) plots the prices of tradable goods arising from the two non-homothetic models in an economy characterized by OECD countries[42]. The general model is not as successful at capturing the price-income relationship as the simple non-homothetic model analyzed above. First, trade barriers are no longer calibrated to deliver observed bilateral trade flows. Second, once the elasticity of substitution takes on the value of 6, goods become significantly more substitutable than in the log-utility case. This necessarily gives each monopolistically-competitive firm a lower market share and therefore less of an ability to price-discriminate

[41] Asymmetric trade barriers cannot be computed in this model because of dimensionality issues. Fieler (2007) proposes a methodology to estimate symmetric trade costs in a Ricardian model with non-homothetic preferences, which is an approach I am currently exploring.

[42] I restrict the analysis to these 30 countries for computational ease.

across markets. Nonetheless, the model is still able to generate a positive and statistically significant price-income relationship. Thus, given its ability to capture both firm-level and aggregate observations, the model performs very well both qualitatively and quantitatively.

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 at least a half of the price differences across a large sample of countries. Alternative parametrizations of the model enable it to also capture cross-sectional facts at the firm-level, however, at the expense of lowering its degree of quantitative success along the price-income dimension.

Finally, 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 framework in future studies. Given the model's desirable features and tractability, it can be easily extended to a dynamic framework in which real exchange rate fluctuations can be explored, or it can be used to explore changes in welfare of agents with differing income levels in countries that undergo trade liberalization episodes.

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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)[43].

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

$$\max_{\{q^c_{\upsilon j}\}_{\upsilon=1}^{I} \geq 0} \left(\sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}} \left(q^c_{\upsilon j}(\omega)\right)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}$$

$$\text{s.t.} \quad \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}} p_{\upsilon j}(\omega) q^c_{\upsilon j}(\omega) d\omega \leq w_j.$$

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 by[44]:

$$q_{ij}(\phi) = w_j L_j \frac{p_{ij}(\phi)^{-\sigma}}{P_j^{1-\sigma}}, \tag{27}$$

where

$$P_j^{1-\sigma} = \sum_{\upsilon=1}^{I} N_{\upsilon j} \int_{\phi^*_{\upsilon j}}^{\infty} p_{\upsilon j}(\phi)^{1-\sigma} \mu_{\upsilon j}(\phi) d\phi, \qquad \sigma > 1. \tag{28}$$

From (27), 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 (27), the profit maximization problem of a firm with productivity draw ϕ originat-

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

[44] I 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:

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

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 country[45].

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 2005 round of the International Comparison Program (ICP) at the basic heading level provided by the World Bank. According to the ICP Handbook[46], 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 narrowly-defined group of goods for which expenditure data are available. There are a total of 129 BHs in the data set. Each BH contains a certain number of products. Hence, the reported price of a BH is an aggregate price. An example of a basic heading is "1101111 Rice" which is made up of prices of different types of rice contained in specific packages.

In order to derive the price of a BH, the ICP uses a Jevons index[47]. For all N countries

[45]These 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.

[46]The ICP Handbook prepared by the World Bank is available at
$http://go.worldbank.org/VMCB80AB40$.

[47]See Hill and Hill (2009) for an excellent discussion of price index derivation methods in the 2005 ICP round.

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 numeraire country is chosen, USA, and prices are expressed in 2005 US dollars. The Jevons index at the BH-level is a geometric average of relative prices of goods available in the US and another country. However, not all goods are found in all countries, resulting in price indices that are not transitive. Consequently, geometric averages are taken for every pair of countries in the sample and then prices relative to the US are computed using cross prices. The procedure, which yields transitive price indices, can be summarized as follows:

Step 1: Relative price of BH between countries j and k based on goods available in j and k is:

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

where R_{jk} denotes the number of goods available in countries j and k.

Step 2: The transitive Jevons index of BH between countries j and k becomes:

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

where N denotes the number of countries actually used in the relative price comparison. Notice that if a pair of countries does not have any goods in common, the relative price observation is missing and cannot be used to compute cross prices. Hence N is reduced accordingly.

I use prices at the BH-level to arrive at the price level of tradable goods by computing geometric averages across goods that correspond to tradable categories for 121 countries. Since there are no zero observations across these categories for the sample of countries I study, the price levels are transitive.

I now describe the Jevons index as it applies to the two models studied in this paper. The procedure is equivalent for the two models, but the price entries differ, since the optimal pricing rules of firms in the two models are different.

In the models, a good is differentiated by the productivity of the firm producing it as well as the source country of the firm. First, I compute Jevons indices across goods originating from a particular source and then I proceed to compute a Jevons index across all source countries. Consider two destinations, j and k, and a common source country υ. If $\phi^*_{\upsilon j} \neq \phi^*_{\upsilon k}$, then not all firms from country υ serve both destinations. Hence, only prices of firms with productivity draws $\phi \geq \max[\phi^*_{\upsilon j}, \phi^*_{\upsilon k}]$ are relevant in my comparison. In order to arrive at a geometric average of relative prices for a continuum of firms, the geometric mean formula

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

becomes

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

where $f(k)$ is the appropriate pdf of firm productivities.

The relative price of goods from country υ sold in destinations j and k is:

$$P^{j,k}_{\upsilon jk} = \exp\left\{ \int_{\max(\phi^*_{\upsilon j}, \phi^*_{\upsilon k})}^{\infty} \log\left[\frac{p_{\upsilon j}(\phi)}{p_{\upsilon k}(\phi)} \right] \frac{\theta[\max(\phi^*_{\upsilon j}, \phi^*_{\upsilon k})]^{\theta}}{\phi^{\theta+1}} d\phi \right\}. \tag{29}$$

However, the relative price a given 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 model. Thus, (29) for the CES and non-homothetic model, respectively, becomes:

$$\begin{aligned} \text{CES:} \quad P^{j,k}_{\upsilon jk} &= \exp\left\{ \log\left[\frac{\tau_{\upsilon j}}{\tau_{\upsilon k}} \right] \right\} \\ \text{NH:} \quad P^{j,k}_{\upsilon jk} &= \exp\left\{ \log\left[\frac{\tau_{\upsilon j}}{\tau_{\upsilon k}} \left(\frac{\phi^*_{\upsilon k}}{\phi^*_{\upsilon j}} \right)^{\frac{1}{2}} \right] \right\}. \end{aligned}$$

Using these expressions in step 2 allows me to compute the Jevons index between countries j and k for goods originating from source country υ. Finally, in order to arrive at price levels of tradable goods in the models, I repeat steps 1 and 2 treating each source country υ as a BH. This is necessary since there are a number of zero price observations corresponding to the zeros in the bilateral trade matrix, which implies that geometric averages across source countries would not yield transitive Jevons indices.

C Algebraic Derivations

C.1 Deriving Consumer's Demand

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

$$\max_{\{q^c_{\upsilon j}\}^I_{\upsilon=1} \geq 0} \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}} \log(q^c_{\upsilon j}(\omega) + \bar{q}) d\omega$$
$$\text{s.t.} \quad \lambda_j \left[\sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}} p_{\upsilon j}(\omega) q^c_{\upsilon j}(\omega) d\omega \leq w_j \right],$$

where λ_j is the Lagrange multiplier.

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

$$\lambda_j p_{ij}(\omega) = \frac{1}{q^c_{ij}(\omega) + \bar{q}}. \tag{30}$$

Let $\Omega^*_j \equiv \sum_{\upsilon=1}^{I} \Omega^*_{\upsilon j}$ be the set of all consumed varieties in country j. Letting $N_{\upsilon j}$ be the measure of set $\Omega^*_{\upsilon j}$, the measure of Ω^*_j, N_j, is given by $N_j = \sum_{\upsilon=1}^{I} N_{\upsilon j}$.

For any pair of goods $\omega_{ij}, {\omega'}_{\upsilon j} \in \Omega^*_j$, (30) gives:

$$p_{ij}(\omega)(q^c_{ij}(\omega) + \bar{q}) = p_{\upsilon j}(\omega') q^c_{\upsilon j}(\omega') + p_{\upsilon j}(\omega') \bar{q}. \tag{31}$$

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

$$\int_{\Omega_j^*} \left[p_{ij}(\omega)\left(q_{ij}^c(\omega)+\bar{q}\right)\right] d\omega' = \int_{\Omega_j^*} \left[p_{\upsilon j}(\omega') q_{\upsilon j}^c(\omega') + p_{\upsilon j}(\omega')\bar{q}\right] d\omega'$$

$$\Rightarrow \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}^*} \left[p_{ij}(\omega)\left(q_{ij}^c(\omega)+\bar{q}\right)\right] d\omega' = \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}^*} \left[p_{\upsilon j}(\omega') q_{\upsilon j}^c(\omega') + p_{\upsilon j}(\omega')\bar{q}\right] d\omega'$$

$$\Rightarrow \left[p_{ij}(\omega)\left(q_{ij}^c(\omega)+\bar{q}\right)\right] \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}^*} 1 d\omega' = \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}^*} \left[p_{\upsilon j}(\omega') q_{\upsilon j}^c(\omega') + p_{\upsilon j}(\omega')\bar{q}\right] d\omega'$$

$$\Rightarrow \left[p_{ij}(\omega)\left(q_{ij}^c(\omega)+\bar{q}\right)\right] \sum_{\upsilon=1}^{I} N_{\upsilon j} = w_j + \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}^*} p_{\upsilon j}(\omega')\bar{q} d\omega'$$

$$\Rightarrow \left[p_{ij}(\omega)\left(q_{ij}^c(\omega)+\bar{q}\right)\right] N_j = w_j + \bar{q}P_j$$

$$\Rightarrow q_{ij}^c(\omega) = \frac{w_j+\bar{q}P_j}{N_j p_{ij}(\omega)} - \bar{q} \tag{32}$$

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

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

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

C.2 Solving the Firm's Problem

Recall (6), which gives the profit maximization problem of a firm with productivity draw ϕ originating in country i and considering to sell to country j:

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

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

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

which results in the optimal price of:

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

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, (15), and the income/spending equality, (16).

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

$$\begin{aligned}
& w_i f_e = \pi_i \\
\Rightarrow\ & w_i f_e = \sum_{\upsilon}\left(\frac{b_i}{\phi^*_{i\upsilon}}\right)^{\theta}\frac{\bar{q}\tau_{i\upsilon}w_iL_{\upsilon}}{2\phi^*_{i\upsilon}(\theta+1)(\theta+0.5)}
\end{aligned} \tag{33}$$

The income/spending identity requires that country i's consumers spend their entire income on imported and domestically-produced final goods:

$$L_iw_i=\sum_{\upsilon}J_i\frac{b_i^{\theta}}{{\phi^*_{i\upsilon}}^{\theta}}\frac{\bar{q}\tau_{i\upsilon}w_iL_{\upsilon}}{2\phi^*_{i\upsilon}(\theta+0.5)} \tag{34}$$

Expressions (33) and (34) yield:

$$J_i=\frac{L_i}{(\theta+1)f_e} \tag{35}$$

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:

$$\frac{w_i^{\theta+1}}{b_i^{\theta}} = \sum_j \left(\frac{L_j w_j}{\tau_{ij}{}^{\theta} \sum_v L_v b_v^{\theta} (\tau_{vj} w_v)^{-\theta}} \right) \tag{36}$$

This equation implicitly solves for the wage rate w_i for each country i, where any i can be taken to be the numeraire country, with remaining wages expressed relative to it.

C.4 Distribution of Firms' Sales

Section (4.3.1) derives the sales of a firm with productivity ϕ from source country i in destination j, relative to average sales there:

$$s_{ij}(\phi) \equiv \frac{r_{ij}(\phi)}{t_{ij}} = \begin{cases} (1+2\theta)\left(1 - \left[\frac{\phi_{ij}^*}{\phi}\right]^{\frac{1}{2}}\right) & \text{if } \phi \geq \phi_{ij}^* \\ 0 & \text{otherwise.} \end{cases} \tag{37}$$

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

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

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:

$$1 - F(s) = \left(\frac{\phi^*}{\phi}\right)^{\theta} \tag{38}$$

Using (37) and (38), the cdf F, and its corresponding pdf f, become:

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

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. Clearly,

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

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

D Tables and Figures

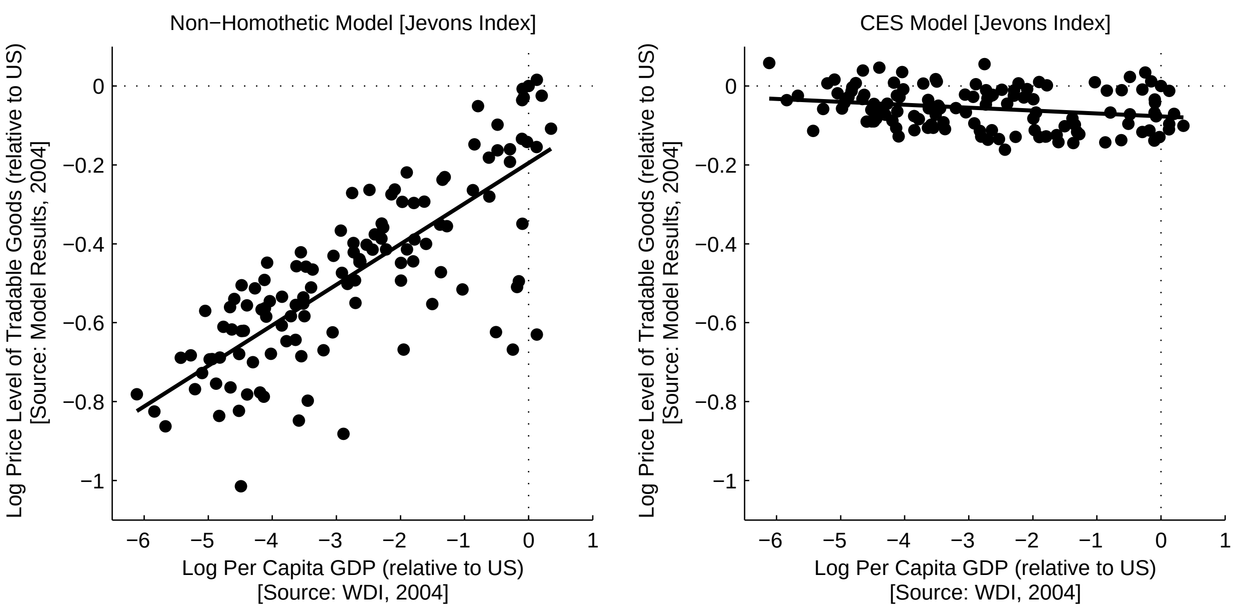

Figure 6: Price Level of Tradable Goods and Per-Capita GDP for 123 Countries

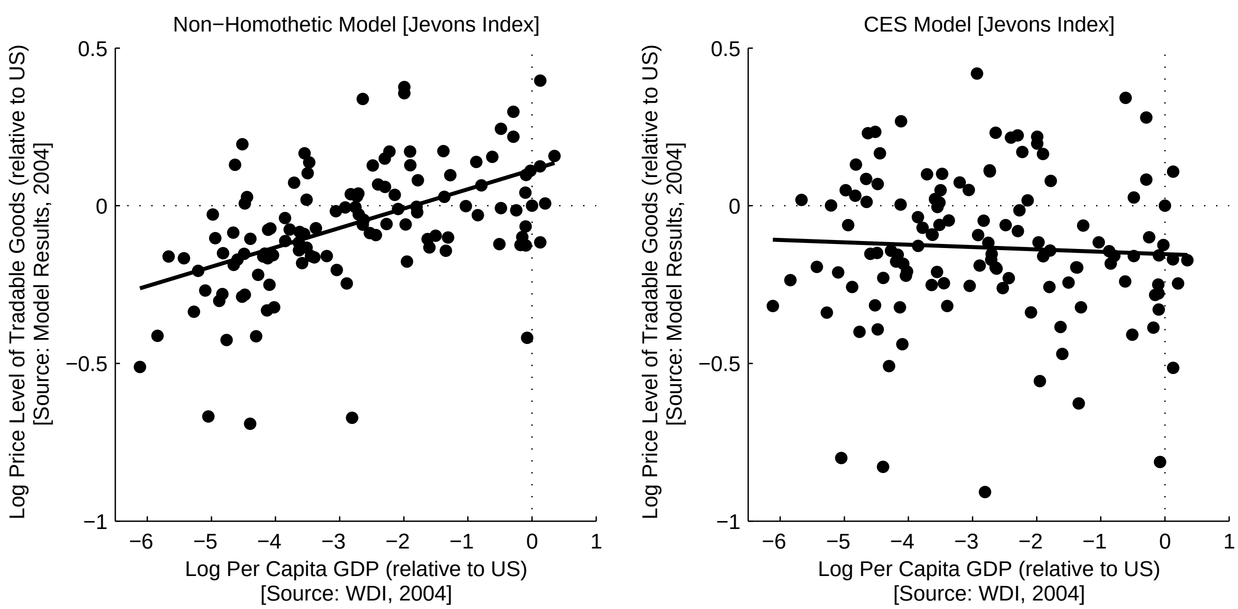

Figure 7: Price Level of Tradable Goods and Per-Capita GDP for 123 Countries

Table 1: Coefficients from Good Fixed-Effects Regression of Log Prices on Logs of Per-Capita Income, DHL Shipping and Controls

Regression Included Variables ——— Coefficient (St. Error) *t-stat	(1) PCGDP DHL	(2) PCGDP DHL Region Stores Female Pop.	(3) PCGDP DHL Region Stores Female Pop. Gini	(4) PCGDP DHL Region Stores Female Pop. Gini Ad Cost
Log PCGDP	0.0761 (0.0023) *33.66	0.0750 (0.0043) *17.61	0.0736 (0.0076) *9.72	0.3701 (0.0123) *30.17

All prices are converted to Euro using February/August 2008 average monthly exchange rates. Data Sources: Price data obtained by author from March/September 2008 online catalogues of clothing manufacturer Mango. DHL Express quotes collected from DHL Online. Store count data collected from each company's store locator website. Nominal per-capita income and population data for 2007 from WDI. Gini coefficient data is averaged over 96-07 period from WDI. Advertising cost data from ZenithOptimedia. Exchange rate data was obtained from the ECB.
(1) 28 countries including: Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, UK.
(2) Regions: Mediterranean, Scandinavian, Eastern. Competitors: Zara, Miss Sixty, Bershka.
(3) Excludes Cyprus and Malta due to data limitations.
(4) Excludes Canada, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Luxembourg, Malta, Poland, Slovakia, Slovenia and Eastern dummy due to data limitations.

Table 2: (Euro Zone) Coefficients from Good Fixed-Effects Regression of Log Prices on Logs of Per-Capita Income, DHL Shipping and Controls

Regression Included Variables —————— Coefficient (St. Error) *t-stat	(1) PCGDP DHL	(2) PCGDP DHL Region Stores Female Pop.	(3) PCGDP DHL Region Stores Female Pop. Gini	(4) PCGDP DHL Region Stores Female Pop. Gini Ad Cost
Log PCGDP	0.1204 (0.0027) *44.19	0.0663 (0.0032) *20.67	0.2172 (0.0092) *23.55	0.2120 (0.0099) *21.44

All prices in Euro by default.

Data Sources: Price data obtained by author from March/September 2008 online catalogues of clothing manufacturer Mango. DHL Express quotes collected from DHL Online. Store count data collected from each company's store locator website. Nominal per-capita income and population data for 2007 from WDI. Gini coefficient data is averaged over 96-07 period from WDI. Advertising cost data from ZenithOptimedia.

(1) 15 countries including: Austria, Belgium, Cyprus, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovenia, Spain.

(2) Regions: Mediterranean, Scandinavian, Eastern. Competitors: Zara, Miss Sixty, Bershka.

(3) Excludes Cyprus and Malta due to data limitations.

(4) Excludes Cyprus, Luxembourg, Malta, Slovenia and Eastern dummy due to data limitations.