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Income Differences and Prices of Tradables

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Abstract

I study the positive relationship between prices of tradable goods and per-capita income. I develop a highly tractable general equilibrium model of international trade with heterogeneous firms and non-homothetic consumer preferences that outperforms existing frameworks in accounting for the observed cross-country variation in prices along two key dimensions. The model yields a new testable prediction that relates prices to measurable variables. I use the prediction to estimate the price elasticity with respect to per-capita income from unique data featuring prices of 180 identical goods sold via the Internet in eighteen European countries. The empirical findings suggest that variable mark-ups account for a third of observed cross-country variations in prices of tradables.

JEL Classification: F12, F14
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1 Introduction

International trade has increased considerably over the past decades. Since tradable goods account for a rising share of consumption bundles of individuals, their prices directly affect consumer welfare. Consequently, studying the underlying mechanisms that shape the behavior of tradable consumption-good prices across countries has been a major focus of research in international trade.

One of the most robust empirical findings in the literature is that prices of tradable consumption goods are higher in countries that are richer in per-capita terms (see Hsieh and Klenow (2007) and Alessandria and Kaboski (2011)). In this paper, I argue that variable mark-ups make a key contribution toward this relationship between prices of tradables and per-capita income. To that end, I develop a tractable general equilibrium model of international trade with heterogeneous firms and non-homothetic preferences over varieties that accounts for the observed variation in prices across countries with different per-capita incomes and sizes. I construct a unique database of prices of identical goods sold across countries via the Internet and I use it to test the model's mechanism against competing alternatives. The model yields a new testable prediction that links relative prices to measurable variables. I use the prediction to structurally estimate the elasticity of price with respect to per-capita income and to assess the importance of variable mark-ups in explaining the observed cross-country variation in prices of tradable consumption goods.

In the model, trade barriers enable monopolistically-competitive firms with varying productivities to supply their products at destination-specific prices. Due to non-homothetic preferences, different per-capita income levels result in different consumption sets across countries. Non-constant expenditure shares yield varying price elasticities of demand for a given positively-consumed variety across destinations. In particular, rich countries' consumers are less responsive to price changes than those of poor ones, so firms optimally price identical varieties higher in more affluent markets. Moreover, firms suffer competitive pressures in larger markets and extract lower mark-ups there. Overall, the model predicts that relative prices of identical varieties are higher in countries where per-capita income levels are relatively higher and lower in relatively larger countries.

Two alternative frameworks in the international-trade literature link prices of tradable consumption goods to per-capita income via varying demand elasticities. First, Alessandria and Kaboski (2011) argue that high-wage earners have a high opportunity cost of searching for goods, which allows firms to charge high prices for identical goods in rich countries. Unlike the present model, their mechanism does not link prices to market size. Second, Hummels and Lugovskyy (2009) argue that richer agents consume more per good, which makes them more finicky and more willing to pay a high price in order to get closer to consuming their ideal variety. In their model, larger and richer (in per-capita terms) markets attract more firms and are consequently more competitive, which forces firms to charge lower prices there. Overall, their model predicts that relative prices of identical varieties are lower in relatively richer (in per-capita terms) and relatively larger markets, which is in contrast to the present framework.

I construct a unique database that features prices of 180 identical apparel products sold via the Internet in eighteen European countries and use it to test the predictions of the three models. Tracking identical goods enables me to directly measure price discrimination on the basis of varying demand elasticities in the absence of product-quality differences. Moreover, focusing on prices of goods sold online allows me to suppress non-tradable price contributions. Finally, since all products are stored and dispatched from a single warehouse via DHL Express to every destination, I obtain information on DHL's pricing rule, which enables me to control for shipping costs in the analysis.

The empirical results suggest that the non-homothetic model is the only one among the alternatives that can account for the observed price variation with respect to the per-capita income and the size of markets. In particular, after controlling for the cost to ship goods to different markets, I find that relative prices are higher in destinations with relatively higher per-capita incomes and lower in ones with relatively larger populations. The findings are in line with the predictions of the non-homothetic model, but they are in contrast with the predictions of the alternative models.

Given the success of the model in explaining the behavior of prices across countries, I use it to assess the importance of variable mark-ups. I derive a new testable prediction from the model that relates prices to measurable variables. For a pair of countries, the model predicts that the relative price of an identical item varies with the destinations' relative per-capita incomes, trade barriers, and import shares. Using this prediction, I structurally estimate the elasticity of price with respect to per-capita income from the unique micro data. The benchmark, mean, and median estimates are roughly 0.06 and lie within a tight range of 0.0570 and 0.0776 across various exercises.

The magnitudes of the estimates suggest that variable mark-ups are potentially important in a quantitative sense. I compare the elasticities that result from the micro-level analysis to estimates that I obtain for the same set of countries for the year 2005 using standard retail price data of aggregate apparel good categories employed by the existing literature. The aggregate data, which potentially reflect variable mark-ups, varying product quality, and varying retail components tied to non-tradable channels, yield a price elasticity of 0.17. Hence, variable mark-ups may be responsible for as much as a third of the cross-country price variation observed in aggregate data.

I contribute to the international pricing literature by developing and using a unique database that features prices of identical products sold across countries via the Internet. To study the relationship between prices of tradables and per-capita income, Hsieh and Klenow (2007) and Alessandria and Kaboski (2011) use prices of aggregate tradable good categories, while Crucini et al. (2005) employ prices of tradable products with similar characteristics, all of which are collected from retail locations across countries.[1] However, as Burstein et al. (2003) and Crucini and Yilmazkuday (2009) argue, retail data reflect the contributions of non-tradable inputs, whose prices vary systematically with countries' per-capita income levels. Consequently, retail prices of tradables may be linked to countries' per-capita income levels through the contributions of non-tradable channels.

To suppress retail components, Hummels and Klenow (2005), Hummels and Lugovskyy (2009),

[1] See Crucini et al. (2005) for a review of the literature that examines prices of retail goods across countries.

Baldwin and Harrigan (2011), Johnson (2011), and Manova and Zhang (2011) use free-on-board unit values to show that importers with high per-capita income levels pay high prices for imports from a given source. The observation may reflect two distinct mechanisms: (i) rich importers demand goods of high quality, as postulated by Verhoogen (2008) and Fajgelbaum et al. (2011); and (ii) exporters extract high mark-ups for identical goods from rich importers with low demand elasticities, as argued in the present paper. While the empirical literature has verified the varying-quality hypothesis, it has been unable to test the presence of variable mark-ups across countries due to the lack of price data of identical goods. In this paper, I aim to fill this gap.

The empirical results that I obtain provide support for an explanation of varying demand elasticities, and therefore variable mark-ups, that builds on non-homothetic preferences. To derive the testable predictions that guide the empirical analysis, I rely on a particular utility function that belongs to the hierarchic-demand class studied by Jackson (1984). Two additional utility functions of this class have been recently introduced to the international-trade literature that features firm heterogeneity. The first is the linear demand system used by Melitz and Ottaviano (2008) and the second is the exponential (CARA) utility used by Behrens et al. (2009). Both frameworks yield identical qualitative predictions as the present model regarding the behavior of prices within a country, but they lack tractability, so they are less informative about the variation of relative prices across countries. In contrast, the utility parametrization that I introduce in this paper maintains tractability in general equilibrium and is useful for cross-country empirical analysis.

In sum, I develop a tractable heterogeneous-firm model of international trade that relates prices of tradable consumption goods to per-capita income differences. I present direct support for the model's mechanism, which builds on non-homothetic preferences, from a unique database that features prices of identical products sold via the Internet. I use the model's testable prediction to estimate the elasticity of price with respect to per-capita income and to assess the importance of variable mark-ups in explaining the observed cross-country variation in prices of tradables. Overall, the paper contributes toward the understanding of the role that non-homothetic preferences play in shaping the pricing behavior of consumption-good producers across countries. Further combining a price-discrimination mechanism with theories of varying product quality and non-tradable distribution channels would potentially allow one to obtain a complete picture of the cross-country patterns of prices of tradables and to quantitatively assess consumers' welfare gains from trade.

2 Model

2.1 Consumer Problem

I consider a world that consists of a finite number of countries, I, engaged in trade of varieties of a final good. Let i represent an exporter and j an importer.

I assume that country j is populated by identical consumers of measure L_j who have preferences over varieties of a good. Varieties originating from different countries enter symmetrically in a consumer's utility function according to the following rule

$$U_j^c = \sum_{i=1}^{I} \int_{\omega \in \Omega_{ij}} \log(q_{ij}^c(\omega) + \bar{q}) d\omega,$$

where $q_{ij}^c(\omega)$ is individual consumption of variety ω from country i in j and $\bar{q} > 0$ is a (non-country-specific) constant. To ensure that the utility function is well defined, I assume that, for all j, $\Omega_j \equiv \sum_{i=1}^{I} \Omega_{ij} \subseteq \bar{\Omega}$, where $\bar{\Omega}$ is a compact set containing all potentially-produced varieties.

Notice that the preference relation described above is non-homothetic. Moreover, marginal utility from each variety, $(q_{ij}^c(\omega)+\bar{q})^{-1}$, is bounded at any level of consumption. Hence, a consumer may not have positive demand for all varieties.

Let y_j denote consumer income in j. Then, demand for variety ω from i consumed in a positive amount in j, $q_{ij}(\omega) > 0$, is given by[2]

$$q_{ij}(\omega) = L_j \left\{ \frac{y_j + \bar{q} P_j}{N_j p_{ij}(\omega)} - \bar{q} \right\}. \tag{1}$$

In the expression above, N_j is the total measure of varieties consumed in j,

$$N_j = \sum_{i=1}^{I} N_{ij}, \tag{2}$$

where N_{ij} is the measure of the set Ω_{ij}, which contains varieties originating from i.

Furthermore, P_j is an aggregate price statistic summarized by

$$P_j = \sum_{i=1}^{I} \int_{\omega \in \Omega_{ij}} p_{ij}(\omega) d\omega. \tag{3}$$

2.2 Firm Problem

The environment is static. Each variety is produced by a single firm using constant-returns-to-scale technology. Labor is the only factor of production. Following Melitz (2003), I assume that firms differ in their productivity, ϕ, and country of origin, i.

In every country i, there exists a pool of potential entrants who pay a one-time cost, $f_e > 0$, which entitles them to a single productivity draw from a distribution, $G(\phi)$, with support $[b_i, \infty)$. A measure J_i of firms that are able to cover their marginal cost of production enter. However, only a subset of productive entrants, N_{ij}, produce and sell to market j. These firms are able to charge a low enough price so as to generate non-negative demand in expression (1), while making non-negative profits. Thus, a subset of entrants immediately exit. Hence, in equilibrium, the expected

[2] See Appendix A.1 for derivation.

profit of an entrant is zero. Aggregate profit rebates to each consumer are therefore also zero. Assuming that each consumer has a unit labor endowment—which, when supplied (inelastically) to the local labor market earns a wage rate of w_j—per-capita income necessarily equals w_j.

Having described the market structure, I proceed to set up an operating firm's maximization problem. Let the production function of a firm with productivity draw ϕ be $x(\phi) = \phi l$, where l is the amount of labor used toward the production of final output. Moreover, assume that each firm from country i wishing to sell to destination j faces an iceberg transportation cost incurred in terms of labor units, $\tau_{ij} \geq 1$, with $\tau_{ii} = 1$ $(\forall i)$. An operating firm must choose the price of its good p, accounting for the demand for its product q. I consider a symmetric equilibrium where all firms of type ϕ from i choose identical optimal pricing rules. Thus, I can index each variety by the productivity and the country of origin of its producer, which allows me to rewrite individual consumer and country demand as follows

$$q_{ij}^{c}(\phi) = \frac{w_j + \bar{q}P_j}{N_j p_{ij}(\phi)} - \bar{q}, \tag{4}$$

$$q_{ij}(\phi) = L_j \left\{ \frac{w_j + \bar{q}P_j}{N_j p_{ij}(\phi)} - \bar{q} \right\}. \tag{5}$$

Using demand from (5), the profit maximization problem of a firm with productivity ϕ from country i that is considering to sell to destination j becomes

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

To solve this problem, each firm takes as given the measure of competitors N_j and the aggregate price statistic P_j. Taking first-order conditions, the resulting optimal price that a firm charges for its variety which is supplied in a positive amount is given by

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

2.3 Productivity Thresholds and Firm Mark-Ups

As noted earlier, in this model, not all firms serve all destinations. In particular, for any pair of source and destination countries, i and j, only firms originating from country i with productivity draws $\phi \geq \phi_{ij}^*$ sell to market j, where ϕ_{ij}^* is a productivity threshold defined by[3]

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

[3] I restrict f_e to ensure that $b_i \leq \phi_{ij}^* (\forall i, j)$.

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

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

The price that 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 (5), 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

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

Substituting (10) in (7), the optimal pricing rule of a firm with productivity draw $\phi \geq \phi^*_{ij}$ becomes

$$p_{ij}(\phi) = \underbrace{\left(\frac{\phi}{\phi^*_{ij}}\right)^{\frac{1}{2}}}_{\text{mark-up}} \underbrace{\frac{\tau_{ij} w_i}{\phi}}_{\text{marginal cost}}. \tag{11}$$

Expression (11) shows that mark-ups vary along two dimensions in this model. First, more productive firms charge higher mark-ups over marginal cost. This prediction is in line with the behavior of Slovenian manufacturers, as documented by Loecker and Warzynski (2009). Second, firms' prices and mark-ups vary systematically with market characteristics, which are summarized by the threshold that firms must surpass in order to serve a destination. The thresholds are, in turn, equilibrium objects. Consequently, I proceed to characterize the equilibrium of the model.

2.4 Equilibrium of the World Economy

The subset of entrants from i who surpass the productivity threshold ϕ^*_{ij} serve destination j. These firms, denoted by N_{ij}, satisfy

$$N_{ij} = J_i[1 - G(\phi^*_{ij})]. \tag{12}$$

Let $g(\phi)$ be the pdf corresponding to the productivity cdf $G(\phi)$. Then, the conditional density of firms operating in j is

$$\mu_{ij}(\phi) = \begin{cases} \frac{g(\phi)}{1-G(\phi^*_{ij})} & \text{if } \phi \geq \phi^*_{ij}, \\ 0 & \text{otherwise.} \end{cases} \tag{13}$$

With these definitions in mind, the aggregate price statistic in (3) can be rewritten as

$$P_j = \sum_{i=1}^{I} N_{ij} \int_{\phi^*_{ij}}^{\infty} p_{ij}(\phi)\mu_{ij}(\phi)d\phi. \tag{14}$$

Using the above objects, total sales to country j by firms originating in country i become

$$T_{ij} = N_{ij} \int_{\phi^*_{ij}}^{\infty} p_{ij}(\phi)x_{ij}(\phi)\mu_{ij}(\phi)d\phi. \tag{15}$$

Furthermore, individual firm profits are the sum of profit flows from each destination that a firm sells to. Hence, the average profits of firms originating from country i are

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

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

$$w_i f_e = \sum_{j=1}^{I}[1 - G(\phi^*_{ij})] \int_{\phi^*_{ij}}^{\infty} \pi_{ij}(\phi)\mu_{ij}(\phi)d\phi. \tag{16}$$

Finally, i's consumers' income, spent on final goods that are produced at home and abroad, is

$$w_i L_i = \sum_{j=1}^{I} T_{ji}. \tag{17}$$

Equilibrium. For $i, j = 1, ..., I$, given $\tau_{ij}, L_j, b_i, f_e, \bar{q}$, and a productivity distribution $G(\phi)$, an equilibrium is a set of total measures of firms serving j $\hat{N}_j$; productivity thresholds $\hat{\phi}^*_{ij}$; measures of firms from i serving j $\hat{N}_{ij}$; conditional densities of firms from i serving j $\hat{\mu}_{ij}(\phi)$; aggregate price statistics $\hat{P}_j$; total sales of firms from i serving j $\hat{T}_{ij}$; wage rates $\hat{w}_i$; measures of entrants $\hat{J}_i$; and, $\forall \phi \in [\phi^*_{ij}, \infty)$, per-consumer allocations $\hat{q}^c_{ij}(\phi)$, country allocations $\hat{q}_{ij}(\phi)$, firm pricing rules $\hat{p}_{ij}(\phi)$, firm production rules $\hat{x}_{ij}(\phi)$, and firm profits $\hat{\pi}_{ij}(\phi)$, such that: (i) $\hat{q}^c_{ij}(\phi)$ is given by (4) and solves the individual consumer's problem; (ii) $\hat{q}_{ij}(\phi)$ is given by (5) and satisfies a country's aggregate demand for a variety; (iii) $\hat{p}_{ij}(\phi)$ is given by (7) and solves the firm's problem; (iv) $\hat{x}_{ij}(\phi)$ satisfies goods' markets clearing $\hat{q}_{ij}(\phi) = \hat{x}_{ij}(\phi)$; (v) $\hat{\pi}_{ij}(\phi)$ is given by (6); (vi) $\hat{N}_j$, $\hat{\phi}^*_{ij}$, $\hat{N}_{ij}$, $\hat{\mu}_{ij}(\phi)$, $\hat{P}_j$, $\hat{T}_{ij}$, $\hat{w}_i$, $\hat{J}_i$ jointly satisfy (2), (10), (12), (13), (14), (15), (16), and (17).

3 Model Predictions

In this section, I derive the model's predictions regarding the behavior of firms within and across countries. I then discuss how the model relates to the existing literature.

In order to analytically solve the model and to derive stark predictions at the firm and aggregate levels, I follow Chaney (2008) and assume that firm productivities are drawn from a Pareto distribution with cdf $G(\phi) = 1 - b_i^\theta/\phi^\theta$, pdf $g(\phi) = \theta b_i^\theta/\phi^{\theta+1}$, and shape parameter $\theta > 0$. The support of the distribution is $[b_i, \infty)$, where b_i summarizes the level of technology in country i.[4] Moreover, varying levels of technology are related to 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 costs of production are low, and by richer consumers, who enjoy higher wages.[5]

3.1 Price Discrimination

In this section, I discuss the predictions of the model regarding the variation of prices with respect to two key country characteristics: per-capita income and size. Appendix A.3 contains the proofs.

3.1.1 Prices and Per-Capita Income

Expression (11) above demonstrated that firm mark-ups across markets depend crucially on the productivity thresholds of the destinations. Under the assumption that firm productivities are Pareto-distributed, I can characterize these thresholds via the following expression[6]

$$\phi^*_{ij} = \frac{\bar{q}^{\frac{1}{\theta+1}} \tau_{ij} w_i}{[(\theta+1) f_e (1+2\theta)]^{\frac{1}{\theta+1}}} \left[\frac{L_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+1}} + \sum_{v \neq j} \frac{L_v b_v^\theta}{w_j \left(\tau_{vj} w_v\right)^\theta} \right]^{\frac{1}{\theta+1}}. \tag{18}$$

Consider an increase in the per-capita income of destination j, w_j, while keeping all other objects fixed. A rise in w_j lowers the threshold in (18), which raises the mark-up in (11). Intuitively, recall that the marginal utility of a variety is bounded at any level of consumption. Since a tiny amount of consumption of a variety does not give infinite increase in utility, the consumer spends her limited income on the subset of potentially-produced items whose prices do not exceed marginal valuations. An increase in an individual's income makes new varieties affordable and

[4]All predictions derived in the remainder of the paper are identical if instead I set $b_i = b_j = b$ for all $i \neq j$ and let firms' production functions be $x_i(\phi) = A_i \phi l$, where A_i is country-specific total factor productivity.

[5]In Appendix A.2, I show that, in general equilibrium, a relative increase in b_i increases the relative wage in i.

[6]See Appendix A.2 for derivations.

the consumer expands her consumption bundle. Hence, the model yields a positive link between countries' per-capita incomes and the set of purchased varieties, which is in line with empirical findings by Jackson (1984), Hunter and Markusen (1988), Hunter (1991), and Movshuk (2004).

A rise in per-capita income does not only expand an agent's consumption bundle, but it also results in an increase in consumption of each positively-consumed variety. To see this, substitute (10) and (11) into (4) to obtain the following expression for an individual's consumption of an item

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

(19) falls in the cutoff productivity, so the quantity consumed rises in individual income. But, variations in consumption change elasticities of substitution and consequently affect prices of varieties. The elasticity of substitution for any two positively-consumed varieties in j, that are produced by firms with productivities ϕ_1 and ϕ_2, which originate from countries i and v respectively, is

$$\sigma_{q_{ij}^{c}(\phi_1),q_{vj}^{c}(\phi_2)} = 1 + \frac{\bar{q}}{2}\left[\frac{1}{q_{ij}^{c}(\phi_1)} + \frac{1}{q_{vj}^{c}(\phi_2)}\right].$$

As the consumer becomes richer, she consumes more of each variety, which drives down the elasticity of substitution between positively-consumed varieties. Prices of these varieties rise in response.

Another intuitive explanation of the price increase involves ordering varieties according to their "importance" to the consumer. As consumer income rises, new varieties produced by less productive firms are added to the consumption set. Conversely, if individual income were to fall, the new varieties are the first to be dropped from a consumer's bundle. Thus, the preference relation is "hierarchic"—a term introduced to the consumer-choice literature by Jackson (1984). The newly-added varieties are less important than the previously-consumed ones, which results in a fall in the demand elasticities of the latter. Hence, as income rises, prices of all previously-consumed varieties also rise.

To see this, let the (absolute value of the) price elasticity of demand for variety (ϕ, i) in j be

$$\epsilon_{ij}(\phi) = \left[1 - \left(\frac{\phi}{\phi_{ij}^{*}}\right)^{-\frac{1}{2}}\right]^{-1}. \tag{20}$$

If the per-capita income in market j rises, the productivity threshold falls. According to expression (20), the demand for a variety becomes less elastic. However, the elasticity of demand is reflected in the price of the item, which can be seen by combining expressions (11) and (20) to obtain

$$p_{ij}(\phi) = \frac{\tau_{ij} w_i}{\phi}\frac{1}{1 - [\epsilon_{ij}(\phi)]^{-1}}. \tag{21}$$

As consumer income rises, demand becomes less elastic, which allows firms to raise their prices.

Having described the behavior of prices within a country, it is easy to understand how prices of identical items vary across countries. Consider a firm with productivity draw ϕ, originating from country i and selling an identical variety to markets j and k, that is, $\phi \geq \max[\phi_{ij}^{*}, \phi_{ik}^{*}]$. Using expression (11), the relative price that this firm charges across the two markets is given by

$$\frac{p_{ij}(\phi)}{p_{ik}(\phi)} = \frac{\tau_{ij}}{\tau_{ik}} \left(\frac{\phi_{ij}^{*}}{\phi_{ik}^{*}} \right)^{-\frac{1}{2}}. \tag{22}$$

Proposition 1 describes how the relative price relates to the countries' relative per-capita incomes.

Proposition 1. *If trade barriers obey the triangle inequality, $(\forall j, k, \upsilon)\tau_{\upsilon j}\tau_{jk} \geq \tau_{\upsilon k}$, then the relative price of a variety sold in two markets is strictly rising in the markets' relative per-capita incomes.*

Intuitively, for a given variety that is sold in two markets, the consumers in the rich country are less responsive to price changes than the consumers in the poor one. A firm exploits this opportunity, amid trade barriers that segment the markets, and charges a high mark-up in the affluent destination.

3.1.2 Prices and Market Size

Consider an increase in the population size of destination j, L_j, while keeping all other objects fixed. The productivity threshold in (18) rises, thus lowering the mark-up in expression (11). Intuitively, as the country becomes larger, it attracts more entrants. Hence, the market becomes more competitive, which forces a surviving firm to reduce the price of its variety there.

Once again, having described the behavior of prices within a country, it is easy to understand how prices of identical items vary across countries. Proposition 2 describes how the relative price relates to the destinations' relative sizes.

Proposition 2. *For any two countries, j and k, $j \neq k$, if trade barriers obey the triangle inequality, $(\forall \upsilon)\tau_{\upsilon j}\tau_{jk} \geq \tau_{\upsilon k}$, and if the inequality for at least one $\upsilon \neq j$ is strict, then the relative price of a variety sold in markets j and k is strictly decreasing in the relative sizes of the markets.*

Proposition 2 ensures that the relative price of a variety across two markets falls in the relative sizes of the markets as long as there is "some gravity" surrounding these markets. One example in which the necessary restriction holds is when the trade barriers for the two countries whose prices are being compared, j and k, satisfy $\tau_{kj}\tau_{jk} > \tau_{kk}$. In this case, the restriction requires that the cost to sell products within country k is strictly lower than the cost to export products to j and then import them back to k. This is guaranteed if international shipping costs are strictly higher than domestic costs of shipping.

In the section that follows, I discuss how the model's predictions relate to the existing literature.

3.2 Relation to Existing Literature

3.2.1 Per-Capita Income, Prices, and Demand Elasticities: Alternatives Models

In the model outlined in this paper, the price of a variety reflects the firm's marginal cost of production and delivery and the consumer's demand elasticity in a country, which can be seen from expression (21). Since the elasticity in expression (20) depends on the productivity threshold, it falls in the per-capita income and rises in the size of the destination. The effects are a byproduct of the assumed non-homothetic preference relation.

Alternative explanations of varying demand elasticities, and therefore varying prices, exist. Lach (2007) hypothesizes that prices of consumption goods in Israel fell in the 1990s because there was a flow of immigrants with low search costs and high demand elasticities into the country during the period. Alessandria and Kaboski (2011) develop a formal model where high-wage earners have a high opportunity cost of searching for goods, which allows firms to charge high prices for identical goods in rich countries. While their model delivers a positive relationship between prices and per-capita income, it does not link prices to competition, or market size. On the contrary, the present model yields a negative relationship between prices and market size.[7]

Hummels and Lugovskyy (2009) use a Lancaster (1979) model to argue that richer agents consume more per good, which makes them more finicky and more willing to pay a high price in order to get closer to consuming their ideal variety. In their model, larger and richer (in per-capita terms) markets attract more firms and are consequently more competitive, which forces firms to charge lower prices there. Overall, the pro-competitive effect associated with higher per-capita income dominates the finickiness effect, so their model predicts that relative prices of identical varieties are lower in relatively richer (in per-capita terms) and relatively larger markets, which is in contrast to the present framework.

In other related literature, Bekkers et al. (2011) identify a difference between the predictions of monopolistically-competitive models with homogeneous firms that feature hierarchic demand versus ones with finickiness effects regarding the relationship between prices and income inequality within a country. The authors study variants of the two frameworks that include finite numbers of income groups within a country and they consider how increases in the mean-preserving spread in income, measured by changes in the Atkinson index, affect average prices in a country. The authors show that, in an ideal-variety framework, a rise in income inequality raises prices, while the opposite relationship prevails in a hierarchic-demand world.

The authors confront the models with disaggregate import unit-value data for 200 countries.[8]

[7] Another model that links prices to market size is Feenstra's (2003) monopolistically-competitive framework with homothetic translog preferences. The model, however, does not feature per-capita income effects on prices.

[8] Bekkers et al. (2011) also examine the quality hypothesis, according to which richer countries pay higher prices because they consume higher-quality goods. They show that the quality model, like the ideal-variety model, relates income inequality and prices in a positive manner. However, since the arguments in the present section are concerned with varying demand elasticities, I do not address the quality hypothesis.

They find that, after controlling for per-capita income, unit values fall in the Atkinson index of inequality, which suggests that prices are falling in within-country income inequality. The finding further supports an explanation of price variation that builds on non-homothetic preferences.

Overall, the discussion in this section suggests that the three competing models that generate varying demand elasticities have distinctive predictions about the behavior of prices in markets of different sizes and different levels of per-capita income. In the empirical section that follows shortly, I test the predictions of the three models using unique data that allows me to directly link prices to varying demand elasticities.

3.2.2 Non-Homothetic Preferences and International Trade

The utility function that I employ in this paper represents a preference relation that is non-homothetic. Non-homothetic preferences have recently made a come-back in international trade (see Markusen (2010) for a comprehensive discussion on the usefulness of non-homothetic preferences in accounting for a variety of facts in international economics). Verhoogen (2008) introduces non-homothetic preferences over goods of varying qualities in a heterogeneous-firm model of trade featuring workers with different skills in order to examine the effect that product quality upgrading has on within-industry wage inequality. Furthermore, Fajgelbaum et al. (2011) develop a framework with non-homothetic preferences over goods of different quality which can reconcile the observation that rich countries are net exporters of higher-quality goods and net importers of lower-quality goods. The authors use the model to study the effects of trade liberalization on the welfare of households with varying income levels in rich and poor countries.

Fieler (2010) incorporates non-homothetic preferences in the Ricardian model of Eaton and Kortum (2002) in order to quantitatively explain the lack of trade between rich and poor countries. In that framework, the set of consumed goods is fixed and identical across countries, so consumption shares vary with per-capita income, which makes the model potentially useful for cross-sectoral analysis. In contrast, the preference relation that I employ yields hierarchic demand due to bounded marginal utility of consumption. This feature of the utility function gives consumption sets that are expanding in per-capita income. Sauré (2009) argues that this mechanism has implications about trade patterns. The author uses the present utility function in the homogeneous monopolistic-competition framework of Krugman (1980) and derives a positive relationship between per-capita income and the extensive margin of imports.[9] The author's theoretical results are consistent with the empirical findings of Hummels and Klenow (2005) and Feenstra (2010).

Two additional functional forms that belong to the class of hierarchic demand systems have recently been introduced to the international trade literature featuring firm heterogeneity. First, Melitz and Ottaviano (2008) use linear demand for varieties to study how mark-ups respond to changes in market size and trade policy. Their framework features a numéraire good that is

[9] Young (1991) uses the same preference relation in a Ricardian framework to analyze the growth patterns of countries when firms engage in learning-by-doing.

produced with identical linear technology across countries and is freely traded. These assumptions imply wage equalization across countries and thus income effects on prices are absent from their model. In Appendix B, I drop the numéraire good and I characterize the general equilibrium of their model allowing for income effects. I then demonstrate that, in this model, the price of a variety responds to changes in market characteristics in the same qualitative fashion as in the model that is introduced in the present paper. However, upon inspecting the individual firm's pricing rule obtained from Melitz and Ottaviano's (2008) model, one can verify that the behavior of relative prices across countries can only be studied numerically. In addition, a testable prediction relating relative prices to measurable variables across countries cannot be derived since thresholds are not explicit functions of parameters and wages.

Second, Behrens et al. (2009) employ exponential (CARA) utility in a general equilibrium model of international trade with heterogeneous firms. They use the model to quantitatively assess the effects of the Canada-US trade liberalization on regional market aggregates such as wages, productivity, mark-ups, the mass of produced and consumed varieties, as well as welfare. While their model has desirable aggregate properties such as a gravity equation of trade under Pareto-distributed firm productivities, individual-firm prices and mark-ups are characterized via the Lambert-W function. Behrens et al. (2009) demonstrate that the model predicts a similar response of the price of a variety to changes in market characteristics as the two models discussed above. However, once again, due to lack of tractability, relative prices across countries can only be examined numerically and a testable prediction that relates them to measurable variables is not available.

On the contrary, the non-homothetic preference representation that I employ throughout the paper allows me to obtain a testable prediction that links relative prices to measurable variables, one of which is per-capita income. I propose this particular utility function because it offers tractability and it allows me to relate the model's prediction to observed data. In the empirical section of the paper, I derive the testable prediction about the behavior of prices across countries. I then use the expression to structurally estimate the elasticity of price with respect to per-capita income from unique price data and to gauge the quantitative relevance of variable mark-ups. Before engaging in this exercise, however, I demonstrate that observed cross-country price patterns support an explanation of price variation that builds on hierarchic demand.

4 Empirical Analysis

In subsection 3.2.1, I described three models that feature varying demand elasticities and link prices of tradables to destinations' per-capita incomes. In this section, I present a unique database that includes prices of *identical* goods sold *online*, which allows me to establish a link between demand elasticities and mark-ups across countries. First, I use the database in order to learn what mechanism is responsible for delivering varying demand elasticities, and therefore varying prices, across countries. Second, I use the model supported by the data in order to evaluate the importance of variable mark-ups.

4.1 Description of Data

I collect price data from the *online* catalogues of a Spanish apparel manufacturer called Mango. Mango specializes in the production of clothing, footwear, and accessories for middle-income female consumers, although in 2009, they also established a men's line. The company opened its first store in Barcelona in 1984. Currently, Mango has 1220 stores in 91 countries. Mango's financial statement dated 2007 shows that total annual sales amounted to 1.956 billion USD, out of which 76 percent was generated from exports. Mango is the second largest textile exporter in Spain and it employs 7800 people.

Mango operates a large-scale online store at http://shop.mango.com.[10] Each participating 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 shipping address in Germany can only have items delivered to her if purchased from the German Mango website.

Two unique features of the data allow me to empirically test the price-discrimination hypothesis. First, products sold in each market are identical, so quality differences are not responsible for the variation in prices across markets. This feature of the data distinguishes the analysis from studies that employ unit values (see Hummels and Klenow (2005), Hummels and Lugovskyy (2009), Baldwin and Harrigan (2011), Johnson (2011), and Manova and Zhang (2011)). Second, all products are sold online and prices do not reflect non-tradable contributions, which typically appear in retail prices, such as those used by Hsieh and Klenow (2007), Alessandria and Kaboski (2011), and Crucini et al. (2005). I expand on each of these points below.

The online catalogue constitutes an identical basket of nearly one hundred products offered in all participating countries each season.[11] Each item in the catalogue has a unique name and an 8-digit code reported in every country. All items are stored and ship out of a single warehouse located in Palau de Plegamans, Spain, regardless of the shipping destination. Thus, prices do not reflect destination-specific production and storage costs. Upon receiving an online order, Mango ships the items via DHL Express.[12] So, in addition to mark-ups, prices may reflect shipping costs.

The shipping and handling policy of Mango is such that no explicit fee is paid on purchases above a minimum value, which differs across countries. All other purchases incur an explicit

[10] Recently, some of Mango's competitors have begun to operate similar stores online. These companies include Zara (http://www.zara.com)—Spain's largest apparel exporter, H & M (http://www.hm.com/entrance.ahtml)—Sweden's largest apparel exporter, and Miss Sixty (http://www.misssixty.com/Index.aspx)—a division of Italy's Sixty Spa. At the time the study was conducted (in 2008), Mango's online store had the widest coverage of countries and items, which is necessary for empirical analysis, and it allowed one to collect prices of items in every country. As of 2011, Mango has expanded its online store to a larger set of countries.

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

[12] I conducted a controlled experiment and collected DHL tracking codes for an identical item sent to all destinations and verified that the shipping and production origin are identical, regardless of destination.

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 across markets. Thus, it is necessary to control for shipping costs in the analysis.

Information on the actual cost of shipping and handling that Mango incurs is not publicly available. In addition, the shipping and handling fees that Mango reports online may reflect variable mark-ups rather than true costs of shipping. So, it is not desirable to use this information to measure Mango's shipping costs. Instead, I use the structure of the model and the pricing rule reported by DHL, the company that Mango uses for shipping, in order to estimate trade barriers. I discuss estimation details in the next subsection.

Finally, prices reported on all EU-member websites are inclusive of sales taxes, or VAT. According to the European Commission, a company headquartered in an EU country, selling products online, and dispatching its products from its domestic location to another EU market, faces the following tax rule: (a) Add destination-specific VAT if annual sales per destination exceed a threshold value; (b) Choose between domestic and destination-specific VAT if annual sales per destination are below a threshold value.[13] Mango's sales data per destination are not publicly available. However, the European Commission reports the VAT rates on clothing for each member country, and Spain's rate is the third lowest in the sample. Thus, it is reasonable to assume that Mango would choose to apply the Spanish tax rate, if possible. So, in the benchmark analysis, I use prices collected from each country's website under the assumption that they reflect Spanish VAT. I conduct robustness exercises that account for destination-specific sales taxes in Appendices C.1 and C.2.

Table 1: Per-Capita Income and Average Price of Items, 18 Countries

Country	Austria	Belgium	Estonia	Finland	France	Germany
Mean Price	66.10	63.51	64.74	67.06	62.30	65.80
Country	Greece	Hungary	Ireland	Italy	Norway	Portugal
Mean Price	57.29	65.25	73.29	64.13	74.10	51.71
Country	Slovakia	Slovenia	Spain	Sweden	Switzerland	United Kingdom
Mean Price	72.19	64.10	51.57	72.50	73.22	63.44

corr(mean price, per-capita income)=0.5248**

** significance at 5%-level

Data Sources: Prices for 180 goods from March/September 2008 online catalogues of clothing manufacturer Mango. Exchange rates for March/September 2008 from ECB. Nominal per-capita GDP for 2007 from WDI.

I conclude the discussion with a summary of the price data. Table 1 reports the mean product price in Euro in each of the eighteen countries used in the analysis. The cross-country correlation between per-capita income and the average price is 0.52. Norway—the richest country in the sample—experiences the highest average price, which is 1.44 times higher than the lowest average

[13] See http://ec.europa.eu/taxation_customs/taxation/vat/how_vat_works/vat_on_services/index_en.htm

price observed in the home country—Spain.

4.2 Empirical Tests of Three Models

4.2.1 Ingredients

To test the predictions of the models, I use prices of 180 goods in 18 markets. I consider products from the Summer and Winter 2008 catalogues, which became available online in March and September of 2008, respectively. By pooling the data, I minimize the possibility of seasonal bias.

Prices are recorded in local currency. Two thirds of the countries in the sample were members of the Euro area in 2008. For the remaining countries in the sample, I convert prices into Euro using the European Central Bank's average exchange rate for March/September of 2008—the months when the catalogues were posted online and the data were collected. I also report results that I obtain using exchange rates for February/August and January/July of 2008 to capture the fact that Mango may have priced its products one or two months prior to posting the catalogues online. The reader can verify that the findings are robust across different specifications.[14]

I now discuss the approximation of shipping costs. Mango ships its products via DHL, which offers a menu of prices for repeated shipments.[15] Thus, the actual cost that Mango incurs cannot be inferred. But, DHL prices all shipments according to regions. For an exporter, the main determinant of the price to ship to a region is distance, and regions are ranked according to numbers, with 1 being the cheapest region.

To control for the effect that Mango's shipping costs have on goods' prices, I construct distance-interval dummy variables with DHL's regional classification in mind. From CEPII, I obtain the distance between Spain and every European country featured in the Spanish DHL catalogue. I construct four non-overlapping distance intervals. The upper bound on each distance interval is the maximum distance between Spain and the destinations within a given DHL region. Then, I construct an $M \cdot (I-1)-\text{by}-4$ matrix c, where M and I are the numbers of goods and countries in the study (with Spain being the numéraire), respectively. In column i of matrix c, $i = 1, ..., 4$, I make an entry of one if the destination-good pair is associated with a country whose distance from Spain lies in the i-th interval, and zero otherwise.

Finally, I use per-capita GDP (in current US dollars) and population size for the year 2007 from the World Development Indicators.

[14] It is redundant to repeat the analysis using exchange rates that were effective three or more months prior to the month when the catalogue was posted online since seasonal catalogues have a lifespan of three months. Given the short product lifespan, exchange rate volatility is likely not a major concern for Mango. Hence, the data are useful for a cross-sectional study such as the one undertaken in this paper. In that respect, the nature of the exercise is very different from typical empirical pricing-to-market investigations, which rely on time variation in prices of products with similar characteristics in order to infer the degree of nominal exchange-rate pass through (see Goldberg and Knetter (1997) for a comprehensive review of the relevant literature).

[15] All information on DHL contained in this and subsequent paragraphs is available at http://www.dhl.es/en.html.

4.2.2 Econometric Model

To motivate the econometric specification, I revisit the predictions of the three models in more detail. First, in a two-country, two-tradable-good search framework, Alessandria and Kaboski (2011) show that firms add a mark-up to the marginal cost of production in each market. The mark-up is higher in the country where consumers enjoy higher per-capita income levels. Hence, the model predicts that the relative price of an item across two markets depends on good-specific characteristics (since mark-ups are additive) and relative per-capita incomes of the destinations. Market size plays no role in determining the price of individual goods in the model.

Second, the ideal-variety framework of Hummels and Lugovskyy (2009) predicts that the relative price of a variety is lower in markets with relatively higher per-capita incomes and relatively larger populations. In addition, goods' characteristics affect relative prices because relative (net) mark-ups reflect marginal costs of production and delivery.

Third, the non-homothetic model predicts that relative prices are higher in relatively richer (in per-capita terms) and lower in relatively larger markets (in terms of population size). This prediction is in contrast with the search model, which does not link prices to market size, and with the ideal-variety model, which negatively links relative prices to both relative per-capita incomes and relative market sizes. Finally, (22) suggests that good-specific characteristics do not affect relative prices across different destinations in the non-homothetic model.

With the above discussion in mind, I propose the following econometric model

$$\log\left(\frac{p_{jm}}{p_{sm}}\right) = \hat{\gamma}_m + \hat{\gamma}_w \log\left(\frac{w_j}{w_s}\right) + \hat{\gamma}_{\scriptscriptstyle L} \log\left(\frac{L_j}{L_s}\right) + \hat{\gamma}_c c + \xi_{jm}. \tag{23}$$

In the above expression, p_{jm}/p_{sm} is the Euro-denominated price of item m in country j, relative to the item's price in Spain. $\hat{\gamma}_m$ is item m's fixed-effect coefficient estimate. w_j/w_s is country j's per-capita income, relative to Spain's, and $\hat{\gamma}_w$ is the corresponding estimated coefficient. L_j/L_s is country j's population, relative to Spain's, and $\hat{\gamma}_{\scriptscriptstyle L}$ is the corresponding estimated coefficient. c is the shipping cost matrix discussed above and $\hat{\gamma}_c$ is the associated vector of coefficients, with typical element $\hat{\gamma}_{c_i}$, $i = 1, ..., 4$. ξ_{jm} is an error term.

In the above specification, a positive and statistically significant estimate of $\hat{\gamma}_w$ and a negative and statistically significant estimate of $\hat{\gamma}_{\scriptscriptstyle L}$ is in line with the predictions of the non-homothetic model only. The search model predicts that $\hat{\gamma}_{\scriptscriptstyle L}$ is not different from zero, while the ideal-variety model predicts that both $\hat{\gamma}_w$ and $\hat{\gamma}_{\scriptscriptstyle L}$ are negative and statistically significant.

Before proceeding to the empirical results, I should note that the ideal-variety model predicts that the relative price of a variety is higher in markets with relatively higher per-capita incomes, after controlling for relative incomes. Intuitively, when one controls for total income, which is the product of per-capita income and market size, one disentangles the finickiness effect from the pro-competitive effect caused by rising per-capita. Since, overall, the model yields a negative relationship between relative prices and relative per-capita incomes, it must be the case that the model predicts that the (positive) elasticity of relative prices with respect to relative per-capita incomes falls short of the (negative) elasticity of relative prices with respect to relative incomes.

In a supplementary appendix, I demonstrate that the non-homothetic model also predicts that relative prices are increasing in relative per-capita incomes, after controlling for relative incomes. However, contrary to the ideal-variety framework, the non-homothetic model generates a higher (positive) elasticity of relative prices with respect to relative per-capita income than the (negative) elasticity of relative prices with respect to relative income. Hence, a second test for the non-homothetic versus the ideal-variety framework is whether the sum of the elasticities is positive in the data. In the same appendix, I perform this test and demonstrate that the empirical results offer support to the non-homothetic model.

4.2.3 Results

Table 2: Test of Alternative Models, 18 Countries

Exchange Rate	$\hat{\gamma}_w$ (s.e.)	$\hat{\gamma}_L$ (s.e.)	$\hat{\gamma}_{c,1}$ (s.e.)	$\hat{\gamma}_{c,2}$ (s.e.)	$\hat{\gamma}_{c,3}$ (s.e.)	$\hat{\gamma}_{c,4}$ (s.e.)
Mar/Sep	0.0646**	-0.0282**	-0.0105	0.2063***	0.2497***	0.2036***
	(0.0309)	(0.0126)	(0.0226)	(0.0180)	(0.0141)	(0.0383)
Feb/Aug	0.0699**	-0.0243**	-0.0046	0.2049***	0.2491***	0.2123***
	(0.0304)	(0.0117)	(0.0221)	(0.0173)	(0.0143)	(0.0384)
Jan/Jul	0.0635**	-0.0231*	-0.0055	0.2071***	0.2527***	0.2146***
	(0.0303)	(0.0120)	(0.0221)	(0.0172)	(0.0154)	(0.0388)

* significance at 10% level, ** significance at 5%-level, *** significance at 1%-level

Price regressions: N. Obs 3060, Country clusters 17 (Spain is numéraire), Fixed Effects 179 (relative to good 1)

Distance Intervals (in km): $[0, 501]$, $(501, 1367]$, $(1367, 1482]$, $(1482, 2953]$

Data Sources: Prices from Mar/Sep 2008 online catalogues of clothing manufacturer Mango. Exchange rates for Mar/Sep, Aug/Feb, and Jan/Jul 2008 from ECB. DHL Express shipping zones from DHL Spain Online. Distance from CEPII. Nominal per-capita GDP and population for 2007 from WDI.

I estimate the coefficients in (23) using the OLS estimator and I cluster all errors by destination. The results from the empirical test of the three models are reported in Table 2. The coefficient estimates on per-capita income are positive and statistically significant and the coefficients on country size are negative and statistically significant. These results support the non-homothetic model over the two alternatives.

The dummy associated with the first region is not statistically different from zero. This result is due to the fact that Portugal is the only country that belongs to the first distance region, as it is the only country that is classified in the first zone of shipping according to DHL Spain. The remainder of the regions display very high and statistically-significant positive coefficients, which suggests that prices increase sharply in the cost of shipping.

4.2.4 Endogeneity and Robustness

A potential source of endogeneity in the empirical analysis above is omitted-variables bias. For example, in addition to distance, other destination-specific variables may be responsible for the DHL shipping costs that Mango incurs. If the omitted variables are reflected in the items' prices and if they co-vary with the per-capita income or the size of the destinations, then the estimates of $\hat{\gamma}_w$ and $\hat{\gamma}_L$ will be biased (see Chapter 4 in Wooldridge (2002)).

While distance is a critical determinant of the cost to ship a product, international shipping costs may reflect additional geographic characteristics of countries. For example, if the destination is an island, ground transport cannot be used. If air of sea transport is used instead, the shipping cost may differ. Consequently, for robustness, I expand the benchmark specification in (23) to accommodate a dummy variable, isl, which takes on the value of one if the destination is an island country, and zero otherwise. Table 3 reports the results from the exercise. $\hat{\gamma}_{isl}$ represents the coefficient estimate of the "island" effect and it is not statistically different from zero. In addition, the estimated coefficients on per-capita income and size remain practically unchanged.

Table 3: Robust Test of Alternative Models, 18 Countries

Exchange Rate	$\hat{\gamma}_w$ (s.e.)	$\hat{\gamma}_L$ (s.e.)	$\hat{\gamma}_{c,1}$ (s.e.)	$\hat{\gamma}_{c,2}$ (s.e.)	$\hat{\gamma}_{c,3}$ (s.e.)	$\hat{\gamma}_{c,4}$ (s.e.)	$\hat{\gamma}_{isl}$ (s.e.)
Mar/Sep	0.0651**	-0.0286**	-0.0109	0.2077***	0.2533***	0.2027***	-0.0083
	(0.0315)	(0.0133)	(0.0230)	(0.0204)	(0.0114)	(0.0395)	(0.0204)
Feb/Aug	0.0693**	-0.0238*	-0.0042	0.2034***	0.2451***	0.2133***	0.0092
	(0.0309)	(0.0124)	(0.0221)	(0.0185)	(0.0112)	(0.0394)	(0.0174)
Jan/Jul	0.0626**	-0.0224*	-0.0048	0.2051***	0.2471***	0.2160***	0.0132
	(0.0307)	(0.0127)	(0.0220)	(0.0181)	(0.0115)	(0.0398)	(0.0175)

* significance at 10% level, ** significance at 5%-level, *** significance at 1%-level

Price regressions: N. Obs 3060, Country clusters 17 (Spain is numéraire), Fixed Effects 179 (relative to good 1)

Distance Intervals (in km): $[0, 501]$, $(501, 1367]$, $(1367, 1482]$, $(1482, 2953]$

Data Sources: Prices from Mar/Sep 2008 online catalogues of clothing manufacturer Mango. Exchange rates for Mar/Sep, Aug/Feb, and Jan/Jul 2008 from ECB. DHL Express shipping zones from DHL Spain Online. Distance from CEPII. Nominal per-capita GDP and population for 2007 from WDI.

Finally, as discussed in section 4.1, cross-country sales-tax variation may cause systematic price deviations. So, for robustness purposes, in Table 6 of Appendix C.1, I repeat the analysis by explicitly controlling for differences in sales taxes across destinations. Sales tax variation does not appear to be a source of bias in the analysis, since the estimated coefficient of a destination's gross sales tax, relative to Spain's tax, is not statistically different from zero in any of the specifications.

In sum, the empirical results suggest that the non-homothetic model outlined in this paper has the ability to account for the observed cross-country variation in prices along two key dimensions: per-capita income and size of destinations. On a broader scale, the empirical findings can be viewed as providing support for an explanation of price variation that builds on hierarchic demand.

4.3 Structural Estimates of Price Elasticities

Section 4.2 above empirically tests three theories that aim to explain the positive relationship between per-capita income and prices of tradables. However, the estimation thus far has not been structural, so the empirical analysis has not been informative about the magnitude of the elasticity of price with respect to per-capita income and the importance of variable mark-ups. Given that the non-homothetic model appears to be qualitatively in line with the pricing behavior observed in the data, I use it to accomplish this task. First, I derive a testable prediction of the model that relates prices to measurable variables. Second, I use the prediction, together with the dataset described above, to structurally estimate the elasticity of price with respect to per-capita income and to quantify the role of variable mark-ups in international trade.

4.3.1 A Testable Prediction

To derive the model's testable prediction about price variation, substitute the thresholds from (18) for destinations j and k into the relative-price expression in (22) to obtain

$$\frac{p_{ij}\left(\phi\right)}{p_{ik}\left(\phi\right)} = \underbrace{\left(\frac{\tau_{ij}}{\tau_{ik}}\right)^{\frac{1}{2}}}_{\text{barriers}} \underbrace{\left(\frac{w_j}{w_k}\right)^{\frac{1}{2(\theta+1)}}}_{\text{pc income}} \underbrace{\left(\frac{\sum_v L_v b_v^{\theta}(\tau_{vj} w_v)^{-\theta}}{\sum_v L_v b_v^{\theta}(\tau_{vk} w_v)^{-\theta}}\right)^{-\frac{1}{2(\theta+1)}}}_{\text{general equilibrium object}}. \tag{24}$$

The first term emphasizes the role of trade barriers, while the third represents an equilibrium object, where the contributions of each destination's per-capita income and size are marginal since they are contained within a summation term. Hence, identification of the price elasticity with respect to per-capita income must come from the second term, which is simply a ratio of per-capita incomes of two destinations. The problem with taking this expression to the data, however, is the fact that the lower bound on each country's productivity distribution, b_v, is not observable.

To solve the problem, make use of predicted trade shares, which are observable statistics. First, multiply (19) by the destination's size L_j to obtain the quantity sold in j by a firm with productivity ϕ from i. To derive i's total sales in j, substitute this quantity, as well as the price from (11), the conditional density from (13) under the Pareto parametrization, and the measure of exporters from (12) using the equilibrium measure of entrants $J_i = L_i/[(\theta+1)f_e]$ derived in Appendix A.2, into expression (15). Then, using expression (18) and the fact that $\tau_{ij}w_i/\phi^*_{ij} = \tau_{jj}w_j/\phi^*_{jj}$ ($\forall i \neq j$) (which is apparent in expression (10)), the import share of i-goods in j can be defined as

$$\lambda_{ij} \equiv \frac{T_{ij}}{\sum_{v=1}^{I} T_{vj}} = \frac{L_i b_i^{\theta}(\tau_{ij} w_i)^{-\theta}}{\sum_{v=1}^{I} L_v b_v^{\theta}(\tau_{vj} w_v)^{-\theta}}. \tag{25}$$

Finally, substitute (25) into (24) to obtain the following testable prediction that relates relative prices to measurable variables

$$\frac{p_{ij}(\phi)}{p_{ik}(\phi)} = \underbrace{\left(\frac{\tau_{ij}}{\tau_{ik}}\right)^{\frac{2\theta+1}{2(\theta+1)}}}_{\text{barriers}} \underbrace{\left(\frac{w_j}{w_k}\right)^{\frac{1}{2(\theta+1)}}}_{\text{pc income}} \underbrace{\left(\frac{\lambda_{ij}}{\lambda_{ik}}\right)^{\frac{1}{2(\theta+1)}}}_{\text{market share}}.$$

Below, I rewrite this expression in logs and I multiply and divide logged trade barriers by θ for reasons that will become apparent shortly,

$$\log\left(\frac{p_{ij}(\phi)}{p_{ik}(\phi)}\right) = \underbrace{\frac{2\theta+1}{2(\theta+1)\theta}}_{\beta_\tau} \theta \log\left(\frac{\tau_{ij}}{\tau_{ik}}\right) + \underbrace{\frac{1}{2(\theta+1)}}_{\beta_w} \log\left(\frac{w_j}{w_k}\right) + \underbrace{\frac{1}{2(\theta+1)}}_{\beta_\lambda} \log\left(\frac{\lambda_{ij}}{\lambda_{ik}}\right). \tag{26}$$

The model predicts that, after controlling for relative import shares and scaled relative trade barriers, the elasticity of relative prices with respect to relative per-capita incomes is $\beta_w \equiv 1/[2(\theta+1)]$. In the proceeding subsections, I estimate this elasticity from Mango's price data. First, I discuss the additional data ingredients necessary for estimation. Then, I proceed to describe the econometric model employed. Finally, I report the empirical results and I conduct robustness exercises.

4.3.2 Ingredients

In order to estimate the elasticity of relative prices with respect to relative per-capita incomes, I need four variables. The two key variables, namely prices and per-capita income, were described in Section 4.2. I discuss the remaining variables next.

Given Mango's line of work, to measure trade shares λ_{ij}, I focus on the industry titled "Textiles, textile products, leather and footwear" in the Stats.OECD database. I let the denominator in the trade-share expression be Gross Output + Imports (from countries in the sample) - Exports (to countries in the sample), which represents a country's total expenditure on goods of the particular industry. The numerator in (25) is country j's imports from country i in the industry.

While trade shares are observable, trade barriers are not. Since I assume that trade barriers are of the iceberg form, I can estimate them from the model's gravity equation of trade. To derive gravity between an exporter i and an importer j, simply take the log of the ratio of the import share λ_{ij} to the domestic expenditure share of the importer λ_{jj}, which from expression (25) is

$$\log\left(\frac{\lambda_{ij}}{\lambda_{jj}}\right) = S_j - S_i - \theta \log \tau_{ij}. \tag{27}$$

In the expression above, $S_j = \theta \log(w_j) - \log(L_j) - \theta \log(b_j) (\forall j)$. Intuitively, this variable captures the average effect that a particular country's characteristics have on its imports. S_i captures the effect that a country's characteristics have on its exports. From expression (26), however, the variables of interest for the pricing analysis are the logged trade barriers, scaled by θ.

Motivated by DHL's pricing rule, I assume that trade barriers take on the following form

$$\log \tau_{ij} = d_k + \delta_{ij}, \tag{28}$$

where d_k, $k = 1, ..., 5$, quantifies the effect of the distance between i and j lying in the k-th interval.[16] δ_{ij} is an error term, assumed to be a random variable distributed according to $N(0, \Sigma)$, where Σ is a diagonal square matrix with a typical entry of σ^2 along the diagonal.

I apply least squares to estimate scaled logged bilateral trade barriers for all the countries in the sample using equations (27) and (28). S_j and S_i are simply the estimated coefficients of importer- and exporter-specific dummy variables, respectively. Although I only need the trade barriers that Spain faces for the estimation of price elasticities that follows, I use the full sample of countries to estimate the trade barriers in order to be able to separately identify the contributions of distance on scaled logged trade barriers from importer-specific characteristics.

The R-squared of the regression is 0.8606. The coefficient estimates and summary statistics are reported in Table 11 in Appendix D. Using the coefficient estimates on the five distance intervals, I construct the scaled logged trade barriers that Spain faces to export to every destination. The goal is to use these estimates in the econometric model corresponding to (26), which I derive next.

4.3.3 Econometric Model

Using Spain as numéraire, dropping country-of-origin subscripts since Mango is from Spain, and discretizing the set of varieties, the econometric model corresponding to (26) can be written as

$$\log\left(\frac{p_{jm}}{p_{sm}}\right) = \hat{\beta}_\tau \log\left(\frac{\hat{t}_j}{\hat{t}_s}\right) + \hat{\beta}_w \log\left(\frac{w_j}{w_s}\right) + \hat{\beta}_\lambda \log\left(\frac{\lambda_j}{\lambda_s}\right) + \psi_{jm}. \tag{29}$$

In the above expression, p_{jm}/p_{sm} is the Euro-denominated price of item m in country j, relative to Spain. $\log\left(\hat{t}_j/\hat{t}_s\right) \equiv \theta \log\left(\hat{\tau}_{sj}/\hat{\tau}_{ss}\right) = \theta \log \hat{\tau}_{sj}$ represents the difference between the scaled logged trade barriers from Spain to destination j and the scaled logged trade barriers from Spain to itself. By the assumptions of the model, iceberg costs are expressed relative to domestic shipping costs, which are normalized to unity. Hence, $\hat{\tau}_{ss} = 1$, which implies that $\theta \log \hat{\tau}_{ss} = 0$. The "hat" appearing in $\theta \log \hat{\tau}_{sj}$ is to remind the reader that scaled logged trade barriers are estimates

[16] I use the following distance intervals (in km): $[0, 501]$, $(501, 1367]$, $(1367, 1482]$, $(1482, 2953]$, $(2953, \max]$. The first four distance intervals are from Section 4.2 and the fifth ensures that all bilateral distances are accounted for. Quantifying the effects of distance on trade flows via distance interval dummies is reminiscent of Eaton and Kortum's (2002) work. A variety of specifications for trade barriers exist (see Anderson and van Wincoop (2004)). For example, it is common to use data on tariffs and freight charges in order to approximate trade barriers. This approach is not applicable in the present study. First, all the countries in the sample are members of the European Economic Area, so bilateral tariffs are zero. Second, Mango's actual shipping costs are not publicly available.

obtained from the gravity regression in the previous section. w_j/w_s is the per-capita income of country j, relative to Spain. λ_j/λ_s is the import share of country j from Spain, relative to Spain's domestic expenditure share. ψ_{jm} is an error term which arises because Mango's true trade costs may differ from the trade-barrier estimates that I employ in the analysis.

4.3.4 Trade-Barrier Measurement Error

An important measurement-error issue needs to be addressed. In the econometric model in (29), I use estimates of trade barriers obtained from bilateral trade data. A classical error-in-variables problem may arise if trade barriers are measured with error, and the estimates of $\hat{\beta}_\tau$ may be biased toward zero, as discussed in Levi (1973). The direction of the bias in the estimate of any remaining coefficient depends on the covariance between the variable whose coefficient is being estimated and the variable measured with error. In the present study, it would be worrisome if trade barriers co-varied with destinations' per-capita incomes because estimates of $\hat{\beta}_w$ would be biased if the trade barriers were measured with error.

To understand how the measurement error of trade barriers behaves, I compute the residuals from the gravity estimation. From expressions (27) and (28) it is clear that, by assumption, the gravity residuals represent the negative of the measurement error of logged trade barriers, scaled by θ. I focus on the seventeen residuals associated with Spain's export shares per market. An OLS regression of the residuals on the logged per-capita incomes of the destinations, relative to Spain, and a constant term yields a slope coefficient estimate of -0.6446 with a t-statistic of -1.92 (see Table 9 in Appendix D). Hence, the measurement error of trade barriers is systematically related to the per-capita income of the destination and it may bias the estimate of the price elasticity.

I tackle the issue of measurement error in two steps. First, I use the entire expression (28), scaled by θ, rather than $\theta \log \hat{\tau}_{ij}$ only, in the estimation of the price elasticity in (29). This way I explicitly account for the error terms in the elasticity estimation.

Second, I employ an instrumental variable (2SLS) approach. When I use the estimated trade barriers (without the error terms) in (29), I instrument per-capita income with labor productivity in the "Textiles, textile products, leather and footwear" industry. The argument for the 2SLS estimation is that the per-capita income (or wage) vector is endogenous to the model and it is determined in equilibrium (see expression (a.9) in Appendix A.2). In particular, the per-capita income vector depends on trade barriers, among other parameters, so it is correlated with the measurement error in trade barriers. Moreover, as I demonstrate in the same Appendix, in the general equilibrium of this model, per-capita income is mainly driven by average productivity, which is intimately linked to the lower bound of the Pareto productivity distribution b. Hence, it is reasonable to use labor productivity as an instrument in the analysis. In the empirical exercise that follows, I compute labor productivity as the ratio of value added of the "Textiles, textile products, leather and footwear" industry (in volumes) and employment in the same industry.

4.3.5 Results

Below I report the results from the two estimations. I cluster all standard errors by destination.

Table 4: Benchmark Estimation With Error-Adjusted Trade Barriers, 18 Countries

Exchange Rate	$\hat{\beta}_w$ (s.e.)	$\hat{\beta}_\lambda$ (s.e.)	$\hat{\beta}_\tau$ (s.e.)
Mar/Sep	0.0599*	-0.0254	0.0334*
	(0.0321)	(0.0242)	(0.0180)
Feb/Aug	0.0623**	-0.0229	0.0355*
	(0.0305)	(0.0239)	(0.0180)
Jan/Jul	0.0580*	-0.0253	0.0337*
	(0.0310)	(0.0248)	(0.0183)

* significance at 10% level, ** significance at 5%-level

Price regressions: N. Obs 3060, Country clusters 17 (Spain is numéraire).

Distance Intervals for Gravity (in km): $[0, 501]$, $(501, 1367]$, $(1367, 1482]$, $(1482, 2953]$, $(2953, \max]$

Data Sources: Prices from Mar/Sep 2008 online catalogues of clothing manufacturer Mango. Exchange rates for Mar/Sep, Aug/Feb, and Jan/Jul 2008 from ECB. DHL Express shipping zones from DHL Spain Online. Distance from CEPII. Bilateral trade and gross output for "Textiles, textile products, leather and footwear" industry for 2006 from Stats.OECD.

Table 5: Benchmark Instrumental Variable (2SLS) Estimation, 18 Countries

First-Stage Regression

F(3,3057)	$\hat{\beta}^{FS}_{prod}$ (s.e.)	$\hat{\beta}^{FS}_\lambda$ (s.e.)	$\hat{\beta}^{FS}_\tau$ (s.e.)
129.97	0.5708***	0.0203	0.0215
	(0.0434)	(0.0474)	(0.0393)

Instrumental Variables (2SLS) Regression

Exchange Rate	$\hat{\beta}_w$ (s.e.)	$\hat{\beta}_\lambda$ (s.e.)	$\hat{\beta}_\tau$ (s.e.)
Mar/Sep	0.0590**	-0.0587*	0.0080
	(0.0255)	(0.0324)	(0.0246)
Feb/Aug	0.0627***	-0.0557*	0.0104
	(0.0244)	(0.0321)	(0.0246)
Jan/Jul	0.0570**	-0.0558*	0.0105
	(0.0244)	(0.0322)	(0.0248)

* significance at 10% level, ** significance at 5% level, *** significance at 1%-level

Price regressions: N. Obs 3060, Country clusters 17 (Spain is numéraire).

Distance Intervals for Gravity (in km): $[0, 501]$, $(501, 1367]$, $(1367, 1482]$, $(1482, 2953]$, $(2953, \max]$

Data Sources: Prices from Mar/Sep 2008 online catalogues of clothing manufacturer Mango. Exchange rates for Mar/Sep, Aug/Feb, and Jan/Jul 2008 from ECB. DHL Express shipping zones from DHL Spain Online. Distance from CEPII. Bilateral trade, gross output, value added (in volumes), and number of persons employed for "Textiles, textile products, leather and footwear" industry for 2006 from Stats.OECD.

The results from the OLS regression that uses the estimated trade barriers adjusted by the error terms are reported in Table 4. The estimated elasticity of price with respect to per-capita income, $\hat{\beta}_w$, is roughly 0.06. Across the different exchange-rate specifications, the estimate lies within a tight range of 0.0580 to 0.0623.

Table 5 reports the results from the two stages of the 2SLS estimation. $\hat{\beta}^{FS}$ represents the vector of coefficient estimates from the first stage of the 2SLS regression, where per-capita income is the endogenous covariate and labor productivity is the instrument. In theory, labor productivity is a good instrument because it is assumed to be exogenous to the model. The results from the first stage of the estimation suggest that productivity is indeed a strong instrument. More importantly, once again, the estimate of the price elasticity is roughly 0.06. Across the different exchange-rate specifications the estimate ranges between 0.0570 and 0.0627.

4.3.6 Robustness

While distance is a critical determinant of the cost to ship a product, international trade barriers may reflect additional geographic characteristics of countries. For robustness purposes, I expand the trade-barrier specification in (28) as follows

$$\log \tau_{ij} = d_k + d_b + d_c + d_l + d_o + \delta_{ij}. \tag{30}$$

Among the new variables, d_b quantifies the effect of sharing a border, d_c captures the effect of having coastal access, d_l quantifies the effect of sharing a common language, and d_o captures the effect of having common legal origin. Each variable takes on the value of one if the statement applies to a pair of countries and zero otherwise.

Table 12 in Appendix D reports the results from the gravity estimation, which yields an R-squared of 0.8781. Compared to the benchmark, the richer trade-cost specification marginally improves the fit of the gravity equation. Once again, the residuals vary systematically with countries' per-capita incomes. An OLS regression of the residuals of Spanish exports on the log of per-capita income of the destination, relative to Spain, and a constant term yields a slope coefficient estimate of -0.6989 with a t-statistic of -2.30 (see Table 9 in Appendix D).

Table 13 in the same Appendix summarizes the results from an OLS estimation of the price elasticity that includes the error-adjusted trade barriers from (30). The estimated elasticity of price with respect to per-capita income varies between 0.0652 and 0.0701. The estimates are somewhat higher than the benchmark estimates reported above. Table 14 in the same appendix reports the results from the 2SLS estimation which uses labor productivity as instrument. The coefficient estimates on per-capita income are similar and they lie within the range of 0.0722 and 0.0776.

Finally, in Appendix C.2, I introduce destination-specific sales taxes into the benchmark model and I derive an augmented testable prediction that accounts for cross-country tax variation. The estimates of $\hat{\beta}_w$ remain unchanged, while the coefficients on taxes are not statistically different from zero, which suggests that sales-tax variation is not responsible for the systematic price variation.

4.4 Discussion on the Importance of Variable Mark-ups

Across the various empirical exercises, the estimates of the elasticity of price with respect to per-capita income range between 0.0570 and 0.0776. The mean and the median among the eighteen estimates amount to 0.0635 and 0.0619, respectively, or roughly six percent. Notice that these estimates compare favorably to the estimates of the price elasticity obtained from the non-structural econometric model that aimed to test the three frameworks in Section 4.2. This serves as evidence in support of the choice of the econometric model that was used to test the different explanations of varying demand elasticities.

Overall, it is reasonable to conclude that doubling a country's per-capita income results in at least a six-percent rise in the price level of tradable apparel products due to variable mark-ups. Does this mean that variable mark-ups are important in accounting for the observed differences in prices of tradables across countries?

A simple way to answer this question is to compare the elasticity estimates arising from the exercises above to estimates obtained from aggregate data. The existing literature typically uses data from the International Comparison Program (ICP) in order to study the relationship between prices of tradables and per-capita income (see Hsieh and Klenow (2007) and Alessandria and Kaboski (2011) for example). Following this literature, I obtain the latest ICP data for the year 2005, which includes prices of aggregate good categories, or basic headings, collected in retail locations across countries. In these data, prices potentially differ across countries due to variable mark-ups (as argued in this paper), varying product quality (perhaps due to non-homothetic preferences over quality as in Verhoogen (2008) and Fajgelbaum et al. (2011)), and varying retail components tied to non-tradable channels (as in Burstein et al. (2003) and Crucini and Yilmazkuday (2009)).

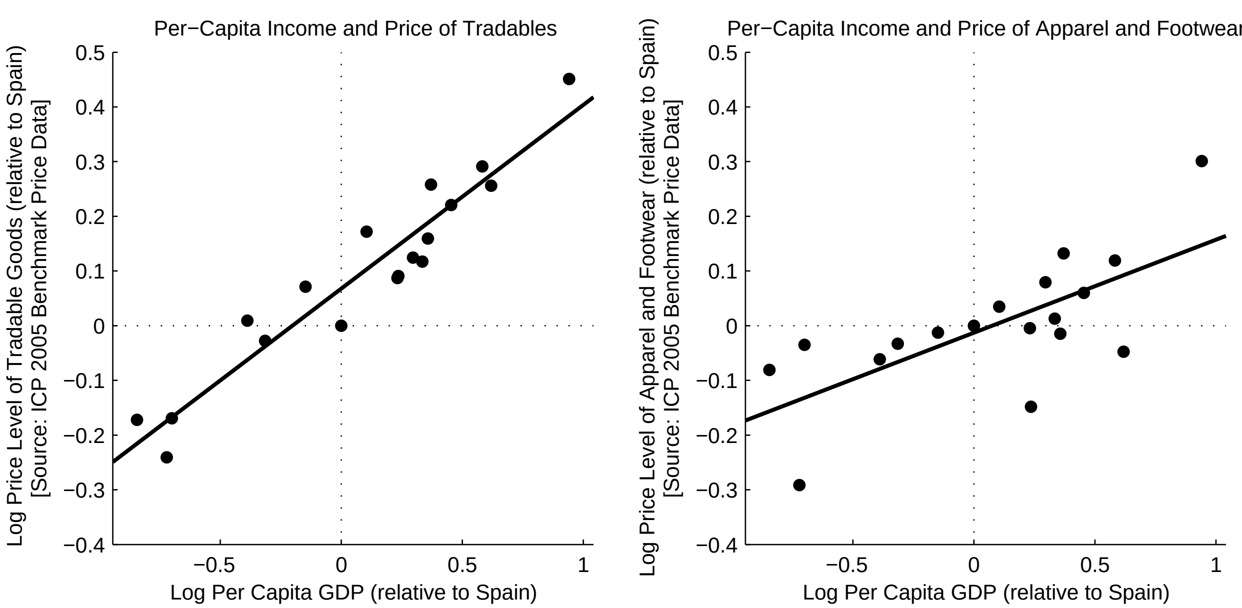

Figure 1: Per-Capita Income and Prices

In the left panel of Figure 1 I plot the price levels of tradables against the per-capita incomes of the countries in Table 1. Following the literature, I compute the price level of tradables as the geometric average of prices of basic headings that correspond to tradable good categories. Clearly, prices of tradables are higher in countries with higher per-capita incomes. A linear regression of logged price levels of tradables, relative to Spain, on a constant and logged per-capita incomes, relative to Spain, yields a slope coefficient of 0.3361 and a t-statistic of 12.85 (see Table 10 in Appendix D). This result is robust in the literature. Hsieh and Klenow (2007) and Alessandria and Kaboski (2011) find an elasticity of 0.3 using the 1996 ICP data across a large set of countries.

The observations in the left panel of the figure, however, span across industries, so it is difficult to relate them to the statistics obtained in this paper. For this reason, in the right panel of the figure, I plot the geometric average of prices of basic headings corresponding to apparel, footwear, and accessories. A linear regression of logged prices of these products on logged per-capita income and a constant yields a slope coefficient of 0.17 and a t-statistic of 13.85 (again see Table 10).

One simple way to assess the importance of variable mark-ups is to compare the slope coefficient estimate of 0.17 with the estimate of 0.06, which resulted from the structural analysis that used prices of identical products in the same industry across the same set of countries. The difference in magnitudes suggests that variable mark-ups may be responsible for roughly a third of the observed variation in prices of apparel across countries. So, while mark-ups are potentially important, combining a price-discrimination mechanism with theories of varying product quality and non-tradable distribution channels would allow one to obtain a complete picture of the cross-country behavior of prices of tradables and to quantitatively assess consumers' welfare gains from trade.

5 Conclusion

In this paper, I argue that firms' variable mark-ups represent a key contributor to the empirically documented regularity that final tradable goods' prices are systematically positively related to countries' per-capita incomes. I outline a parsimonious and highly tractable heterogeneous-firm model of international trade that relates prices of tradable goods to per-capita income differences. I present direct support for the model's mechanism, which builds on non-homothetic consumer preferences, from a unique database that features prices of identical apparel products sold via the Internet. Finally, I use the model's testable prediction to structurally estimate the elasticity of price with respect to per-capita income and to assess the importance of variable mark-ups.

On a broader scale, this paper emphasizes the role that income differences play in shaping cross-country price variations in tradable consumption goods as well as in determining aggregate consumption patterns. Since tradable goods account for an ever increasing portion of consumption bundles of individuals, their prices directly affect consumer welfare. Hence, having obtained an understanding of one of the key mechanisms that affect the behavior of prices across countries, we can further pursue the measurement of welfare of consumers in an integrated world economy.

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A Appendix: Consumer Problem and Equilibrium

A.1 Deriving Consumer Demand

The maximization problem of a consumer in j, potentially buying varieties from $i = 1, ..., I$ is

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

where ν_j is the Lagrange multiplier. The FOCs yield ($\forall q^c_{ij}(\omega) > 0$)

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

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

For any pair of varieties $\omega_{ij}, \omega'_{\upsilon j} \in \Omega_j$, (a.1) gives

$$p_{ij}(\omega)\left(q^c_{ij}(\omega) + \bar{q}\right) = p_{\upsilon j}(\omega')\, q^c_{\upsilon j}(\omega') + p_{\upsilon j}(\omega')\, \bar{q}.$$

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 $\omega_{ij} \in \Omega_j$

$$\begin{aligned}
\int_{\Omega_j} \left[p_{ij}(\omega)\left(q^c_{ij}(\omega) + \bar{q}\right)\right] d\omega' &= \int_{\Omega_j} \left[p_{\upsilon j}(\omega')\, q^c_{\upsilon j}(\omega') + p_{\upsilon j}(\omega')\, \bar{q}\right] d\omega', \\
\Rightarrow \left[p_{ij}(\omega)\left(q^c_{ij}(\omega) + \bar{q}\right)\right] \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}} 1 d\omega' &= \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}} \left[p_{\upsilon j}(\omega')\, q^c_{\upsilon j}(\omega') + p_{\upsilon j}(\omega')\, \bar{q}\right] d\omega', \\
\Rightarrow \left[p_{ij}(\omega)\left(q^c_{ij}(\omega) + \bar{q}\right)\right] \sum_{\upsilon=1}^{I} N_{\upsilon j} &= y_j + \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}} p_{\upsilon j}(\omega')\, \bar{q} d\omega', \\
\Rightarrow \left[p_{ij}(\omega)\left(q^c_{ij}(\omega) + \bar{q}\right)\right] N_j &= y_j + \bar{q} P_j, \\
\Rightarrow q^c_{ij}(\omega) &= \frac{y_j + \bar{q} P_j}{N_j p_{ij}(\omega)} - \bar{q},
\end{aligned}$$

where $P_j \equiv \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}} p_{\upsilon j}(\omega')\, d\omega'$ is an aggregate price statistic.

The total demand for variety ω from i by consumers in j becomes

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

A.2 Equilibrium: Characterization, Existence, and Uniqueness

In this section, I rely on the Pareto distribution of firm productivities and characterize the equilibrium objects of the model. I express all objects in terms of wages and I derive a set of equations that solve for the wage rates of all countries simultaneously. I use υ as a counter throughout.

Using the optimal price (11), the measure of firms (12), and the conditional density (13) under the Pareto distribution in (14) yields

$$P_j = \sum_{\upsilon=1}^{I} J_\upsilon \left(\frac{b_\upsilon}{\phi^*_{\upsilon j}} \right)^\theta \int_{\phi^*_{\upsilon j}}^{\infty} \frac{\tau_{\upsilon j} w_\upsilon}{\left(\phi \phi^*_{\upsilon j}\right)^{\frac{1}{2}}} \frac{\theta \left(\phi^*_{\upsilon j}\right)^\theta}{\phi^{\theta+1}} d\phi = \sum_{\upsilon=1}^{I} J_\upsilon \left(\frac{b_\upsilon}{\phi^*_{\upsilon j}} \right)^\theta \frac{\tau_{\upsilon j} w_\upsilon}{\phi^*_{\upsilon j}} \frac{\theta}{\theta + 0.5}. \tag{a.2}$$

Then, using (2), (10), and (12) into (a.2) gives

$$P_j = \frac{2\theta w_j}{\bar{q}}. \tag{a.3}$$

Moreover, using (a.3) and (10) into (2) yields

$$N_j = \left[\left(\frac{(1+2\theta) w_j}{\bar{q}} \right)^\theta \sum_{\upsilon=1}^{I} \frac{J_\upsilon b_\upsilon^\theta}{\left(\tau_{\upsilon j} w_\upsilon\right)^\theta} \right]^{\frac{1}{\theta+1}}. \tag{a.4}$$

Substituting (a.3) and (a.4) into (10) gives the following expression for the cutoff productivity

$$\phi^*_{ij} = \tau_{ij} w_i \left[\frac{\bar{q} \sum_{\upsilon=1}^{I} J_\upsilon b_\upsilon^\theta (\tau_{\upsilon j} w_\upsilon)^{-\theta}}{(1+2\theta) w_j} \right]^{\frac{1}{\theta+1}}. \tag{a.5}$$

In order to solve the model, it is necessary to jointly determine the wages, w_i, and the measures of entrants, J_i, $\forall i$. The system of equilibrium equations consists of the free entry condition, (16), and the income/spending equality, (17), for each country.

Free entry requires that average profits cover the fixed cost of entry, so

$$w_i f_e = \sum_{\upsilon=1}^{I} \left(\frac{b_i}{\phi^*_{i\upsilon}} \right)^\theta \frac{\bar{q} \tau_{i\upsilon} w_i L_\upsilon}{\phi^*_{i\upsilon} (\theta+1)(2\theta+1)}. \tag{a.6}$$

The income/spending identity requires that country i's consumers spend their entire income on imported and domestically-produced varieties, so

$$w_i L_i = \sum_{\upsilon=1}^{I} J_i \left(\frac{b_i}{\phi^*_{i\upsilon}}\right)^{\theta} \frac{\bar{q}\tau_{i\upsilon} w_i L_\upsilon}{\phi^*_{i\upsilon}(2\theta+1)}. \tag{a.7}$$

Expressions (a.6) and (a.7) yield

$$J_i = L_i[(\theta+1)f_e]^{-1}. \tag{a.8}$$

Substituting (a.8) into (a.5) yields expression (18) for the cutoff productivity in the text, where the terms in the summation that are particular to country j are emphasized for expositional purposes.

To characterize wages, use the definition for import shares (25) and trade balance $\sum_j T_{ij} = \sum_j T_{ji}$ in the definition of income/spending (17) to express income as $w_i L_i = \sum_j T_{ij} = \sum_j w_j L_j \lambda_{ij}$. Finally, in this expression, substitute out import shares using (25) to obtain

$$\frac{w_i^{\theta+1}}{b_i^{\theta}} = \sum_{j=1}^{I} \left(\frac{L_j w_j}{\tau_{ij}{}^{\theta} \sum_{\upsilon=1}^{I} L_\upsilon b_\upsilon^{\theta} (\tau_{\upsilon j} w_\upsilon)^{-\theta}} \right). \tag{a.9}$$

(a.9) implicitly solves for the wage rate w_i for each country i as a function of the remaining countries' wages. Rearrange (a.9) and use it to define

$$Z_i(w) \equiv \frac{b_i^{\theta}}{w_i^{\theta+1}} \sum_{j=1}^{I} \left(\frac{L_j w_j}{\tau_{ij}{}^{\theta} \sum_{\upsilon=1}^{I} L_\upsilon b_\upsilon^{\theta} (\tau_{\upsilon j} w_\upsilon)^{-\theta}} \right) - 1.$$

$Z_i(w)$ is the i-th contribution to the system of I equations that characterizes the equilibrium wage vector. Equilibrium wages satisfy $Z_i(w) = 0$ $(\forall i)$. It is straightforward to show that there exists a unique equilibrium wage vector that satisfies the system equality, after setting one w_i to be a numéraire (see Alvarez and Lucas (2007)). The idea is to treat the system above as an aggregate excess demand function of an exchange economy. For existence, it suffices to verify that the system satisfies properties 1-5 listed in Proposition 17.B.2 of Mas-Colell et al. (1995), p. 581. Existence follows from Proposition 17.C.1 of Mas-Colell et al. (1995), p. 585, which is essentially a reference to Kakutani's fixed point theorem. For uniqueness, notice that the system has the gross substitution property (differential version of Definition 17.F.2 in Mas-Colell et al. (1995), p. 612), $\forall i, k, k \neq i, \partial Z_i(w)/\partial w_k > 0$, and the result follows from Proposition 17.F.3 of Mas-Colell et al. (1995), p. 613.

When gross substitution holds, comparative static exercises with respect to wages are straightforward. Let $B \equiv \{\tau_{ij}, L_j, b_i, \theta\}_{i,j=1,\ldots,I}$ denote the set of relevant parameters. Then the equilibrium system can be written as $Z(w; B)$. Let w^* be the unique wage vector corresponding to B^*; $Z(w^*; B^*) = 0$. WLOG, consider a positive productivity shock in country I, namely a rise in b_I.

To determine the effect on wages, I need to characterize $Dw(B^*)$. By Implicit Function Theorem,

$$Dw(B^*) = -[D_w Z(w^*; B^*)]^{-1} D_B Z(w^*; B^*).$$

Since the system has the gross substitution property, Proposition 17.G.3 in Mas-Colell et al. (1995), p. 618, ensures that $[D_w Z(w^*; B^*)]^{-1}$ has all its entries negative. Moreover, differentiation shows that $D_B Z(w^*; B^*) db_I << 0$ for the first $I-1$ countries (and therefore the sign is positive for country I). Then, $Dw(B^*) db_I << 0$ for the first $I-1$ countries. Hence, a positive productivity shock in I lowers the wages of all countries relative to I; or, it raises I's relative wage. A more detailed proof is beyond the scope of the paper and is available upon request.

A.3 Comparative Statics and Proofs of Propositions

In this section, I show how productivity thresholds vary with respect to destinations' per-capita incomes and sizes. I maintain the ceteris paribus assumption and I consider changes in one market characteristic at a time, holding all other objects fixed.

The analysis is in the spirit of Hummels and Lugovskyy (2009), who choose the parameters of their model so that wages across countries are identical and fixed, and per-capita income differences reflect labor-efficiency differences. I conduct a similar exercise, however, I fix efficiency levels and consider changes in per-capita incomes that occur due to changes in wages.

Since prices are inversely related to thresholds, it is sufficient to show how thresholds change with market characteristics and take the opposite sign.

Differentiating (18) with respect to w_j, while keeping all other objects fixed, yields

$$\frac{\partial \phi_{ij}^*}{\partial w_j} = -\frac{\bar{q}^{\frac{1}{\theta+1}} \tau_{ij} w_i}{[(\theta+1) f_e (1+2\theta)]^{\frac{1}{\theta+1}}} \left[\frac{L_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+1}} + \sum_{v \neq j} \frac{L_v b_v^\theta}{w_j \left(\tau_{vj} w_v\right)^\theta} \right]^{-\frac{\theta}{\theta+1}} \left[\frac{L_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \frac{1}{\theta+1} \sum_{v \neq j} \frac{L_v b_v^\theta}{w_j^2 \left(\tau_{vj} w_v\right)^\theta} \right] < 0.$$

Differentiating (18) with respect to L_j, while keeping all other objects fixed, yields

$$\frac{\partial \phi_{ij}^*}{\partial L_j} = \frac{\bar{q}^{\frac{1}{\theta+1}} \tau_{ij} w_i}{[(\theta+1) f_e (1+2\theta)]^{\frac{1}{\theta+1}}} \left[\frac{L_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+1}} + \sum_{v \neq j} \frac{L_v b_v^\theta}{w_j \left(\tau_{vj} w_v\right)^\theta} \right]^{-\frac{\theta}{\theta+1}} \frac{1}{\theta+1} \frac{b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+1}} > 0.$$

Clearly, the threshold is falling in the destination's per-capita income and rising in the destination's size. From expression (11), the opposite must be true for the price of a variety.

Proof of Proposition 1. Consider expression (22), which represents the price of variety ϕ from i in destination j relative to k, $k \neq j$. Since I can always relabel countries, without loss of generality, consider an increase in w_j, keeping w_k fixed. The goal is to show that $\partial(p_{ij}(\phi)/p_{ik}(\phi))/\partial w_j > 0$. From (22), it suffices to show that $\partial(\phi_{ij}^*/\phi_{ik}^*)/\partial w_j < 0$.

Using expression (18) for destination j and rewriting the sum in (18) for destination k so as to isolate the j-term yields

$$\frac{\phi_{ij}^*}{\phi_{ik}^*} = \frac{\tau_{ij}}{\tau_{ik}} \left[\frac{\frac{L_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+1}} + \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{w_j (\tau_{\upsilon j} w_\upsilon)^\theta}}{\frac{L_j b_j^\theta}{w_k \tau_{jk}^\theta w_j^\theta} + \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{w_k (\tau_{\upsilon k} w_\upsilon)^\theta}} \right]^{\frac{1}{\theta+1}} . \tag{a.10}$$

Differentiating (a.10) with respect to w_j yields

$$\frac{\partial(\phi_{ij}^*/\phi_{ik}^*)}{\partial w_j} = \frac{\frac{\tau_{ij}}{\tau_{ik}} \frac{1}{\theta+1}}{\left[\frac{L_j b_j^\theta}{w_k \tau_{jk}^\theta w_j^\theta} + \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{w_k (\tau_{\upsilon k} w_\upsilon)^\theta} \right]^2} \left[\frac{\frac{L_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+1}} + \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{w_j (\tau_{\upsilon j} w_\upsilon)^\theta}}{\frac{L_j b_j^\theta}{w_k \tau_{jk}^\theta w_j^\theta} + \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{w_k (\tau_{\upsilon k} w_\upsilon)^\theta}} \right]^{\frac{1}{\theta+1}-1} \left[-\frac{L_j^2 b_j^{2\theta}}{\tau_{jj}^\theta w_k w_j^{2\theta+2} \tau_{jk}^\theta} \dots \right.$$
$$\dots - \frac{L_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2} w_k} \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon k} w_\upsilon)^\theta} - \frac{L_j b_j^\theta}{w_k w_j^{\theta+2} \tau_{jk}^\theta} \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon j} w_\upsilon)^\theta} - \frac{1}{w_k w_j^2} \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon j} w_\upsilon)^\theta} \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon k} w_\upsilon)^\theta} \dots$$
$$\left. \dots - \theta \frac{L_j b_j^\theta}{w_j^{\theta+2} w_k} \left\{ \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{(\tau_{jj} \tau_{\upsilon k} w_\upsilon)^\theta} - \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon j} \tau_{jk} w_\upsilon)^\theta} \right\} \right] . \tag{a.11}$$

A sufficient condition for (a.11) to be strictly negative is that the term in the curly bracket is non-negative. Since, by assumption $\tau_{jj} = 1$ $(\forall j)$, the term in the curly bracket is non-negative when trade barriers obey the triangle inequality, $(\forall j, k, \upsilon) \tau_{\upsilon j} \tau_{jk} \geq \tau_{\upsilon k}$. □

Proof of Proposition 2. Consider expression (22), which represents the price of variety ϕ from i in destination j relative to k, $k \neq j$. Since I can always relabel countries, without loss of generality, consider an increase in L_j, keeping L_k fixed. The goal is to show that $\partial(p_{ij}(\phi)/p_{ik}(\phi))/\partial L_j < 0$. From (22), it suffices to show that $\partial(\phi_{ij}^*/\phi_{ik}^*)/\partial L_j > 0$.

Differentiating (a.10) with respect to L_j yields

$$\frac{\partial(\phi_{ij}^*/\phi_{ik}^*)}{\partial L_j} = \frac{\frac{\tau_{ij}}{\tau_{ik}} \frac{1}{\theta+1}}{\left[\frac{L_j b_j^\theta}{w_k \tau_{jk}^\theta w_j^\theta} + \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{w_k (\tau_{\upsilon k} w_\upsilon)^\theta} \right]^2} \left[\frac{\frac{L_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+1}} + \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{w_j (\tau_{\upsilon j} w_\upsilon)^\theta}}{\frac{L_j b_j^\theta}{w_k \tau_{jk}^\theta w_j^\theta} + \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{w_k (\tau_{\upsilon k} w_\upsilon)^\theta}} \right]^{\frac{1}{\theta+1}-1} \dots$$
$$\dots \frac{b_j^\theta}{w_j^{\theta+1} w_k} \left\{ \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{(\tau_{jj} \tau_{\upsilon k} w_\upsilon)^\theta} - \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon j} \tau_{jk} w_\upsilon)^\theta} \right\} . \tag{a.12}$$

A sufficient condition for (a.12) to be strictly positive is that the term in the curly bracket is strictly positive. Since, by assumption $\tau_{jj} = 1$ $(\forall j)$, the term in the curly bracket is strictly positive when the trade barriers for j and k obey the triangle inequality, $(\forall \upsilon) \tau_{\upsilon j} \tau_{jk} \geq \tau_{\upsilon k}$, and when the inequality for at least one $\upsilon \neq j$ is strict. □

B Appendix: Linear Demand in General Equilibrium

In this section, I characterize the equilibrium of a heterogeneous-firm model of international trade with linear demand à la Melitz and Ottaviano (2008). I assume that the market structure is identical to the one in the main body of the paper, so I let per-capita income equal the wage rate.

The maximization problem of a consumer in country j is

$$\max_{q_j^c(\omega)\geq 0} \int_{\omega\in\Omega_j} q_j^c(\omega)d\omega - \frac{1}{2}\alpha \int_{\omega\in\Omega_j} (q_j^c(\omega))^2 d\omega - \frac{1}{2}\eta \left(\int_{\omega\in\Omega_j} q_j^c(\omega)d\omega \right)^2 \text{ s.t. } \nu_j \left[\int_{\omega\in\Omega_j} p_j(\omega) q_j^c(\omega) d\omega \leq w_j \right],$$

where η and α are positive parameters, and high values of α make the varieties less substitutable. Taking the ratio of FOCs for a pair of varieties and integrating out ν_j yields individual demand for $q_{ij}^c(\omega) > 0$

$$q_{ij}^c(\omega) = \frac{1}{\alpha P_j} \left[P_j(1 - \eta Q_j^c) - p_{ij}(\omega)(N_j - \alpha Q_j^c - \eta Q_j^c N_j) \right], \tag{b.1}$$

where $Q_j^c \equiv \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}} q_{\upsilon j}^c(\omega')\, d\omega'$ is an aggregate demand statistic for a consumer. In the above expression, aggregate statistics P_j and N_j are defined in (3) and (2), respectively. The total demand from country j is simply the product of individual demand (b.1) and country size L_j.

After relabeling a variety by the productivity and the country of origin of the firm that produces it, I use (b.1) in the firm problem in (6) and maximize with respect to price to obtain

$$p_{ij}(\phi) = \frac{1}{2} \left(\frac{\tau_{ij} w_i}{\phi} + \frac{P_j(1 - \eta Q_j^c)}{N_j - \alpha Q_j^c - \eta Q_j^c N_j} \right). \tag{b.2}$$

To characterize the cutoff productivity $\bar{\phi}_{ij}$ combine zero-demand and zero-profit to obtain

$$\bar{\phi}_{ij} = \frac{\tau_{ij} w_i (N_j - \alpha Q_j^c - \eta Q_j^c N_j)}{P_j(1 - \eta Q_j^c)}. \tag{b.3}$$

Substituting (b.3) into (b.2) yields the following pricing rule

$$p_{ij}(\phi) = \frac{\tau_{ij} w_i}{2} \left[\frac{1}{\phi} + \frac{1}{\bar{\phi}_{ij}} \right], \tag{b.4}$$

Next, I modify the steps in Appendix A.2 to characterize the equilibrium in the present model. After relabeling varieties, substitute (b.4) into (b.1) and use (b.1) in the definition of Q_j^c to obtain

$$Q_j^c = \frac{N_j}{2\alpha(\theta + 1) + \eta N_j}, \tag{b.5}$$

where $N_j \equiv \sum_{\upsilon=1}^{I} J_\upsilon b_\upsilon^\theta \bar{\phi}_{\upsilon j}^{-\theta}$. Then, using the optimal price from (b.4) in the price index P_j yields

$$P_j = \frac{2\theta + 1}{2\theta + 2} \frac{w_j}{\bar{\phi}_{jj}} N_j.$$

To solve the model, it is necessary to jointly determine wages, w_i, and measures of entrants, J_i, $\forall i$. The system of equilibrium equations consists of a free entry condition and an income/spending equality for each country. Free entry requires that average profits cover the fixed cost of entry, so

$$w_i f_e = \sum_{v=1}^{I} \frac{b_i^\theta}{\bar{\phi}_{iv}^\theta} \frac{L_v(1 - \eta Q_v^c)}{2\alpha(\theta + 1)(\theta + 2)} \frac{\tau_{iv} w_i}{\bar{\phi}_{iv}}. \tag{b.6}$$

The income/spending identity requires that country i's consumers spend their entire income on imported and domestically-produced varieties, so

$$w_i L_i = \sum_{v=1}^{I} J_i \frac{b_i^\theta}{\bar{\phi}_{iv}^\theta} \frac{L_v(1 - \eta Q_v^c)}{2\alpha(\theta + 2)} \frac{\tau_{iv} w_i}{\bar{\phi}_{iv}}. \tag{b.7}$$

Expressions (b.6) and (b.7) yield

$$J_i = L_i[(\theta + 1) f_e]^{-1}. \tag{b.8}$$

Substituting (b.8) and (b.5) in (b.7) for country j obtains the following characterization of cutoffs

$$\frac{\theta + 1}{\theta + 2} = \frac{\eta w_j \bar{\phi}_{ij}}{w_i \tau_{ij}} + \frac{2\alpha(\theta + 1)^2 f_e w_j (\bar{\phi}_{ij})^{\theta+1}}{(\tau_{ij} w_i)^{\theta+1} \sum_{v=1}^{I} L_v b_v^\theta (\tau_{vj} w_v)^{-\theta}}. \tag{b.9}$$

Finally, to characterize wages, first derive import shares, which are identical to the model in the main text and are given by (25). Together with trade balance $\sum_j T_{ij} = \sum_j T_{ji}$, substitute them into the income/spending equality (b.7) to arrive at

$$\frac{w_i^{\theta+1}}{b_i^\theta} = \sum_{j=1}^{I} \left(\frac{L_j w_j}{{\tau_{ij}}^\theta \sum_{v=1}^{I} L_v b_v^\theta (\tau_{vj} w_v)^{-\theta}} \right). \tag{b.10}$$

(b.10) implicitly solves for the wage rate w_i for each country i as a function of the remaining countries' wages.

It is straightforward to verify that the price of a variety is increasing in a destination's per-capita income and falling in a destination's market size. From the pricing rule in (b.4), notice that it is sufficient to examine how productivity cutoffs vary with destination-specific characteristics.

Using the implicit function theorem and the characterization of thresholds in (b.9) yields

$$\frac{\partial \bar{\phi}_{ij}}{\partial w_j} = -\left[\frac{ \frac{\eta \bar{\phi}_{ij}}{\tau_{ij} w_i} + \frac{2\alpha(\theta+1)^2 f_e (\bar{\phi}_{ij})^{\theta+1} \left[(\theta+1) L_j b_j^\theta (\tau_{jj} w_j)^{-\theta} + \sum_{\upsilon \neq j} L_\upsilon b_\upsilon^\theta (\tau_{\upsilon j} w_\upsilon)^{-\theta}\right]}{(\tau_{ij} w_i)^{\theta+1} \left[\sum_{\upsilon=1}^{I} L_\upsilon b_\upsilon^\theta (\tau_{\upsilon j} w_\upsilon)^{-\theta}\right]^2} }{ \frac{\eta w_j}{w_i \tau_{ij}} + \frac{2\alpha(\theta+1)^3 f_e w_j (\bar{\phi}_{ij})^\theta}{(\tau_{ij} w_i)^{\theta+1} \sum_{\upsilon=1}^{I} L_\upsilon b_\upsilon^\theta (\tau_{\upsilon j} w_\upsilon)^{-\theta}} } \right] < 0,$$

$$\frac{\partial \bar{\phi}_{ij}}{\partial L_j} = \frac{ \frac{2\alpha(\theta+1)^2 f_e (\bar{\phi}_{ij})^{\theta+1} w_j b_j^\theta (\tau_{jj} w_j)^{-\theta}}{(\tau_{ij} w_i)^{\theta+1} \left[\sum_{\upsilon=1}^{I} L_\upsilon b_\upsilon^\theta (\tau_{\upsilon j} w_\upsilon)^{-\theta}\right]^2} }{ \frac{\eta w_j}{w_i \tau_{ij}} + \frac{2\alpha(\theta+1)^3 f_e w_j (\bar{\phi}_{ij})^\theta}{(\tau_{ij} w_i)^{\theta+1} \sum_{\upsilon=1}^{I} L_\upsilon b_\upsilon^\theta (\tau_{\upsilon j} w_\upsilon)^{-\theta}} } > 0.$$

Thresholds are falling in the per-capita income and rising in the size of the destination, so the opposite is true of the price of a variety. However, since prices feature additive mark-ups, it is not trivial to determine how the relative price of an identical variety behaves across countries.

C Appendix: Destination-Specific Sales Taxes

C.1 Robust Tests of Alternative Models

In this section, I demonstrate that cross-country variations in sales taxes are not a source of bias in the empirical tests of the three models discussed in the main body of the paper. I augment the econometric model in (23) by $\log[(1 + vat_j)/(1 + vat_s)]$, where vat_j (vat_s) is the percentage sales tax on apparel in j (Spain). I denote the coefficient for this variable by $\hat{\gamma}_{vat}$ in Table 6. Clearly, differences in sales taxes are not responsible for the systematic behavior of prices across countries, as the estimates for $\hat{\gamma}_{vat}$ are not statistically different from zero.

Table 6: Robust Test of Alternative Models (Sales Taxes), 18 Countries

Exchange Rate	$\hat{\gamma}_w$ (s.e.)	$\hat{\gamma}_L$ (s.e.)	$\hat{\gamma}_{c,1}$ (s.e.)	$\hat{\gamma}_{c,2}$ (s.e.)	$\hat{\gamma}_{c,3}$ (s.e.)	$\hat{\gamma}_{c,4}$ (s.e.)	$\hat{\gamma}_{vat}$ (s.e.)
Mar/Sep	0.0691**	-0.0257*	0.0052	0.2082***	0.2582***	0.2193***	-0.2455
	(0.0314)	(0.0137)	(0.0396)	(0.0175)	(0.0249)	(0.0569)	(0.4971)
Feb/Aug	0.0712**	-0.0236*	-0.0001	0.2054***	0.2515***	0.2168***	-0.0712
	(0.0304)	(0.0137)	(0.0398)	(0.0179)	(0.0255)	(0.0574)	(0.4894)
Jan/Jul	0.0647**	-0.0225	-0.0014	0.2076***	0.2549***	0.2186***	-0.0629
	(0.0304)	(0.0140)	(0.0401)	(0.0178)	(0.0259)	(0.0579)	(0.4901)

* significance at 10% level, ** significance at 5%-level, *** significance at 1%-level

Price regressions: N. Obs 3060, Country clusters 17 (Spain is numéraire), Fixed Effects 179 (relative to good 1)

Distance Intervals (in km): $[0, 501]$, $(501, 1367]$, $(1367, 1482]$, $(1482, 2953]$

Data Sources: Prices from Mar/Sep 2008 online catalogues of clothing manufacturer Mango. Exchange rates for Mar/Sep, Aug/Feb, and Jan/Jul 2008 from ECB. DHL Express shipping zones from DHL Spain Online. Distance from CEPII. Nominal per-capita GDP and population for 2007 from WDI. Apparel VAT from European Commission.

C.2 Model With Destination-Specific Sales Taxes

Suppose that the consumer in destination j pays a sales tax $vat_j > 0$. Let $\kappa_j \equiv 1 + vat_j$ be the gross sales tax. The maximization problem of a consumer in j, potentially buying varieties from $i = 1, ..., I$, is

$$\max_{\{q_{ij}^c(\omega)\}_{i=1}^I \geq 0} \quad \sum_{i=1}^I \int_{\omega \in \Omega_{ij}} \log(q_{ij}^c(\omega) + \bar{q}) d\omega \quad \text{s.t.} \quad \nu_j \left[\sum_{i=1}^I \int_{\omega \in \Omega_{ij}} \kappa_j p_{ij}(\omega) q_{ij}^c(\omega) d\omega \leq y_j \right].$$

Following the solution algorithm outlined in the text, one obtains the following relative pricing rule for a given variety across destinations j and k, in logs,

$$\log\left(\frac{p_{ij}(\phi)}{p_{ik}(\phi)}\right) = \underbrace{\frac{2\theta+1}{2(\theta+1)\theta}}_{\beta_\tau} \theta \log\left(\frac{\tau_{ij}}{\tau_{ik}}\right) + \underbrace{\frac{1}{2(\theta+1)}}_{\beta_w} \log\left(\frac{w_j}{w_k}\right) + \underbrace{\frac{1}{2(\theta+1)}}_{\beta_\lambda} \log\left(\frac{\lambda_{ij}}{\lambda_{ik}}\right) + \underbrace{\frac{2\theta+1}{2(\theta+1)}}_{\beta_\kappa} \log\left(\frac{\kappa_j}{\kappa_k}\right).$$

The pricing rule is augmented by a fourth object, which captures relative sales taxes.

I derive an econometric model from the pricing rule above and I estimate the coefficients using the two methodologies outlined in the text. I consider the benchmark trade-barrier specification in expression (28). The results from the estimation of the model augmented by gross sales taxes, expressed relative to Spain's tax, are reported in Tables 7 and 8. The coefficients on per-capita income are virtually unchanged relative to the benchmark estimates. Furthermore, the coefficients on sales taxes are not statistically different from zero. Thus, it cannot be concluded that sales taxes have any systematic effect on prices.

Table 7: Estimation With Error-Adjusted Trade Barriers and VAT, 18 Countries

Exchange Rate	$\hat{\beta}_w$ (s.e.)	$\hat{\beta}_\lambda$ (s.e.)	$\hat{\beta}_\tau$ (s.e.)	$\hat{\beta}_\kappa$ (s.e.)
Mar/Sep	0.0587*	-0.0214	0.0392**	-0.4122
	(0.0322)	(0.0248)	(0.0191)	(0.2548)
Feb/Aug	0.0616*	-0.0205	0.0389**	-0.2475
	(0.0308)	(0.0245)	(0.0189)	(0.2426)
Jan/Jul	0.0573*	-0.0230	0.0370*	-0.2379
	(0.0313)	(0.0251)	(0.0193)	(0.2443)

* significance at 10% level, ** significance at 5% level

Price regressions: N. Obs 3060, Country clusters 17 (Spain is numéraire).

Distance Intervals for Gravity (in km): $[0, 501]$, $(501, 1367]$, $(1367, 1482]$, $(1482, 2953]$, $(2953, \max]$

Data Sources: Prices from Mar/Sep 2008 online catalogues of clothing manufacturer Mango. Exchange rates for Mar/Sep, Aug/Feb, and Jan/Jul 2008 from ECB. DHL Express shipping zones from DHL Spain Online. Distance from CEPII. Bilateral trade and gross output for "Textiles, textile products, leather and footwear" industry for 2006 from Stats.OECD. Apparel VAT from European Commission.

Table 8: Instrumental Variable (2SLS) Estimation With VAT, 18 Countries

First-Stage Regression

F(4,3056)	$\hat{\beta}^{FS}_{prod}$ (s.e.)	$\hat{\beta}^{FS}_{\lambda}$ (s.e.)	$\hat{\beta}^{FS}_{\tau}$ (s.e.)	$\hat{\beta}^{FS}_{\kappa}$ (s.e.)
99.89	0.5691***	0.0082	0.0060	0.9161
	(0.0418)	(0.0503)	(0.0411)	(1.5691)

Instrumental Variables (2SLS) Regression

Exchange Rate	$\hat{\beta}_{w}$ (s.e.)	$\hat{\beta}_{\lambda}$ (s.e.)	$\hat{\beta}_{\tau}$ (s.e.)	$\hat{\beta}_{\kappa}$ (s.e.)
Mar/Sep	0.0601***	-0.0545*	0.0134	-0.3201
	(0.0251)	(0.0334)	(0.0267)	(0.4136)
Feb/Aug	0.0632***	-0.0537*	0.0131	-0.1538
	(0.0243)	(0.0336)	(0.0269)	(0.3985)
Jan/Jul	0.0575***	-0.0538	0.0131	-0.1532
	(0.0243)	(0.0337)	(0.0271)	(0.3931)

* significance at 10% level, *** significance at 1%-level

Price regressions: N. Obs 3060, Country clusters 17 (Spain is numéraire).

Distance Intervals for Gravity (in km): $[0, 501]$, $(501, 1367]$, $(1367, 1482]$, $(1482, 2953]$, $(2953, \max]$

Data Sources: Prices from Mar/Sep 2008 online catalogues of clothing manufacturer Mango. Exchange rates for Mar/Sep, Aug/Feb, and Jan/Jul 2008 from ECB. DHL Express shipping zones from DHL Spain Online. Distance from CEPII. Bilateral trade, gross output, value added (in volumes), and number of persons employed for "Textiles, textile products, leather and footwear" industry for 2006 from Stats.OECD. Apparel VAT from European Commission.

D Appendix: Supplementary Tables

Table 9: Trade-Barrier Measurement Error and Per-Capita Income

Trade-Barrier Specification	Log Per-Capita Income (s.e.)	Constant (s.e.)	R-squared	#Obs
Benchmark (28)	-0.6446	0.0535	0.1966	17
	(0.3365)	(0.1711)		
Alternative (30)	-0.6989	0.0580	0.2600	17
	(0.3044)	(0.1548)		

Table 10: Per-Capita Income and Price of Tradables, ICP 2005

Basic Headings	Log Per-Capita Income (s.e.)	Constant (s.e.)	R-squared
Tradables	0.3361	0.0680	0.9117
	(0.0261)	(0.0129)	
Apparel, Footwear, and Accessories	0.1700	-0.0127	0.4841
	(0.0439)	(0.0217)	

Table 11: Benchmark Gravity Estimates and Summary Statistics, 18 Countries

Exporter	$\hat{S}_i$	S.E.	Importer	$\hat{S}_j$	S.E.	Distance	$-\theta\hat{d}_k$	S.E.
Austria	1.2669	0.3220	Austria	−0.8595	0.2183	[0,501]	−2.6474	0.1510
Belgium	2.3998	0.3219	Belgium	−1.1046	0.2183	(501,1367]	−4.1112	0.0962
Estonia	−1.4263	0.3218	Estonia	−0.6516	0.2183	(1367,1482]	−4.3786	0.1816
Finland	−0.3959	0.3314	Finland	−0.7564	0.2218	(1482,2953]	−5.0042	0.0965
France	0.8026	0.3188	France	0.7302	0.2172	(2953, max]	−5.4053	0.4308
Germany	2.6148	0.3248	Germany	−0.1371	0.2194			
Greece	−0.6956	0.3266	Greece	0.4817	0.2201			
Hungary	−0.7645	0.3177	Hungary	0.0859	0.2168			
Ireland	−1.6676	0.3181	Ireland	−0.3286	0.2169			
Italy	1.1214	0.3163	Italy	1.8463	0.2163			
Norway	−2.2828	0.3151	Norway	−0.9115	0.2158			
Portugal	0.3171	0.3748	Portugal	1.1163	0.2385			
Slovakia	−1.3603	0.3200	Slovakia	0.2139	0.2176	Summary Statistics		
Slovenia	−2.6471	0.3172	Slovenia	0.9723	0.2166	No. Obs	306	
Spain	0.3151	0.3165	Spain	1.2501	0.2163	TSS	1588	
Sweden	1.3180	0.3165	Sweden	−1.5318	0.2163	SSR	221	
Switzerland	0.5571	0.3165	Switzerland	−0.8855	0.2163	σ^2	0.8293	
United Kingdom	0.5271	0.3189	United Kingdom	0.4699	0.2172	R-squared	0.8606	

Exporter and importer fixed effect coefficients satisfy $\sum_i \hat{S}_i = 0$ and $\sum_j \hat{S}_j = 0$, respectively.

Table 12: Alternative Gravity Estimates and Summary Statistics, 18 Countries

Exporter	$\hat{S}_i$	S.E.	Importer	$\hat{S}_j$	S.E.	Distance	$-\theta\hat{d}_k$	S.E.
Austria	2.1534	0.5007	Austria	−1.3027	0.2864	[0,501]	−3.8867	0.3027
Belgium	2.1425	0.3576	Belgium	−0.9992	0.2234	(501,1367]	−4.7033	0.1876
Estonia	−1.6300	0.3327	Estonia	−0.5730	0.2144	(1367,1482]	−4.8888	0.2406
Finland	−0.7262	0.3357	Finland	−0.6145	0.2155	(1482,2953]	−5.4765	0.2003
France	0.3808	0.3209	France	0.9179	0.2101	(2953, max]	−5.8567	0.4675
Germany	2.2640	0.3534	Germany	0.0151	0.2217			
Greece	−1.1644	0.3463	Greece	0.6929	0.2194	Border	0.6215	0.2345
Hungary	0.2682	0.5072	Hungary	−0.4304	0.2892	Coastal Access	0.8361	0.3333
Ireland	−1.9195	0.3358	Ireland	−0.2258	0.2150	Common Language	-0.0088	0.2751
Italy	0.5035	0.3295	Italy	2.1321	0.2130	Common Origin	0.3855	0.1623
Norway	−2.6121	0.3299	Norway	−0.7701	0.2129			
Portugal	−0.2114	0.3805	Portugal	1.3573	0.2339			
Slovakia	−0.2248	0.5013	Slovakia	−0.3539	0.2866	Summary Statistics		
Slovenia	−1.5477	0.5182	Slovenia	0.4227	0.2940	No. Obs	306	
Spain	−0.2036	0.3277	Spain	1.4863	0.2124	TSS	1588	
Sweden	1.1293	0.3222	Sweden	−1.4606	0.2104	SSR	194	
Switzerland	0.8110	0.3325	Switzerland	−0.7106	0.2283	σ^2	0.7364	
United Kingdom	0.5871	0.3363	United Kingdom	0.4166	0.2155	R-squared	0.8781	

Exporter and importer fixed effect coefficients satisfy $\sum_i \hat{S}_i = 0$ and $\sum_j \hat{S}_j = 0$, respectively.

Table 13: Alternative Estimation With Error-Adjusted Trade Barriers, 18 Countries

Exchange Rate	$\hat{\beta}_w$ (s.e.)	$\hat{\beta}_\lambda$ (s.e.)	$\hat{\beta}_\tau$ (s.e.)
Mar/Sep	0.0671**	-0.0118	0.0462***
	(0.0279)	(0.0181)	(0.0147)
Feb/Aug	0.0701***	-0.0095	0.0482***
	(0.0261)	(0.0176)	(0.0144)
Jan/Jul	0.0652**	-0.0111	0.0470***
	(0.0264)	(0.0179)	(0.0145)

** significance at 5% level, *** significance at 1%-level

Price regressions: N. Obs 3060, Country clusters 17 (Spain is numéraire).

Distance Intervals for Gravity (in km): $[0, 501]$, $(501, 1367]$, $(1367, 1482]$, $(1482, 2953]$, $(2953, \max]$

Data Sources: Prices from Mar/Sep 2008 online catalogues of clothing manufacturer Mango. Exchange rates for Mar/Sep, Aug/Feb, and Jan/Jul 2008 from ECB. DHL Express shipping zones from DHL Spain Online. Distance, border, language, and origin from CEPII. Bilateral trade and gross output for "Textiles, textile products, leather and footwear" industry for 2006 from Stats.OECD.

Table 14: Alternative Instrumental Variable (2SLS) Estimation, 18 Countries

First-Stage Regression

F(3,3057)	$\hat{\beta}^{FS}_{prod}$ (s.e.)	$\hat{\beta}^{FS}_\lambda$ (s.e.)	$\hat{\beta}^{FS}_\tau$ (s.e.)
112.44	0.5823***	0.0393	0.0379
	(0.0481)	(0.0454)	(0.0395)

Instrumental Variables (2SLS) Regression

Exchange Rate	$\hat{\beta}_w$ (s.e.)	$\hat{\beta}_\lambda$ (s.e.)	$\hat{\beta}_\tau$ (s.e.)
Mar/Sep	0.0732***	-0.0389*	0.0244
	(0.0261)	(0.0226)	(0.0185)
Feb/Aug	0.0776***	-0.0366*	0.0264
	(0.0255)	(0.0223)	(0.0185)
Jan/Jul	0.0722***	-0.0362*	0.0268
	(0.0249)	(0.0222)	(0.0185)

* significance at 10% level, *** significance at 1%-level

Price regressions: N. Obs 3060, Country clusters 17 (Spain is numéraire).

Distance Intervals for Gravity (in km): $[0, 501]$, $(501, 1367]$, $(1367, 1482]$, $(1482, 2953]$, $(2953, \max]$

Data Sources: Prices from Mar/Sep 2008 online catalogues of clothing manufacturer Mango. Exchange rates for Mar/Sep, Aug/Feb, and Jan/Jul 2008 from ECB. DHL Express shipping zones from DHL Spain Online. Distance, border, language, and origin from CEPII. Bilateral trade, gross output, value added (in volumes), and number of persons employed for "Textiles, textile products, leather and footwear" industry for 2006 from Stats.OECD.

Web Appendix for "Income Differences and Prices of Tradables" Alternative Test of Non-Homothetic and Ideal-Variety Models

In this section, I derive two predictions of the model introduced in this paper and I describe how they relate to the predictions of Hummels and Lugovskyy's (2009) ideal-variety model. I then test these predictions using the price data described in the main text.

To begin, the ideal-variety model predicts that the relative price of a variety is higher in markets with relatively higher per-capita incomes, after controlling for relative incomes. Intuitively, when one controls for total income—the product of per-capita income and market size—one disentangles the finickiness effect, which positively links prices to per-capita income, from the pro-competitive effect, which negatively links prices to market income. Since, overall, the model yields a negative relationship between relative prices and relative per-capita incomes, it must be the case that the model predicts that the (positive) elasticity of relative prices with respect to relative per-capita incomes falls short of the (negative) elasticity of relative prices with respect to relative incomes.

In order to understand how relative prices relate to relative incomes in the present model, it is sufficient to examine how relative thresholds vary. Multiplying and dividing the first term in the bracket in (18) by w_j allows one to relate the threshold in j to country j's total income, $Y_j \equiv w_j L_j$,

$$\phi^*_{ij} = \frac{\bar{q}^{\frac{1}{\theta+1}} \tau_{ij} w_i}{[(\theta+1) f_e (1+2\theta)]^{\frac{1}{\theta+1}}} \left[\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{w_j \left(\tau_{\upsilon j} w_\upsilon\right)^\theta} \right]^{\frac{1}{\theta+1}}. \tag{d.1}$$

Consider an increase in the income of destination j, Y_j, for a given level of per-capita income, w_j. Differentiating (d.1) with respect to Y_j, while keeping all other objects (including w_j) fixed, yields

$$\frac{\partial \phi^*_{ij}}{\partial Y_j} = \frac{\bar{q}^{\frac{1}{\theta+1}} \tau_{ij} w_i}{[(\theta+1) f_e (1+2\theta)]^{\frac{1}{\theta+1}}} \left[\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{w_j \left(\tau_{\upsilon j} w_\upsilon\right)^\theta} \right]^{-\frac{\theta}{\theta+1}} \frac{1}{\theta+1} \frac{b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} > 0. \tag{d.2}$$

The productivity threshold in (d.1) rises, thus lowering the mark-up in (11). Clearly, when one controls for a country's per-capita income, a rise in income must be driven by a rise in the country's population, which lowers the price of a variety.

Conversely, keep the total income fixed, and consider a rise in per-capita income. Differentiating (d.1) with respect to w_j, while keeping all other objects (including Y_j) fixed, yields

$$\frac{\partial \phi^*_{ij}}{\partial w_j} = - \frac{\bar{q}^{\frac{1}{\theta+1}} \tau_{ij} w_i}{[(\theta+1) f_e (1+2\theta)]^{\frac{1}{\theta+1}}} \left[\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{w_j \left(\tau_{\upsilon j} w_\upsilon\right)^\theta} \right]^{-\frac{\theta}{\theta+1}} \frac{1}{\theta+1} \cdots$$
$$\cdots \left[(\theta+2) \frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+3}} + \sum_{\upsilon \neq j} \frac{L_\upsilon b_\upsilon^\theta}{w_j^2 \left(\tau_{\upsilon j} w_\upsilon\right)^\theta} \right] < 0. \tag{d.3}$$

The productivity threshold in (d.1) falls, thus raising the mark-up in (11).

Finally, one can verify that the sum of the elasticities of thresholds with respect to per-capita income, w_j, and total income, Y_j, is negative. Using (d.2) and (d.1), the elasticity of ϕ^*_{ij} with respect to Y_j is

$$\frac{\partial \phi^*_{ij}}{\partial Y_j}\frac{Y_j}{\phi^*_{ij}} = \frac{\frac{1}{\theta+1}\left[\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}}\right]}{\left[\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_j(\tau_{\upsilon j} w_\upsilon)^\theta}\right]} > 0. \tag{d.4}$$

Using (d.3), (d.1), and (d.4), the elasticity of ϕ^*_{ij} with respect to w_j is

$$\frac{\partial \phi^*_{ij}}{\partial w_j}\frac{w_j}{\phi^*_{ij}} = -\frac{\frac{1}{\theta+1}\left[(\theta+2)\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_j(\tau_{\upsilon j} w_\upsilon)^\theta}\right]}{\left[\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_j(\tau_{\upsilon j} w_\upsilon)^\theta}\right]} = -(\theta+2)\frac{\partial \phi^*_{ij}}{\partial Y_j}\frac{Y_j}{\phi^*_{ij}} - \frac{\frac{1}{\theta+1}\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_j(\tau_{\upsilon j} w_\upsilon)^\theta}}{\left[\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_j(\tau_{\upsilon j} w_\upsilon)^\theta}\right]}.$$

Clearly, the sum of the elasticity of the threshold with respect to per-capita income and the elasticity of the threshold with respect to income is negative. Thus, in (11), the positive effects of per-capita income on prices dominate the negative effects caused by higher income.

A similar intuition applies to the relationship between relative prices and relative incomes of destinations, controlling for relative per-capita incomes. Proposition 3 summarizes the result.

Proposition 3. *For any two countries, j and k, $j \neq k$, if trade barriers obey the triangle inequality, $(\forall \upsilon)\tau_{\upsilon j}\tau_{jk} \geq \tau_{\upsilon k}$, and if the inequality for at least one $\upsilon \neq j$ is strict, then the relative price of a variety sold in markets j and k is strictly decreasing in the relative incomes of the markets, after controlling for the markets' relative per-capita incomes.*

Proof of Proposition 3. Consider expression (22), which represents the price of variety ϕ from i in destination j relative to k, $k \neq j$. Since I can always relabel countries, without loss of generality, consider an increase in Y_j, keeping w_j, and w_k and L_k (therefore also Y_k) fixed. The goal is to show that $\partial(p_{ij}(\phi)/p_{ik}(\phi))/\partial Y_j < 0$. From (22), it suffices to show that $\partial(\phi^*_{ij}/\phi^*_{ik})/\partial Y_j > 0$.

Using expression (d.1) for destination j and rewriting the sum in (d.1) for destination k so as to isolate the Y_j-term yields

$$\frac{\phi^*_{ij}}{\phi^*_{ik}} = \frac{\tau_{ij}}{\tau_{ik}}\left[\frac{\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_j(\tau_{\upsilon j} w_\upsilon)^\theta}}{\frac{Y_j b_j^\theta}{w_k\tau_{jk}^\theta w_j^{\theta+1}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_k(\tau_{\upsilon k} w_\upsilon)^\theta}}\right]^{\frac{1}{\theta+1}}. \tag{d.5}$$

Differentiating (d.5) with respect to Y_j yields

$$\frac{\partial(\phi^*_{ij}/\phi^*_{ik})}{\partial Y_j} = \frac{\frac{\tau_{ij}}{\tau_{ik}}\frac{1}{\theta+1}}{\left[\frac{Y_j b_j^\theta}{w_k \tau_{jk}^\theta w_j^{\theta+1}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_k(\tau_{\upsilon k}w_\upsilon)^\theta}\right]^2}\left[\frac{\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_j(\tau_{\upsilon j}w_\upsilon)^\theta}}{\frac{Y_j b_j^\theta}{w_k \tau_{jk}^\theta w_j^{\theta+1}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_k(\tau_{\upsilon k}w_\upsilon)^\theta}}\right]^{\frac{1}{\theta+1}-1} \cdots$$

$$\cdots \frac{b_j^\theta}{w_j^{\theta+2}w_k}\left\{\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{jj}\tau_{\upsilon k}w_\upsilon)^\theta} - \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon j}\tau_{jk}w_\upsilon)^\theta}\right\}. \tag{d.6}$$

A sufficient condition for (d.6) to be strictly positive is that the term in the curly bracket is strictly positive. Since, by assumption $\tau_{jj} = 1$ $(\forall j)$, the term in the curly bracket is strictly positive when the trade barriers for j and k obey the triangle inequality, $(\forall \upsilon)\tau_{\upsilon j}\tau_{jk} \geq \tau_{\upsilon k}$, and when the inequality for at least one $\upsilon \neq j$ is strict. □

Finally, Proposition 4 states the conditions under which the positive effect of relative per-capita income dominates the negative effect of relative income on relative prices. For a pair of countries, j and k, $j \neq k$, let $\zeta_{Y\,j,k}$ denote the elasticity of the relative price of any variety between j and k with respect to the relative incomes between j and k. Similarly, let $\zeta_{w\,j,k}$ denote the elasticity of the relative price between j and k with respect to the relative per-capita incomes of the markets.

Proposition 4. *If trade barriers obey the triangle inequality, $(\forall j,k,\upsilon)\tau_{\upsilon j}\tau_{jk} \geq \tau_{\upsilon k}$, then the relative price of a variety sold in two markets is strictly increasing in the relative per-capita incomes of the markets, after controlling for the markets' relative incomes. If in addition $\theta \geq 1$, then for any two countries, j and k, $j \neq k$, $\zeta_{Y\,j,k} + \zeta_{w\,j,k} > 0$.*

Proof of Proposition 4. Consider expression (22), which represents the price of variety ϕ from i in destination j relative to k, $k \neq j$. Since I can always relabel countries, without loss of generality, consider an increase in w_j, keeping Y_j, and w_k and L_k (therefore also Y_k) fixed. The goal is to show that $\partial(p_{ij}(\phi)/p_{ik}(\phi))/\partial w_j > 0$. From (22), it suffices to show that $\partial(\phi^*_{ij}/\phi^*_{ik})/\partial w_j < 0$.

Differentiating (d.5) with respect to w_j yields

$$\frac{\partial(\phi^*_{ij}/\phi^*_{ik})}{\partial w_j} = \frac{\frac{\tau_{ij}}{\tau_{ik}}\frac{1}{\theta+1}}{\left[\frac{Y_j b_j^\theta}{w_k \tau_{jk}^\theta w_j^{\theta+1}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_k(\tau_{\upsilon k}w_\upsilon)^\theta}\right]^2}\left[\frac{\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_j(\tau_{\upsilon j}w_\upsilon)^\theta}}{\frac{Y_j b_j^\theta}{w_k \tau_{jk}^\theta w_j^{\theta+1}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_k(\tau_{\upsilon k}w_\upsilon)^\theta}}\right]^{\frac{1}{\theta+1}-1} \cdots$$

$$\cdots \left[-\frac{Y_j^2 b_j^{2\theta}}{\tau_{jj}^\theta w_k w_j^{2\theta+4}\tau_{jk}^\theta} - 2\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+3}w_k}\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon k}w_\upsilon)^\theta} - \frac{1}{w_k w_j^2}\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon j}w_\upsilon)^\theta}\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon k}w_\upsilon)^\theta} \cdots\right.$$

$$\left.\cdots -\theta\frac{Y_j b_j^\theta}{w_j^{\theta+3}w_k}\left\{\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{jj}\tau_{\upsilon k}w_\upsilon)^\theta} - \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon j}\tau_{jk}w_\upsilon)^\theta}\right\}\right]. \tag{d.7}$$

A sufficient condition for (d.7) to be strictly negative is that the term in the curly bracket is non-negative. Since, by assumption $\tau_{jj} = 1$ $(\forall j)$, the term in the curly bracket is non-negative when trade barriers obey the triangle inequality, $(\forall j, k, \upsilon)\tau_{\upsilon j}\tau_{jk} \geq \tau_{\upsilon k}$.

Finally, from (22), notice that, in order to determine the sign of the sum of the elasticities of relative prices with respect to relative incomes and relative per-capita incomes, $\zeta_{Y\,j,k} + \zeta_{w j,k}$, it is sufficient to compute the negative of the sum of the elasticities of relative thresholds with respect to the same variables. Denote the elasticities of thresholds by $\chi_{Y\,j,k}$ and $\chi_{w j,k}$. To derive the elasticity of relative thresholds with respect to relative incomes, $\chi_{Y\,j,k}$, multiply (d.6) by $Y_j/(\phi^*_{ij}/\phi^*_{ik})$, where ϕ^*_{ij}/ϕ^*_{ik} is given in (d.5), which yields

$$\chi_{Y\,j,k} \equiv \frac{Y_j}{\left[\frac{\phi^*_{ij}}{\phi^*_{ik}}\right]} \frac{\partial\left[\frac{\phi^*_{ij}}{\phi^*_{ik}}\right]}{\partial Y_j} = \frac{\frac{Y_j b_j^\theta}{w_j^{\theta+2} w_k}\left\{\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{jj}\tau_{\upsilon k} w_\upsilon)^\theta} - \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{\left(\tau_{\upsilon j}\tau_{jk} w_\upsilon\right)^\theta}\right\}}{(\theta+1)\left[\frac{Y_j b_j^\theta}{w_k \tau_{jk}^\theta w_j^{\theta+1}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_k(\tau_{\upsilon k} w_\upsilon)^\theta}\right]\left[\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_j(\tau_{\upsilon j} w_\upsilon)^\theta}\right]}. \quad \text{(d.8)}$$

Similarly, to derive the elasticity of relative thresholds with respect to relative per-capita incomes, $\chi_{w j,k}$, multiply (d.7) by $w_j/(\phi^*_{ij}/\phi^*_{ik})$, where ϕ^*_{ij}/ϕ^*_{ik} is given in (d.5), and use (d.8) to obtain

$$\chi_{w j,k} \equiv \frac{w_j}{\left[\frac{\phi^*_{ij}}{\phi^*_{ik}}\right]} \frac{\partial\left[\frac{\phi^*_{ij}}{\phi^*_{ik}}\right]}{\partial w_j} = -\theta \frac{\frac{Y_j b_j^\theta}{w_j^{\theta+2} w_k}\left\{\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{jj}\tau_{\upsilon k} w_\upsilon)^\theta} - \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{\left(\tau_{\upsilon j}\tau_{jk} w_\upsilon\right)^\theta}\right\}}{(\theta+1)\left[\frac{Y_j b_j^\theta}{w_k \tau_{jk}^\theta w_j^{\theta+1}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_k(\tau_{\upsilon k} w_\upsilon)^\theta}\right]\left[\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_j(\tau_{\upsilon j} w_\upsilon)^\theta}\right]} \ldots$$

$$\ldots - \frac{\left[\frac{Y_j^2 b_j^{2\theta}}{\tau_{jj}^\theta w_k w_j^{2\theta+3}\tau_{jk}^\theta} + 2\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2} w_k}\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon k} w_\upsilon)^\theta} + \frac{1}{w_k w_j}\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon j} w_\upsilon)^\theta}\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon k} w_\upsilon)^\theta}\right]}{(\theta+1)\left[\frac{Y_j b_j^\theta}{w_k \tau_{jk}^\theta w_j^{\theta+1}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_k(\tau_{\upsilon k} w_\upsilon)^\theta}\right]\left[\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_j(\tau_{\upsilon j} w_\upsilon)^\theta}\right]}$$

$$= -\theta\chi_{Y\,j,k} - \frac{\left[\frac{Y_j^2 b_j^{2\theta}}{\tau_{jj}^\theta w_k w_j^{2\theta+3}\tau_{jk}^\theta} + 2\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2} w_k}\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon k} w_\upsilon)^\theta} + \frac{1}{w_k w_j}\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon j} w_\upsilon)^\theta}\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon k} w_\upsilon)^\theta}\right]}{(\theta+1)\left[\frac{Y_j b_j^\theta}{w_k \tau_{jk}^\theta w_j^{\theta+1}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_k(\tau_{\upsilon k} w_\upsilon)^\theta}\right]\left[\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_j(\tau_{\upsilon j} w_\upsilon)^\theta}\right]}. \quad \text{(d.9)}$$

Finally, using (d.9), the sum of the two elasticities is

$$\chi_{w_{j,k}} + \chi_{Y_{j,k}} = -(\theta-1)\chi_{Y\,j,k} - \frac{\left[\frac{Y_j^2 b_j^{2\theta}}{\tau_{jj}^\theta w_k w_j^{2\theta+3}\tau_{jk}^\theta} + 2\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2} w_k}\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon k} w_\upsilon)^\theta} + \frac{1}{w_k w_j}\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon j} w_\upsilon)^\theta}\sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon k} w_\upsilon)^\theta}\right]}{(\theta+1)\left[\frac{Y_j b_j^\theta}{w_k \tau_{jk}^\theta w_j^{\theta+1}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_k(\tau_{\upsilon k} w_\upsilon)^\theta}\right]\left[\frac{Y_j b_j^\theta}{\tau_{jj}^\theta w_j^{\theta+2}} + \sum_{\upsilon\neq j}\frac{L_\upsilon b_\upsilon^\theta}{w_j(\tau_{\upsilon j} w_\upsilon)^\theta}\right]}.$$

By assumption, $\tau_{jj} = 1$ $(\forall j)$ and trade barriers obey the triangle inequality, $(\forall j, k, \upsilon)\tau_{\upsilon j}\tau_{jk} \geq \tau_{\upsilon k}$. Hence, $\chi_{Y\,j,k} \geq 0$. A sufficient condition for the sum to be strictly negative is that $\theta \geq 1$. $\square$

In order to test the two predictions of the models, I use a variant of the econometric model proposed by Hummels and Lugovskyy (2009),

$$\log\left(\frac{p_{jm}}{p_{sm}}\right) = \hat{\gamma}_m + \hat{\gamma}_w \log\left(\frac{w_j}{w_s}\right) + \hat{\gamma}_{Y} \log\left(\frac{Y_j}{Y_s}\right) + \hat{\gamma}_c c + \xi_{jm}. \tag{d.10}$$

Expression (d.10) is similar to the econometric model that I use to test the predictions of the three competing theories in the main text. The new variable is Y_j/Y_s, which represents country j's income, relative to Spain's, with $\hat{\gamma}_{Y}$ being the corresponding coefficient. Thus, rather than using relative country sizes, I use relative incomes in the present test. This is exactly the specification that Hummels and Lugovskyy (2009) use in order to test their model. Since the authors use f.o.b. unit values to proxy the prices of varieties, they do not control for shipping costs in the analysis.

A positive and statistically significant estimate of $\hat{\gamma}_w$ and a negative and statistically significant estimate of $\hat{\gamma}_{Y}$ are in line with the predictions of either model. However, a positive sum of the estimates of $\hat{\gamma}_w$ and $\hat{\gamma}_{Y}$ provides support for the non-homothetic model only.

The results from the test of the ideal-variety versus the non-homothetic model are reported in Table 15. The coefficients are estimated via OLS and the standard errors are clustered by country. The first set of estimates uses the benchmark trade-barrier specification, which depends on distance intervals only. The second set expands the trade-barrier specification to accommodate the "island" effect, while the third controls for sales tax variations across countries.

The coefficient estimates on per-capita income are positive and statistically significant, while the coefficients on total income are negative and statistically significant. These findings are in line with Hummels and Lugovskyy (2009), who estimate a similar econometric model using unit-value data collected at the port of shipping to approximate prices of varieties from eleven source countries sold in two-hundred destinations over the 1990-2003 period.

However, the sum of the estimated coefficients on per-capita and total income in Table 15 is positive—an empirical finding that is also documented by Hummels and Lugovskyy (2009). This result supports the non-homothetic over the ideal-variety model which predicts a negative sum.

The last result should be interpreted with caution. While testing the signs and significance of the coefficient estimates is reasonable in a non-structural econometric model, comparing the magnitudes of the elasticities is not as straightforward. Since the econometric model is not a structural equation obtained from either theoretical model, it is not clear whether the magnitudes of the elasticities are meaningful. It is for this reason that I derive a structural equation from the non-homothetic model in the main body and I use it in order to estimate the elasticity of price with respect to per-capita income and to interpret the parameter's magnitude.

Table 15: Alternative Test of Non-Homothetic VS. Ideal-Variety Model, 18 Countries

Exchange Rate	$\hat{\gamma}_w$ (s.e.)	$\hat{\gamma}_Y$ (s.e.)	$\hat{\gamma}_{c,1}$ (s.e.)	$\hat{\gamma}_{c,2}$ (s.e.)	$\hat{\gamma}_{c,3}$ (s.e.)	$\hat{\gamma}_{c,4}$ (s.e.)	$\hat{\gamma}_{isl}$ (s.e.)
Mar/Sep	0.0928***	-0.0282**	-0.0105	0.2064***	0.2497***	0.2036***	—
Distance	(0.0333)	(0.0126)	(0.0226)	(0.0180)	(0.0141)	(0.0383)	—
Feb/Aug	0.0943***	-0.0243**	-0.0046	0.2049***	0.2491***	0.2122***	—
Distance	(0.0324)	(0.0118)	(0.0221)	(0.0173)	(0.0143)	(0.0384)	—
Jan/Jul	0.0867**	-0.0232*	-0.0054	0.2071***	0.2527***	0.2146***	—
Distance	(0.0329)	(0.0120)	(0.0221)	(0.0172)	(0.0153)	(0.0388)	—
Mar/Sep	0.0938***	-0.0286**	-0.0109	0.2077***	0.2533***	0.2027***	-0.0083
Distance/Island	(0.0347)	(0.0133)	(0.0230)	(0.0204)	(0.0113)	(0.0395)	(0.0204)
Feb/Aug	0.0932***	-0.0239*	-0.0041	0.2035***	0.2452***	0.2132***	0.0092
Distance/Island	(0.0337)	(0.0124)	(0.0220)	(0.0185)	(0.0112)	(0.0394)	(0.0173)
Jan/Jul	0.0851**	-0.0225*	-0.0048	0.2051***	0.2471***	0.2160***	0.0132
Distance/Island	(0.0343)	(0.0127)	(0.0220)	(0.0181)	(0.0115)	(0.0398)	(0.0175)
Exchange Rate	$\hat{\gamma}_w$ (s.e.)	$\hat{\gamma}_Y$ (s.e.)	$\hat{\gamma}_{c,1}$ (s.e.)	$\hat{\gamma}_{c,2}$ (s.e.)	$\hat{\gamma}_{c,3}$ (s.e.)	$\hat{\gamma}_{c,4}$ (s.e.)	$\hat{\gamma}_{vat}$ (s.e.)
Mar/Sep	0.0949***	-0.0257*	0.0051	0.2082***	0.2582***	0.2192***	-0.2448
Distance/VAT	(0.0323)	(0.0137)	(0.0396)	(0.0175)	(0.0249)	(0.0569)	(0.4973)
Feb/Aug	0.0949***	-0.0236*	-0.0001	0.2054***	0.2515***	0.2168***	-0.0706
Distance/VAT	(0.0316)	(0.0137)	(0.0398)	(0.0179)	(0.0255)	(0.0574)	(0.4895)
Jan/Jul	0.0872**	-0.0225	0.0015	0.2076***	0.2549***	0.2185***	-0.0623
Distance/VAT	(0.0322)	(0.0140)	(0.0401)	(0.0178)	(0.0259)	(0.0579)	(0.4903)

* significance at 10% level, ** significance at 5%-level, *** significance at 1%-level

Price regressions: N. Obs 3060, Country clusters 17 (Spain is numéraire), Fixed Effects 179 (relative to good 1)

Distance Intervals (in km): $[0, 501]$, $(501, 1367]$, $(1367, 1482]$, $(1482, 2953]$

Data Sources: Prices from Mar/Sep 2008 online catalogues of clothing manufacturer Mango. Exchange rates for Mar/Sep, Aug/Feb, and Jan/Jul 2008 from ECB. DHL Express shipping zones from DHL Spain Online. Distance from CEPII. Nominal per-capita GDP and nominal GDP for 2007 from WDI. Apparel VAT from European Commission.