NBER WORKING PAPER SERIES

INCOME DIFFERENCES AND PRICES OF TRADABLES

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Working Paper 16233
http://www.nber.org/papers/w16233

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
July 2010

I am grateful to Timothy J. Kehoe and Fabrizio Perri for their continued guidance and encouragement throughout this project. I also thank George Alessandria, Cristina Arellano, Costas Arkolakis, Patrick Bajari, Robert Feenstra, Cecilia Fieler, Ioanna Grypari, Pete Klenow, Narayana Kocherlakota, Lin Lu, Erzo Luttmer, Ellen McGrattan, Marc Melitz, Gina Pieters, Daniel Samano, Philip Saure, Michael Waugh, members of the Trade and Development Workshop at the University of Minnesota, as well as participants at various seminars and conferences for their comments and suggestions. All remaining errors are mine. Financial support from the Graduate Research Partnership Program Fellowship is gratefully acknowledged. I am grateful to the World Bank for generously providing me with the price data from the 2005 ICP round. The views expressed herein are those of the author and do not necessarily reflect the views of the National Bureau of Economic Research.

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July 2010
JEL No. E31,F12,L11

ABSTRACT

This paper presents novel evidence of price discrimination, using prices of identical goods in 28 countries. I explain the observed phenomenon via non-homothetic preferences, in a model of trade with product differentiation and firm productivity heterogeneity. The model brings theory and data closer along a key dimension: it generates positively related prices of tradables and income, while preserving exporter behavior and trade flows of existing frameworks. It further captures observations that richer countries buy more per product and consume more diverse bundles. Quantitatively, the model suggests that variable mark-ups account for 80% of the positive price-income relationship across 123 countries.

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An online appendix is available at:
http://www.nber.org/data-appendix/w16233

1 Introduction

A large empirical literature has demonstrated strong and persistent deviations from the law of one price for tradable goods. Evidence stems from studies that examine cross-country price levels of aggregate categories of goods, to tracking individual products across markets.[1] Moreover, tradable goods prices are systematically positively related to countries' per-capita incomes. Hsieh and Klenow (2007) demonstrate that this relationship is particularly pronounced among tradable consumption goods. Since these goods comprise consumption bundles of individuals and their prices directly affect consumer welfare, it is of central importance to understand the underlying mechanisms that affect the behavior of prices across countries.

I argue that firms' variable mark-ups are a key contributor toward the positive price-income relationship observed in the data. To that end, I introduce non-homothetic consumer preferences over varieties into a general equilibrium model of international trade. Due to the presence of trade frictions, monopolistically competitive firms, with varying productivity levels, are able to supply their products at destination-specific prices. With non-homothetic preferences, different levels of income result in non-constant shares of expenditure on different products, thus yielding 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 find it optimal to price identical products higher in more affluent markets. Such systematic price discrimination is evident in a unique dataset that I build, which features prices of hundreds of identical (barcode) products sold online and shipped via courier at publicly-available rates to 28 markets.

The utility specification I propose has the property that the marginal satisfaction agents derive from consuming a good is bounded at any level of consumption. Since a tiny amount of consumption per good does not give infinite increase in utility, a consumer spends her limited income on the subset of potentially produced items, whose prices do not exceed marginal valuations. An increase in income spurs consumers, who value variety, to not only buy more per good, but to also buy a greater pool of goods. Hence, richer countries consume systematically more per good and more diverse sets of products, as reported by Jackson (1984), Hunter and Markusen (1988), Hunter (1991), Movshuk (2004), Hummels and Klenow (2005).

[1] Alessandria and Kaboski (2009) and Hsieh and Klenow (2007) employ prices of aggregate good categories, Hummels and Klenow (2005) and Schott (2004) study unit values from disaggregate trade data, Hummels and Lugovskyy (2009), Crucini et al. (2005a), Crucini et al. (2005b) and Crucini and Shintani (2008) use retail prices of products with identical characteristics, Goldberg and Verboven (2001) and Goldberg and Verboven (2005) track car prices in Europe, Ghosh and Wolf (1994) and Haskel and Wolf (2001) examine prices of the Economist magazine and IKEA products, respectively.

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

The model is very useful for quantitative analysis, when firm productivities are Pareto-distributed, as it yields a standard gravity equation of trade. This tool allows me to use bilateral trade data to estimate trade barriers, which are significantly higher for poor countries plagued by low productivities.[2] The latter yield high costs of production, which coupled with high trade barriers, keep trade shares of poor countries low and prices of tradable goods high. On the contrary, high price elasticities of demand in poor countries force exporters to sell their products at low prices there. Hence, the specification of bilateral trade barriers and the degree to which prices and quantities respond to them, namely the elasticity of trade with respect to trade frictions, constitute key parameters that determine the success of the model to quantitatively account for the price-income relationship observed in aggregate data.

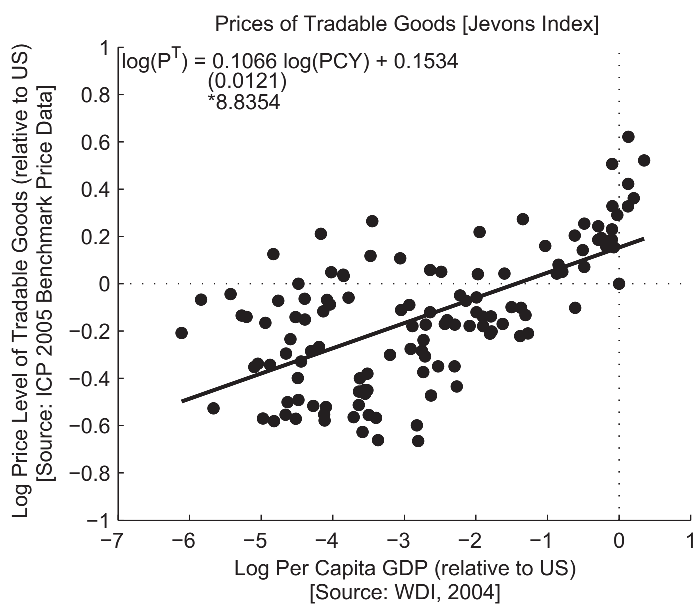

Figure 1: Price Level of Final Tradable Goods and Per-Capita GDP for 123 Countries

[2]Waugh (2009) demonstrates this finding for models of heterogeneity that rely on a Ricardian structure.

Figure 1 plots the 2004 per-capita income and price level of final tradable goods, which constitute 87 percent of exported goods for the set of 123 countries portrayed in this plot.[3] Clearly, final tradable goods are systematically more expensive in richer countries, as the aggregate price elasticity with respect to per-capita income amounts to roughly 0.11.[4]

To evaluate the ability of the model to quantitatively capture the relationship above, I engage in a benchmark calibration exercise, where I choose the elasticity of trade so that average mark-ups in the model are in line with cross-country data reported by Martins et al. (1996), and bilateral trade frictions solely reflect physical barriers such as distance and border. The model then endogenously generates an elasticity of the price level of final tradable goods with respect to per-capita income of roughly 0.08. In addition, the calibrated model suggests that the extensive margin of imports, when measured as in Hummels and Klenow (2005), responds to per-capita and overall income with an elasticity of 0.46 and 0.23, respectively. The corresponding statistics in cross-country data reported by Hummels and Klenow (2005) are 0.45 and 0.26, respectively. Hence, the model generates roughly eighty percent of the observed price-income relationship, while quantitatively reproducing the tight link between the number of imported varieties and a country's (per-capita) income.

The model does not explain the entire variation in prices, which can in turn be attributed to many factors. Product quality differences contribute toward the positive relationship between prices and income. Schott (2004) finds that prices implied by unit values of US imports are significantly higher, if sourced from capital-abundant countries. This suggests that rich (capital-abundant) countries export high-quality goods. In addition, high wage earners in rich countries may find it too costly to spend time searching for goods, allowing retailers to charge high mark-ups there, as argued by Alessandria and Kaboski (2009).

Indeed, the prices of final tradable goods plotted in figure 1 are computed at the retail

[3] To measure the importance of final goods in exports, I employ the publicly available US import data per source country at the HS 6-digit level. I use UN concordance tables to translate HS 6-digit data into Broad Economic Categories (BEC), which classify goods according to their use as intermediate versus final consumption goods. For the year 2004, I then compute each country's share of consumption exports in total goods exports to the United States, which results in an average statistic of 0.87. While an ideal measure of the share of consumption goods in exports would be a bilateral computation of the aforementioned statistic, I only have access to US HS 6-digit data, a level of disaggregation necessary in order to apply the BEC concordance procedure. However, since the US represents a major importer of goods for each country in the sample, this statistic is a good approximation.

[4] This is a typical summary statistic for tradable goods prices that is robust across time and datasets. To verify, I construct geometric averages of 100+ individual tradable final good prices across a sample of 76 countries in 2004, using data from the Economist Intelligence Unit. The price elasticity with respect to per-capita income arising from this database varies from 0.1280(0.0160) to 0.1323(0.0173), depending on whether prices are collected in low- or high-end stores.

level and necessarily reflect local market characteristics, that may or may not be correlated with a country's per-capita income. As Burstein et al. (2003) argue, retail prices of tradables contain local distribution costs. However, while these costs, together with sales taxes, cause law of one price deviations, as documented by Campbell and Lapham (2004), they are not necessarily higher in richer countries. Percentage sales taxes in European Union member countries, the US and Canada do not follow a particular pattern. Furthermore, measured productivity levels of the wholesale and retail trade sector, as well as the transportation and storage sector, are not any lower in richer countries, suggesting prices of these services are not necessarily higher there.[5]

Overall, in order to fully characterize the price-income relationship across countries, the pricing-to-market mechanism proposed in this paper can be enriched by the product-quality dimension of Kugler and Verhoogen (2008) and the elastic labor supply of Alessandria and Kaboski (2009), and incorporated into frameworks that feature standard Balassa-Samuelson effects such as those of Ghironi and Melitz (2005) and Bergin et al. (2006).

To summarize, the present paper contributes toward the understanding of the positive relationship between per-capita income and price level of final tradable goods, which is not only key in determining relative investment and growth patterns across countries as argued by Hsieh and Klenow (2007), but is also central in measuring the welfare of consumers as emphasized by Broda and Romalis (2009). Section 2 of the paper outlines a general equilibrium model of trade. Section 3 derives the qualitative predictions of the model and presents empirical support of the proposed mechanism. Section 4 evaluates the quantitative ability of the model to account for observed patterns in the data. Section 5 concludes. Appendix A outlines a benchmark homothetic model of trade. Appendices B, C, D and E detail measurement, calibration and algebra. Appendix F contains figures and tables.

2 Model

I propose a model in which firms practice pricing-to-market. The model incorporates non-homothetic consumer preferences into the monopolistic competition framework of Melitz (2003) and Chaney (2008), which features product differentiation and firm productivity heterogeneity. The result is a new set of predictions on cross-country consumption and price patterns, complemented by desirable features of exporters and trade flows of existing models.

[5]Figure 7 in appendix F plots the percentage sales tax in European Union countries, US and Canada versus each country's per-capita income. Figure 6 in appendix F plots productivities of each sector, provided by Inklaar and Timmer (2009), against per-capita income for a set of 13 countries in 2004.

2.1 Consumer Problem

I consider a world of I countries engaged in trade of final goods, where I is finite.[6] Let i represent an exporter and j an importer, that is, i is the source country, while j is the destination country.

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

$$U^c = \int_{\omega \in \Omega} \log(q^c(\omega) + \bar{q}) d\omega, \tag{1}$$

where $q^c(\omega)$ is individual consumption of variety ω and $\bar{q} > 0$ is a (non-country-specific) constant.[7] To ensure that the utility function is well defined, I assume $\Omega \subseteq \bar{\Omega}$, where $\bar{\Omega}$ is a compact set containing all potentially produced varieties in the world.

Each variety is produced by a single firm, where firms are differentiated by their productivity, ϕ, and country of origin, i.[8] Any two firms originating from country i and producing with productivity level ϕ choose identical optimal pricing rules.[9] In every country i, there exists a pool of potential entrants who pay a fixed cost, $f_e > 0$, and subsequently draw a productivity from a distribution, $G(\phi)$, with support $[b_i, \infty)$. A measure J_i of them enter in equilibrium, but only a subset of producers, N_{ij}, sell to a particular market j. Their density, conditional on selling to j, is $\mu_{ij}(\phi)$. N_{ij} also represents the measure of goods of i-origin consumed in j.

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

[7] The utility function in the text is the limiting case of the following generalized function:

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

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

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

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

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

The demand for a variety of type ϕ originating from country i consumed in a positive amount in destination j, $q_{ij}(\phi) > 0$, is given by:[10]

$$q_{ij}(\phi) = L_j \left\{ \frac{w_j + \bar{q}P_j}{N_j p_{ij}(\phi)} - \bar{q} \right\}, \tag{2}$$

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

$$N_j = \sum_{\upsilon=1}^{I} N_{\upsilon j}, \tag{3}$$

and P_j is an aggregate price statistic summarized by:

$$P_j = \sum_{\upsilon=1}^{I} N_{\upsilon j} \int_{\phi^*_{\upsilon j}}^{\infty} p_{\upsilon j}(\phi)\mu_{\upsilon j}(\phi)d\phi. \tag{4}$$

2.2 Firm Problem

An operating firm must choose the price of its good p, accounting for the demand for its product q. A firm with productivity draw ϕ faces a constant returns to scale production function, $x(\phi) = \phi l$, where l represents the amount of labor used toward the production of final output. Furthermore, each firm from country i wishing to sell to destination j faces an iceberg transportation cost incurred in terms of labor units, $\tau_{ij} > 1$, with $\tau_{ii} = 1$ $(\forall i)$.

Substituting for the demand function using expression (2), the profit maximization problem of a firm with productivity ϕ, from country i, considering selling to destination j, is:

$$\pi_{ij}(\phi) = \max_{p_{ij} \geq 0} \quad p_{ij} L_j \left\{ \frac{w_j + \bar{q}P_j}{N_j p_{ij}} - \bar{q} \right\} - \frac{\tau_{ij} w_i}{\phi} L_j \left\{ \frac{w_j + \bar{q}P_j}{N_j p_{ij}} - \bar{q} \right\}. \tag{5}$$

Total firm profits are the sum of profit flows from all destinations served. The resulting optimal price a firm charges for its variety supplied in a positive amount is given by:

$$p_{ij}(\phi) = \left(\frac{\tau_{ij} w_i}{\phi} \frac{w_j + \bar{q}P_j}{N_j \bar{q}} \right)^{\frac{1}{2}}. \tag{6}$$

[10] I derive consumer demand in appendix C.1, and optimal prices in appendix C.2.

2.3 Productivity Thresholds and Firm Mark-Ups

In this model, not all firms serve all destinations. In particular, for any source and destination pair of countries, i, j, only firms originating from country i with productivity draws $\phi \geq \phi_{ij}^*$ sell to market j, where ϕ_{ij}^* is a productivity threshold defined by:[11]

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

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

$$p_{ij}\left(\phi_{ij}^*\right) = \frac{\tau_{ij} w_i}{\phi_{ij}^*}. \tag{7}$$

The price a firm would charge for its variety, however, is limited by the variety's demand, which diminishes as the variety's price rises. In particular, it is the case that consumers in destination j are indifferent between buying the variety of type ϕ_{ij}^* or not. To see this, from (2), notice that consumers' demand is exactly zero for the variety whose price satisfies:

$$p_{ij}\left(\phi_{ij}^*\right) = \frac{w_j + \bar{q} P_j}{N_j \bar{q}}. \tag{8}$$

Combining expressions (7) and (8) yields a simple characterization of the threshold:[12]

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

Using (9), the optimal pricing rule of a firm with productivity draw $\phi \geq \phi_{ij}^*$ becomes:

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

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

[12] The model does not rely on fixed costs to pin down productivity cutoffs. Rather, consumer income affects the measure of varieties demanded, thus determining the measure of firms per market. Here, market size plays little role in firm entry, unlike in the CES models with fixed costs of Melitz (2003) and Chaney (2008), a variant of which is in appendix A, or models with quadratic preferences and no fixed costs such as Melitz and Ottaviano (2008), where in the latter, the utility specification gives importance to market size.

In this model, mark-ups are not only higher for more productive firms, as reported by Loecker and Warzynski (2009), but they are also determined by the local conditions of the destination market, summarized by the threshold firms must surpass in order to serve a destination. I proceed to characterize these thresholds next.

2.4 Equilibrium of the World Economy

In this model, a potential entrant from country i pays a fixed cost $f_e > 0$ in labor units, and subsequently draws a productivity from a cdf, $G(\phi)$, with corresponding pdf, $g(\phi)$, and support $[b_i, \infty)$. A measure J_i of firms enter in equilibrium. Firm entry and exit drives average profits to zero. In addition, only a subset of producers, N_{ij}, sell to market j. These firms, in turn, are productive enough so as to surpass the productivity threshold characterizing destination j, ϕ^*_{ij}. Hence, N_{ij} satisfies:

$$N_{ij} = J_i[1 - G(\phi^*_{ij})]. \tag{10}$$

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

$$\mu_{ij}(\phi) = \begin{cases} \frac{g(\phi)}{1-G(\phi^*_{ij})} & \text{if } \phi \geq \phi^*_{ij} \\ 0 & \text{otherwise.} \end{cases} \tag{11}$$

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

$$T_{ij} = N_{ij} \int_{\phi^*_{ij}}^{\infty} p_{ij}(\phi) x_{ij}(\phi) \mu_{ij}(\phi) d\phi. \tag{12}$$

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

$$\pi_i = \sum_{v=1}^{I} [1 - G(\phi^*_{iv})] \int_{\phi^*_{iv}}^{\infty} \pi_{iv}(\phi) \mu_{iv}(\phi) d\phi, \tag{13}$$

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

$$w_i f_e = \sum_{v=1}^{I} [1 - G(\phi^*_{iv})] \int_{\phi^*_{iv}}^{\infty} \pi_{iv}(\phi) \mu_{iv}(\phi) d\phi. \tag{14}$$

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

$$w_i L_i = \sum_{v=1}^{I} T_{vi}. \tag{15}$$

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 productivity thresholds $\hat{\phi}^*_{ij}$; measures of entrants $\hat{J}_i$; measures of firms from i serving j $\hat{N}_{ij}$; total measures of firms serving j $\hat{N}_j$; conditional densities of firms from i serving j $\hat{\mu}_{ij}(\phi)$; aggregate price statistics $\hat{P}_j$; wage rates $\hat{w}_j$; per-consumer allocations $\hat{q}^c_{ij}(\phi)$; total consumer allocations $\hat{q}_{ij}(\phi)$; decision rules $\hat{p}_{ij}(\phi)$ for firms ϕ, $\forall \phi \in [b_i, \infty)$, such that: (i) (32) solves the individual consumer's problem; (ii) (2) satisfies a country's aggregate demand for a variety; (iii) (5) solves the firm's problem;[13] (iv) $\hat{\phi}^*_{ij}$, $\hat{N}_{ij}$, $\hat{N}_j$, $\hat{\mu}_{ij}(\phi)$, $\hat{P}_j$, $\hat{w}_i$, $\hat{J}_i$ jointly satisfy (9), (10), (3), (11), (4), (14) and (15); (v) goods' markets clear, $\hat{q}_{ij}(\phi) = \hat{x}_{ij}(\phi)$.

3 Qualitative Predictions and Empirical Support

In this section, I discuss the model's novel predictions regarding the behavior of prices and margins of trade across countries. While I draw on existing empirical work on the margins of trade, I bring forward new evidence in support of the pricing mechanism that arises in this framework.

In order to analytically solve the model and derive stark predictions at the firm and aggregate levels, I 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 $\theta > 0$.[14] The support of the distribution is $[b_i, \infty)$, where b_i summarizes the level of technology in country i.[15] 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 cost of production is low, and by richer consumers, who enjoy higher wages. The sections below study how exporters respond to such market conditions.

[13] Another equilibrium restriction for models of monopolistic competition is no cross-country arbitrage: $p_{ij}(\phi) \leq p_{iv}(\phi)\tau_{vj}$ $(\forall i, v, j)$. The inequality involves equilibrium objects, such as productivity thresholds, which in turn reflect wages. In the quantitative analysis in section 4, I demonstrate that arbitrage opportunities in calibrated monopolistic competition models, with constant or variable mark-ups, arise only under asymmetric specifications of trade barriers.

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

[15] b_i can be thought of as a source of Ricardian comparative advantage in this framework.

3.1 Per-Capita Income and the Margins of Trade

In this model, per-capita income plays a central role in determining cross-country trade patterns. To illustrate the importance of income in trade, it is useful to examine ϕ^*_{ij}, the productivity threshold in country i that characterizes the firm whose good barely generates demand in j:[16]

$$\phi^*_{ij} = \frac{\bar{q}^{\frac{1}{\theta+1}} \tau_{ij} w_i}{[(\theta+1) f_e (1+2\theta) w_j]^{\frac{1}{\theta+1}}} \left[\sum_{\upsilon=1}^{I} \frac{L_\upsilon b_\upsilon^\theta}{(\tau_{\upsilon j} w_\upsilon)^\theta} \right]^{\frac{1}{\theta+1}}. \tag{16}$$

Looking at comparative statics, expression (16) shows that productivity thresholds respond marginally and positively to the population, but strongly and negatively to the per-capita income of the destination market.[17] Intuitively, recall that the marginal utility of a variety, $(q^c(\phi) + \bar{q})^{-1}$, is bounded at any level of consumption. Since a tiny amount of consumption of a good 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 income makes new goods affordable and the consumer expands her consumption bundle accordingly. Hence, richer countries import, and therefore consume, a larger pool of varieties, as reported by Hummels and Klenow (2005), Jackson (1984), Hunter (1991), Hunter and Markusen (1988), and Movshuk (2004).[18] Finally, high trade barriers, τ_{ij}, raise costs of importing, forcing consumers to import fewer varieties from a particular source.

The effects of income and trade barriers on the measure of imported varieties, or the extensive import margin, are neatly summarized in expression (17) below. To arrive there, substitute expressions (16) and (38) into (10), to obtain the relative measure of varieties from source i imported by countries j and k:

$$\frac{N_{ij}}{N_{ik}} = \underbrace{\left(\frac{\tau_{ij}}{\tau_{ik}}\right)^{-\frac{\theta}{\theta+1}}}_{\text{barriers}} \underbrace{\left(\frac{w_j}{w_k}\right)^{\frac{\theta}{\theta+1}}}_{\text{income}} \underbrace{\left(\frac{\lambda_{ij}}{\lambda_{ik}}\right)^{\frac{\theta}{\theta+1}}}_{\text{mkt share}}, \tag{17}$$

[16] See appendix C.3 for a characterization of all equilibrium objects.

[17] It is easy to verify that the (absolute value of the) elasticity of thresholds with respect to per-capita income exceeds the elasticity with respect to size, making elasticity with respect to destination GDP negative.

[18] Due to the absence of fixed costs in this model, population size has marginal effects on the extensive margin. For fixed trade barriers, comparative statics with respect to L_j suggest that variety consumption is lower in bigger markets, but since the elasticity with respect to per-capita income exceeds that of population, markets with larger GDP consume significantly more varieties, as reported by Hummels and Klenow (2005).

where λ_{ij} represents the share of i goods in j's consumption expenditure:

$$\lambda_{ij} = \frac{T_{ij}}{\sum_v T_{vj}} = \frac{L_i b_i^\theta (\tau_{ij} w_i)^{-\theta}}{\sum_v L_v b_v^\theta (\tau_{vj} w_v)^{-\theta}}. \tag{18}$$

In expression (17), the first term emphasizes the role of trade barriers, the second captures per-capita income effects, and the third represents market share, where the contribution of the particular destination's characteristics is marginal, as it is washed away within a large summation term. Since trade barriers and per-capita income mainly affect consumer demand for varieties, these two variables also guide the behavior of exporting firms across countries.

Large trade barriers keep exporters in the minority, whereas high demand in rich countries draws more firms to enter such markets. Moreover, after adjusting for market share, more firms enter not only richer, but also larger destinations, as can be seen in expression (19):

$$\frac{N_{ij}}{\lambda_{ij}} = \frac{(1+2\theta)^{\frac{\theta}{\theta+1}}}{[(\theta+1)f_e]^{\frac{1}{\theta+1}} \bar{q}^{\frac{\theta}{\theta+1}}} \left(L_j b_j^\theta + w_j^\theta \sum_{v \neq j} \frac{L_v b_v^\theta}{(\tau_{vj} w_v)^\theta} \right)^{\frac{1}{\theta+1}}. \tag{19}$$

The model's predictions regarding entry and sales behavior of exporters is in line with empirical work. In particular, Eaton et al. (2004) and Eaton et al. (2008) use 1986 data to document that French exporters are in the minority, and a larger number of them enter richer and bigger markets, after adjusting for French market share per destination.

Finally, the model predicts that, on average, firms sell more in richer and larger markets, which can be verified via comparative statics with respect to thresholds in expression (20):

$$t_{ij} = \int_{\phi_{ij}^*}^{\infty} p_{ij}(\phi) x_{ij}(\phi) \mu_{ij}(\phi) d\phi = \frac{\bar{q} \tau_{ij} w_i L_j}{\phi_{ij}^* (2\theta+1)} \tag{20}$$

Hence, the model suggests that the intensive margin of trade is positively related to the per-capita income and size of the market, an empirical regularity reported by Hummels and Klenow (2005) for a large sample of countries.

Overall, this section has demonstrated that, in this model, exporters behave in accordance with observations in cross-country data. Moreover, the force to which exporters respond is consumer demand, which is highly sensitive to the per-capita income that characterizes each country.[19] As it turns out, per-capita income also plays a central role in shaping the systematic behavior of prices across countries, to which I turn next.

[19] Fieler (2007) demonstrates the importance of non-homothetic preferences in determining trade patterns across rich and poor countries in the Ricardian framework of Eaton and Kortum (2002).

3.2 Per-Capita Income, Prices and Mark-Ups

In this model, firms' prices and mark-ups across markets vary systematically with the markets' characteristics. Within a market, however, firm behavior is in line with existing frameworks that feature producer heterogeneity.

Consider two firms with productivity draws ϕ_1 and ϕ_2, originating from countries 1 and 2, respectively, and selling to market j. From expression (6), the relative price of the goods these firms sell is determined by the firms' relative marginal costs of production and delivery:

$$\frac{p_{1j}(\phi_1)}{p_{2j}(\phi_2)} = \left(\frac{\tau_{1j} w_1/\phi_1}{\tau_{2j} w_2/\phi_2}\right)^{\frac{1}{2}}.$$

The intimate relationship between relative prices and relative marginal costs of firms within a country is not particular to this model. In fact, a similar prediction arises in frameworks that feature heterogeneous productivity firms and homothetic (CES) preferences, such as the model of Melitz (2003) and Chaney (2008), a variant of which is outlined in appendix A. In the CES model, firms charge a constant and destination-invariant mark-up over marginal cost of production and delivery, as long as consumer preferences are identical across countries. Hence, the (net) average mark-up across firms in a given market is constant, which is also the case in the present model, as can be seen in expression (21) below:

$$\bar{m} = \int_{\phi_{ij}^*}^{\infty} \left(\frac{\phi}{\phi_{ij}^*}\right)^{\frac{1}{2}} \frac{\theta(\phi_{ij}^*)^\theta}{\phi^{\theta+1}} d\phi = \frac{\theta}{\theta - 0.5}, \tag{21}$$

assuming $\theta > 0.5$.[20]

However, in the non-homothetic model, an individual firm behaves very differently *across* markets with different characteristics. For an illustration, consider a firm with productivity draw ϕ, originating from country i and selling an identical variety to markets j and k, that is, $\phi \geq \max[\phi_{ij}^*, \phi_{ik}^*]$. The relative price this firm charges across the two markets is given by:

$$\frac{p_{ij}(\phi)}{p_{ik}(\phi)} = \underbrace{\left(\frac{\tau_{ij}}{\tau_{ik}}\right)^{\frac{1}{2(\theta+1)}}}_{\text{barriers}} \underbrace{\left(\frac{w_j}{w_k}\right)^{\frac{1}{2(\theta+1)}}}_{\text{income}} \underbrace{\left(\frac{\lambda_{ij}}{\lambda_{ik}}\right)^{\frac{1}{2(\theta+1)}}}_{\text{market share}}. \tag{22}$$

[20] The homothetic Bertrand-competition model of Bernard et al. (2003) and the non-homothetic monopolistic-competition model of Melitz and Ottaviano (2008) also predict constant average mark-ups.

Expression (22) shows that a firm primarily accounts for shipping costs and the per-capita income of the destination, when it prices its good across countries. High trade barriers raise the firm's cost of shipping to a market, resulting in a high price of the final good upon arrival. Moreover, the firm is able to sell its good at a high price in a rich destination. Hence, the firm price-dscriminates according to the per-capita income of the destination.

To obtain intuition, rewrite relative prices using productivity thresholds from (16) to get:

$$\frac{p_{ij}(\phi)}{p_{ik}(\phi)} = \frac{\tau_{ij}}{\tau_{ik}} \left(\frac{\phi_{ij}^*}{\phi_{ik}^*} \right)^{-\frac{1}{2}}. \tag{23}$$

The productivity thresholds that appear in the relative prices above actually govern elasticities of demand across countries. In particular, the (absolute value of the) price-elasticity of demand for a variety of type (ϕ, i) in market j is:

$$\epsilon_{ij}(\phi) = \left[1 - \left(\frac{\phi}{\phi_{ij}^*} \right)^{-\frac{1}{2}} \right]^{-1}. \tag{24}$$

If market j is characterized by high per-capita income, the productivity threshold to sell there is low. According to expression (24), a low threshold yields inelastic demand for a good in the rich market. Moreover, the elasticity of demand is reflected in the price of the good, which can be seen by combining expressions (23) and (24) to obtain:

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

In sum, consumers in rich countries are less responsive to price changes than consumers in poor ones. A firm exploits this opportunity, amid trade barriers that segment the markets, and charges a high mark-up in the affluent destination.

However, the same firm extracts a low mark-up in a more populated market. Larger markets are in effect more competitive, thus preventing relatively less productive firms to enter (recall that ϕ_{ij}^* is higher there). Due to tough competition, the price and mark-up of a surviving firm is lower there.[21] Yet, since elasticities of thresholds are higher with respect to per-capita income over population, each firm prices its product higher in a market with greater total output.

The positive relationship between prices and per-capita income predicted by the model is

[21] Along the market size-price dimension, the present model behaves like those of Melitz and Ottaviano (2008), Bergin and Feenstra (2001) and Feenstra (2003).

in line with a series of empirical findings. However, existing studies do not provide direct support for the underlying mechanism that operates in the model, since they cannot measure the effect differing demand elasticities have on firms' mark-ups. Alessandria and Kaboski (2009), Hsieh and Klenow (2007), Hummels and Klenow (2005), Schott (2004), Hummels and Lugovskyy (2009), Crucini et al. (2005a), Crucini et al. (2005b) and Crucini and Shintani (2008) study prices of aggregate good categories or prices of goods with similar characteristics across countries. Since goods are not identical, prices reflect variable product quality, which is higher in rich countries, as Schott (2004) argues. Goldberg and Verboven (2001), Goldberg and Verboven (2005), Ghosh and Wolf (1994) and Haskel and Wolf (2001) track individual goods across countries. But, prices are collected from retail locations and reflect local costs, which are arguably higher in rich countries due to standard Balassa-Samuelson effects.

For these reasons, in the following section, I outline results obtained from a unique database that features prices of *identical* products sold *online*, which allows me to establish a direct link between demand elasticities and mark-ups across countries.

3.3 Pricing-to-Market: Evidence from Mango's Online Store

I present direct evidence that the Spanish clothing manufacturing company Mango systematically price-discriminates according to the per-capita income of the market it sells to.

Mango specializes in the production of clothing for middle-income female consumers and sells its items both online and in stores around the world.[22] I collect data from Mango's online store, which in 2008 served 28 countries in Europe as well as Canada.[23] Each country has a website and customers from one country cannot buy products from another country's website due to shipping restrictions. Thus, a customer with a physical shipping address in Germany can only have items delivered to her if purchased from the German Mango website.

I collect data on all 190 items featured in the Summer/Winter '08 online catalogues, which became available in March/September.[24] In each country, the catalogue lists item prices in the local currency. I use average monthly exchange rates for February and August of 2008, to convert all values into Euro, the currency used in the home country, Spain.[25]

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

[23] I exclude the US market because the set of products sold there differs entirely from other markets. I exclude Spanish and British islands and territories as well as city states due to lack of aggregate data.

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

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

Each item in the catalogue has a unique name and an 8-digit code reported in every country. This enables me to collect prices of identical products across markets. Prices listed on the website include sales taxes (VAT), which I adjust for accordingly, but exclude tariffs since all countries are members of the European Union.[26] Thus, once I remove the sales tax, prices include production costs, mark-ups and transportation costs.[27]

The shipping and handling policy of Mango is such that no fee is incurred for purchases above a minimum value, which differs across countries. Thus, not only does a single product, whose price is above this minimum, incur no shipping charge, but also any bundle of goods with value above the minimum satisfies the free-shipping requirement. All other purchases incur a shipping and handling fee. Many items sold by Mango classify for free shipping. However, it is not always the case that the same product ships at no fee to different destinations, since the minimum price requirement as well as the actual Euro-denominated price of the product often differ. Thus, it is necessary to control for shipping costs in the analysis. This task is facilitated by the fact that Mango uses DHL Express to ship its products from a single warehouse located outside of Barcelona, Spain, to every destination.[28] I collect DHL Express shipping quotes from Mango's warehouse address to each destination country and use them as an independent control for transportation costs in my analysis.[29] Finally, I use 2008 nominal per-capita income from the World Bank in my analysis of the relationship between prices and income.[30]

Equation (25) below summarizes the regression framework used to analyze the pricing practices of Mango:

$$\log p_{ij} = \alpha_i + \beta_y \log y_j + \beta_\tau \log \tau_j + \epsilon_{ij}, \tag{25}$$

where p_{ij} is the pre-tax price of good i in country j in Euros, y_j is per-capita income of

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

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

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

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

[30] I repeat the analysis with PPP-adjusted per-capita income, and for a subset of the countries (for which data are available), I repeat the analysis with manufacturing wages, which correspond to per-capita income in the model. Estimated elasticities of price with respect to income are higher than in the benchmark analysis.

country j and τ_j is the DHL Express shipping charge from Barcelona to destination j. The coefficients β_y and β_τ can be interpreted as the estimated elasticities of price with respect to per-capita income and transportation cost, while α_i is a good i-specific fixed effect.[31]

I use the "within" (fixed-effects) estimator and report White robust standard errors and t-statistics of coefficients in column A of table 1 in appendix F.[32] The regression yields estimates for β_y and β_τ of 0.0761 (0.0023) and 0.1577 (0.0030), respectively. Thus, controlling for transportation costs and good-specific characteristics, countries that are twice as rich in per-capita terms pay over 7% more for identical items.

In the same table, I address the issue of taste heterogeneity by controlling for the Scandinavian, Eastern European and Mediterranean regions.[33] I further control for demographic characteristics of each market, such as the size of the adult female population, and the Gini income inequality coefficient, which affect pricing practices of firms when consumers are modeled to have non-homothetic preferences.[34] Moreover, in order to control for the possibility that Mango responds to competitive pressures when pricing its products, I use data on the number of stores its major competitors Zara, Miss Sixty and Bershka have in each destination. Across these scenarios, price elasticities with respect to income range between 0.0396 and 0.0750. Finally, I obtain per-capita television advertising costs for a subsample of Western European countries, to control for the possible effects marketing expenditures may have on prices charged across different destinations, and find an increase in the price elasticity with respect to income to 0.3701.

In column B of table 1 in appendix F, I repeat all exercises for a subset of countries that belong to the Euro zone as of January 1, 2008, allowing me to exclude exchange rates from the analysis. The estimated elasticity of price with respect to income rises to 0.1204 (0.0027), after controlling for transportation costs and good-specific characteristics.

The empirical analysis in this section allows me to conclude that Mango exploits cross-country differences in price elasticities of demand and sets systematically higher prices and mark-ups in richer destinations.

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

[32] Errors clustered by country do not affect the significance of the results.

[33] Taste heterogeneity would undermine my results if preferences over Mango clothes were systematically (and positively) related to income. Given the presence of much more expensive clothing brands in richer countries, preferences for Mango clothes are likely stronger in poorer rather than richer countries.

[34] See Lu (2010) for an extension of the log non-homothetic model I propose in this paper that features within-country consumer heterogeneity and richer micro-level pricing implications.

4 Quantitative Analysis

The model outlined in the previous section has a rich set of predictions, which are consistent with empirical regularities observed in the data. However, the analysis so far has been reduced to comparative static exercises, under the assumption of exogenously fixed parameter values. But, some of the parameter values vary systematically with certain country characteristics, such as per-capita income. Consequently, in this section, I evaluate the quantitative ability of the mechanism introduced in this paper to account for observed cross-country patterns in aggregate price levels of final tradable goods. The analysis will allow me to address the following two questions: First, what are the key parameters that lie behind the quantitative success of the model? Second, to what extent can the model generate the price-income relationship that characterizes the 123 economies considered in the introductory section, while maintaining quantitative consistency with remaining macroeconomic phenomena across these countries?

To being answering the first question, it is useful to substitute expression (18) into (22), and re-examine the decomposition of the relative price of an identical good produced by a firm with productivity draw ϕ, originating from country i and sold in markets j and k:

$$\frac{p_{ij}(\phi)}{p_{ik}(\phi)} = \underbrace{\left(\frac{\tau_{ij}}{\tau_{ik}}\right)^{\frac{1}{2}}}_{\text{barriers}} \underbrace{\left(\frac{w_j}{w_k}\right)^{\frac{1}{2(\theta+1)}}}_{\text{income}} \underbrace{\left(\frac{\sum_v L_v b_v^\theta (\tau_{vj} w_v)^{-\theta}}{\sum_v L_v b_v^\theta (\tau_{vk} w_v)^{-\theta}}\right)^{-\frac{1}{2(\theta+1)}}}_{\text{general equilibrium object}} \tag{26}$$

Clearly, the numerical value of the entry cost, f_e, and the utility parameter, $\bar{q}$, do not alter relative prices, provided that they are chosen subject to the restrictions imposed by the modeling framework. Furthermore, notice that the first term emphasizes the role of trade barriers, the second determines the extent to which per-capita income affects prices via the Pareto shape parameter, and the third represents a general equilibrium object, where the contribution of the particular destination's characteristics is marginal since they are washed away within a large summation term. Relatively higher trade barriers increase prices as they raise the marginal cost of delivery to the final destination. The Pareto shape parameter affects the extent to which per-capita income differences generate relative price differences across countries. In particular, lower values of θ magnify the importance of per-capita income on the determination of prices. Intuitively, a low Pareto shape parameter results in high variability in firm productivity, thus making goods more dissimilar and less substitutable, which increases the ability of each firm to price-discriminate according to the per-capita income of the consumers. Finally, as is apparent in the third object above, the price of a good is lower in relatively larger and more productive countries due to the tougher competition each firm faces there.

4.1 Benchmark Calibration

4.1.1 Parameter Choices

To begin the exposition, it is useful to analyze the gravity equation of trade suggested by the model. Employing the methodology of Eaton and Kortum (2002), the gravity equation of trade for this model can be written using the bilateral trade shares in (18) as follows:[35]

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

where S_j and S_i represent importer-j and exporter-i fixed effects, with $S_j = \theta \log(w_j) - \log(L_j) - \theta \log(b_j)(\forall j)$. Given θ and an assumed relationship between trade barriers and other exogenous factors, the barriers themselves can be estimated via equation (27), using a simple fixed-effects OLS regression.

I begin by assuming the following functional form for trade barriers corresponding to positive bilateral trade flows:

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

where the dummy variable associated with each effect has been suppressed for notational simplicity. In the above expression, d_k, $k = 1, ..., 6$, quantifies the effect of the distance between i and j lying in the k-th interval[36], b captures the importance of sharing a border and δ_{ij} is an error term.[37] The resulting R-squared from the OLS regression for the sample

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

[36]Intervals are in miles: $[0, 375)$; $[375, 750)$; $[750, 1500)$; $[1500, 3000)$; $[3000, 6000)$; and $[6000, \text{maximum}]$.

[37]I obtain distance and border data from World Bank's Trade, Production and Protection Database provided by Nicita and Olarreaga (2006).

of 123 countries considered in this paper is 0.8031.

For a pair of countries with positive bilateral trade flows, the estimated trade barriers are equivalent. However, for a pair of countries in which only one trading partner exports to the other and not vice verse, the non-exporter is assigned an infinitely high trade barrier, since the log-linear expression above does not allow for zero bilateral trades.[38] Under this specification, I allow the mechanism in the model to generate asymmetric bilateral trade flows, with the exception of zeros.

Continuing on with the gravity equation, a value for the Pareto shape parameter θ is necessary in order to estimate trade barriers. θ, in turn, represents the elasticity of trade, since it governs the rate of change of trade flows with respect to trade barriers, as can be seen from (27). I take a value for θ of 3.8333, which, according to expression (21), yields average mark-up over marginal cost in the economy of 1.15, a midpoint of the estimated mark-up range for the manufacturing sector in OECD countries reported by Martins et al. (1996). This value falls within the $3.6-4.6$ range reported by Simonovska and Waugh (2010), obtained using Simulated Method of Moments in Ricardian and monopolistic competition trade models of heterogeneity.

The remainder of the parameters are determined in the general equilibrium solution of the model, given trade barriers, the elasticity of trade and data on per-capita income, population, average US firm sales and average US firm size.[39] The minimum productivity bound of each country relative to the US, b_i/b_{US}, targets the country's per-capita income relative to the US. b_{US} is in turn chosen to match average US firm sales in 2002 of USD $11,161,200$. Finally, as shown above, fixed costs of market entry and the utility parameter do not affect relative prices. Nonetheless, I select values for them, since they act as scale multiples of the remaining parameters in the model. The utility parameter $\bar{q}$, which scales sales and profits of firms, targets average US firm size of 41 workers per firm. The fixed cost of entry f_e, which scales productivity thresholds, is chosen to ensure that lower productivity bounds do not exceed thresholds, $\min_{i,j} \phi^*_{ij}/b_i = 1$. A detailed description of the system of equations characterizing equilibrium in the calibrated model can be found in appendix D.

[38]This asymmetry has implications regarding cross-country arbitrage. Suppose country i does not export to j, but exports to k. Further suppose k exports to j. Then, $\tau_{ij} = +\infty$, but $\tau_{ik}, \tau_{kj} < +\infty$, and regardless of the price a firm from i would charge to k, there would always be an arbitrage opportunity to re-export to j, where the price is infinite. Ignoring these trivial cases when checking for arbitrage opportunities, the calibrated model violates triangular arbitrage in only one instant, which given the total number of triangular arbitrage permutations possible for 123 countries, is not statistically significant.

[39]2004 per-capita and population data are from WDI. 2002 average US firm sales and firm size data are from Annual Survey of Manufacturers (ASM).

4.1.2 Income Differences and Prices of Tradables

In this section, I evaluate the ability of the model to account for the observed differences in prices of final tradable goods across countries. As discussed in section 1, tradable goods are systematically more expensive in richer (per-capita) countries and the estimated price elasticity with respect to income is 0.1066 (0.0121).[40] In order to evaluate the ability of the model to reconcile these observations, I solve its calibrated version and calculate the price levels of tradable goods.[41]

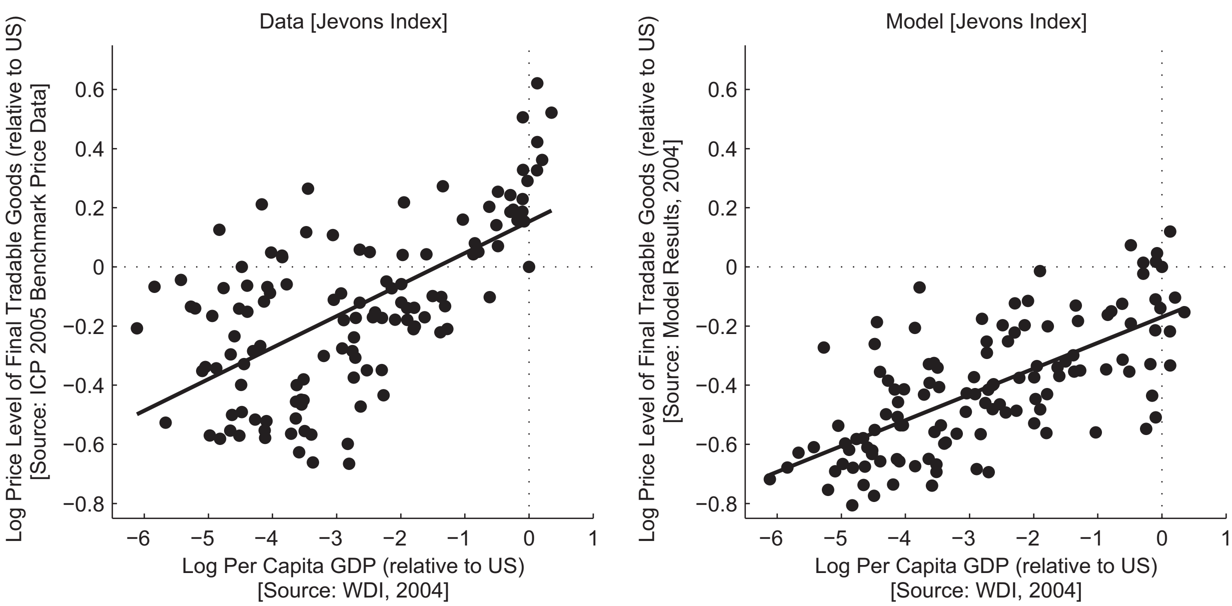

Figure 2: Price Level of Final Tradable Goods and Per-Capita GDP for 123 Countries

Figure 2 plots the price-income relationship for 123 countries resulting from the data and the model, whose parameters have been calibrated to match the moments discussed above.[42] The elasticity of the price level of tradables with respect to per-capita income suggested by the model is 0.0873 (0.0085). Thus, the model captures roughly 80 percent of the relationship

[40]This elasticity drops to 0.1042 (0.0115) when I add country population size to the regression, whose coefficient is in turn -0.0430 (0.0115).

[41]The price data I am interested in is from the 2005 International Comparison Program Benchmark Studies. I use data at the basic-heading level, the lowest level of aggregation possible, and combine it to calculate price indices according to the Jevons method. I repeat the procedure for the model. Appendix B describes the accounting procedure for the data and the model in detail.

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

observed in the data.[43]

To understand the quantitative result, refer to expression (26), which decomposed the relative price of a good into the direct effects of trade barriers and per-capita income, via the elasticity of trade, and the indirect effects caused by the general equilibrium object.

In the benchmark specification, trade barriers are assumed to be symmetric between a pair of countries, as long as both countries positively export to each other. If one country fails to export to another, it is assumed to face an infinitely high trade barrier toward that destination. The latter is particularly common for poor countries, but it has little effect on relative prices, because prices of goods are not recorded when sales are not realized.[44] Moreover, due to the symmetry assumption, bilateral barriers for country pairs with positive trade are not systematically related to per-capita income, so they only add noise to the price-income relationship. The magnitude of the latter relationship is then largely dependent on the elasticity of trade, which if lower, allows for a stronger positive correlation between prices and income. Hence, it is important to verify that the chosen value of this parameter is quantitatively consistent with other macroeconomic variables.

One such variable is the average mark-up in a country, which is entirely pinned down by θ in expression (21). This statistics takes on an average value of 1.15 across manufacturing industries in OECD countries, as reported by Martins et al. (1996), and served as the target for θ in the benchmark calibration. But, more importantly, θ also affects the response of the extensive import margin in this economy to the per-capita income of the importer. The relationship can be seen in expression (17), which shows that the strength of the direct contribution of per-capita income to the extensive import margin is determined by the choice of the elasticity of trade, θ.

In order to verify the choice of θ in the benchmark calibration, I test the quantitative relationship between the extensive import margin and per-capita income predicted by the model. To do so, I derive a measure of the extensive margin for each country in my sample, using the methodology of Hummels and Klenow (2005). While a detailed algebraic derivation can be found in appendix E, a country's extensive import margin essentially measures the fraction of world imports that occur in the source-categories in which that country imports. With this measure in mind, the elasticity of the extensive margin of imports with respect

[43]The price elasticity with respect to per-capita income in the calibrated model drops to 0.0867 (0.0085) when I add country population size to the regression, whose coefficient is in turn -0.0114 (0.0085).

[44]The Jevons methodology to compute price levels is particularly useful in minimizing the bias due to missing goods prices as it computes relative prices via cross exchange rates implied by all countries in the sample. This is discussed in detail in appendix B.

to per-capita income arising from the calibrated model is 0.47(0.06). The same statistic with respect to total income of a country is 0.24(0.05). In turn, the corresponding statistics reported by Hummels and Klenow (2005) for a set of 59 importers from 110 sources in 1996 are 0.45(0.06) and 0.26(0.03), respectively. Hence, the results support the choice of parameters that constitute the benchmark calibration of the model.

4.2 Importance of Trade Barriers

Trade barrier estimates from gravity models of trade have serious quantitative implications about the relationship between prices and income. From the first term in expression (26), notice that, should trade barriers be systematically related to per-capita income, they would affect the quantitative price-income relationship generated by the model. In order to allow for a potential systematic relationship between trade frictions and per-capita income, I depart from the assumed symmetry in the benchmark exercise, and modify the barriers in (28) to incorporate either importer- or exporter-specific fixed effects, as postulated by Eaton and Kortum (2002) and Waugh (2009), respectively.

Trade barrier estimates effectively alter measured bilateral marginal costs of delivery. To illustrate how measured delivery costs behave across countries, it is useful to suppress mark-ups from the analysis. This can be achieved by examining a model in which firms charge *constant* mark-ups, but production and delivery costs are identical to the model with variable mark-ups. The CES framework of Melitz (2003), achieves just that, when firm productivities are assumed to follow the Pareto distribution, as postulated by Chaney (2008). The model is outlined in appendix A. Under the assumption that fixed market access costs are incurred in destination wages, the CES model yields the identical gravity equation of trade in expression (27). Hence, given per-capita income and population data, as well as a value for the Pareto-shape parameter θ, the CES and the non-homothetic model return identical lower productivity bounds. The identical calibrated minimum productivity bounds and trade barriers, together with per-capita and population data, give rise to equivalent Jevons indices of (relative) marginal costs of production and delivery in the two models.

Figure 3 plots the Jevons index of calibrated costs of production and delivery against per-capita income of each country, under the trade barrier specifications of Waugh (2009) and Eaton and Kortum (2002), respectively. For the CES model only, relative marginal costs of production and delivery also represent relative prices across countries, since firms charge constant mark-ups over marginal cost.

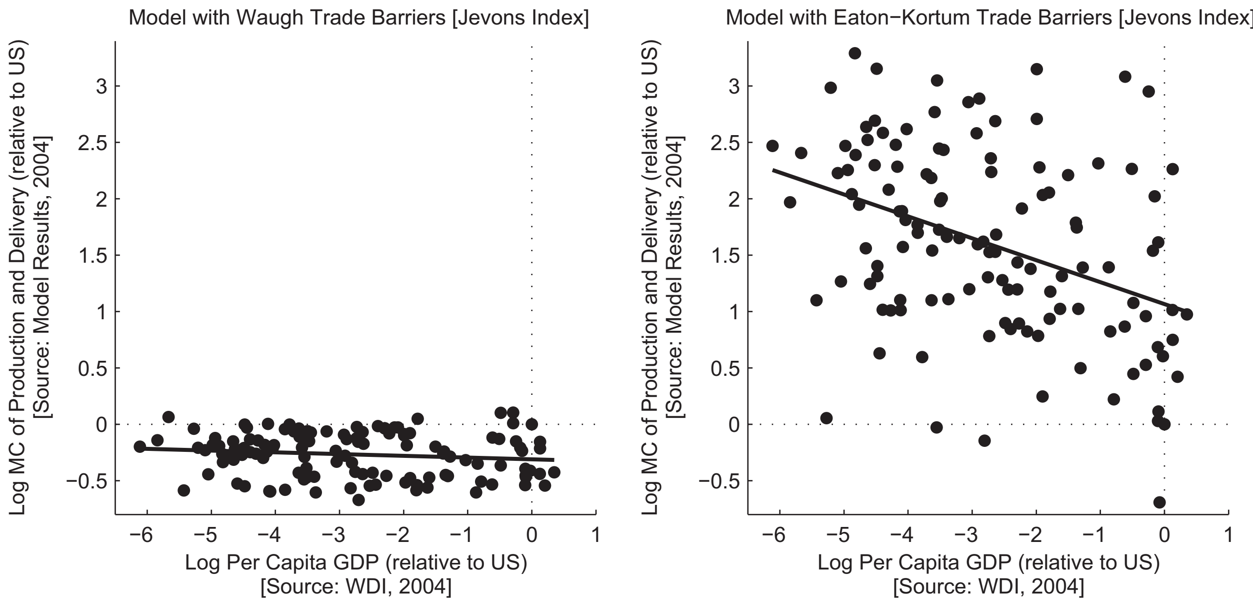

Figure 3: Marginal Cost of Production and Delivery and Per-Capita GDP for 123 Countries

Prices in the CES model, via production and delivery costs, are dramatically different under the two trade-barrier specifications. When trade barriers are exporter-specific, prices do not display a systematic relationship with per-capita income. However, when barriers are importer-specific, poorer countries have systematically higher prices, as the elasticity of price with respect to per-capita income is $-0.1946(0.0418)$. To understand the difference, note that poor countries have relatively low import- and export- to GDP ratios, which suggests they are plagued by low productivity levels, resulting in high marginal costs of production. When trade barriers are modeled to be exporter-specific, the low productivities of poor exporters raise the trade barriers they face to export to any destination. Consequently, poor exporters charge high prices regardless of the per-capita income of the market they sell to, which results in an elasticity of price with respect to the income of a destination that is not statistically different from zero. On the other hand, when trade barriers are assumed to be importer-specific, all exporters find it particularly costly to sell to poor destinations. Hence, poor countries not only incur high costs of production, but also impose high barriers to trade, which results in high prices of tradable goods in these countries.

Waugh (2009) made the above argument for Ricardian models of trade that rely on the CES utility specification.[45] Waugh (2009) further convincingly argued that poor countries

[45]Waugh (2009) demonstrated this finding using exact CES price indices, rather than the Jevons indices used by the ICP, but the results were nearly identical.

not only trade little, but they also export (import) systematically less (more) to (from) rich countries. The observation led the author to conclude that exporter-specific barriers to trade better capture bilateral trade flows. However, even when trade barriers are exporter-specific, CES models fail to generate a positive relationship between prices and per-capita income, which is apparent in the left panel of figure 3, where the elasticity of price with respect to income is not statistically different from zero.

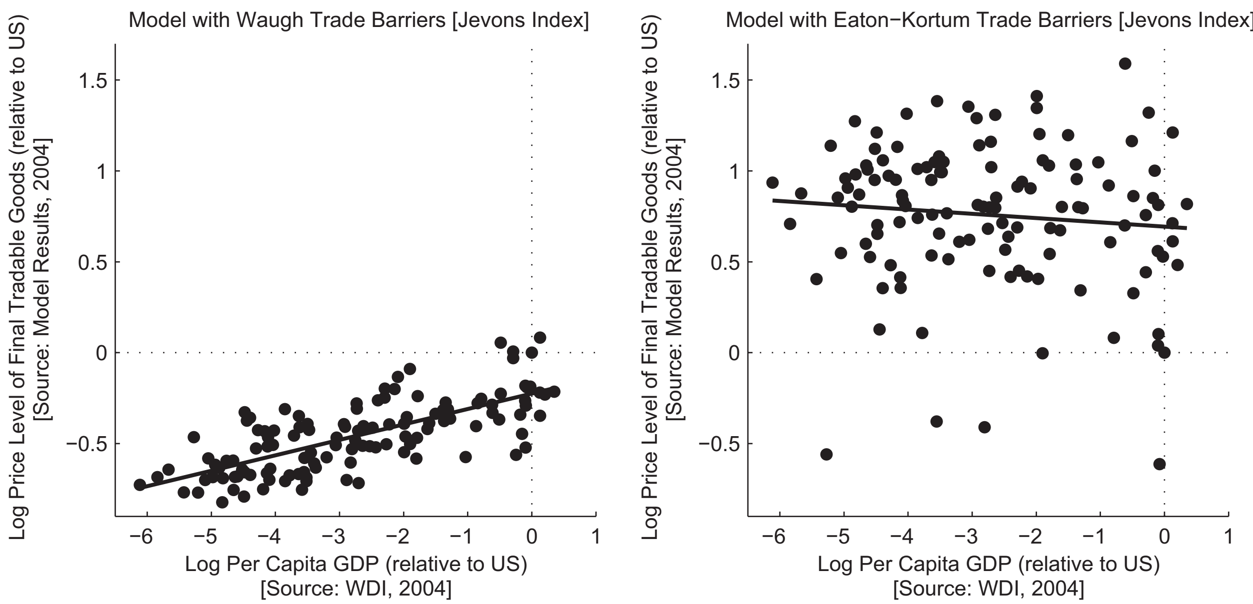

Figure 4: Price Level of Final Tradable Goods and Per-Capita GDP for 123 Countries

The pricing-to-market mechanism introduced in this paper makes a great improvement along the price dimension. Figure 4 plots Jevons price indices arising from the non-homothetic model against per-capita income of each country, under the trade barrier specifications of Waugh (2009) and Eaton and Kortum (2002), respectively.[46] When trade barriers are exporter-specific, the model yields an elasticity of the price level of tradables with respect to per-capita income of 0.0850(0.0074), and when they are importer-specific, the corresponding statistic is −0.0235(0.0213), which is not statistically different from zero.[47] Hence, the

[46]When trade barriers are asymmetric, arbitrage opportunities arise quite often. First, the barriers themselves violate triangular arbitrage 12,228 times. Thus, excluding trivial cases where trade barriers are infinite, $\tau_{ik} > \tau_{ij}\tau_{jk}$ in 12,228 cases. This suggests that asymmetric trade barriers pose a serious problem not only for the non-homothetic model, but also for CES monopolistic competition frameworks, where due to constant mark-ups, prices would violate arbitrage in the same number of instances. In fact, in the model with variable mark-ups, prices violate arbitrage less frequently; 4,757 times when barriers are importer-specific, and 7,133 when they are exporter-specific.

[47]With exporter-specific trade barriers, the elasticity drops to 0.0847 (0.0074) when I add country popu-

pricing-to-market mechanism neutralizes the strong force high trade barriers exert on prices in poor countries when barriers are importer-specific. Moreover, under the preferred barrier specification of Waugh (2009), the non-homothetic model can generate over eighty percent of the relationship between prices and income in the data, which is in line with the results obtained from the benchmark calibration in section 4.1.2.

4.3 Importance of the Elasticity of Trade

The elasticity of trade parameter θ governs the response of prices and imported varieties to the per-capita income of a country. Since each variety is produced by a different firm, θ necessarily affects how the measure of exporting firms varies with destinations' per-capita income, as was shown in expression (19). Empirically, Eaton et al. (2004), Eaton et al. (2008) and Arkolakis (2008b) report that in 1986, the elasticity of the number of French firms selling to a market, normalized by their market share there, with respect to the per-capita income of the destination is 0.71.[48] Thus, for the purpose of sensitivity analysis, I choose θ so that the model delivers an elasticity of the measure of US firms (normalized by market share) to destination per-capita income of 0.71. With this targeted moment, and symmetric trade barriers, I recalibrate the model and generate price levels of tradables.[49]

Figure 5 plots the prices of tradables against income, having chosen a value of θ of 2.625, which matches US firm entry in different markets. Moreover, the right panel of the plot also shows the measure of US firms, normalized by market share per destination, in response to the per-capita income of the market. Clearly, more US firms enter richer markets, with the targeted elasticity of 0.7100(0.0645). Prices of tradables, in turn, respond to per-capita income with an elasticity of 0.1202(0.0101), allowing the model to generate an even stronger relationship than the one observed in the data.[50]

lation size to the regression, whose coefficient is in turn -0.0065 (0.0074); and with importer-specific trade barriers, the elasticity drops to a non-statistically significant value of -0.0290 (0.0193) when I add country population size to the regression, whose coefficient is in turn -0.0998(0.0193) and is highly significant.

[48] The studies also report that the elasticity of the number of French firms selling to a market, normalized by their market share there, with respect to the population size of the destination is 0.57. Expression (19) shows that the elasticity of trade, θ, is the only exogenously-specified parameter that governs the response of firm entry to per-capita income and size, since productivities and trade barriers are calibrated in the general equilibrium solution of the model. Given this restriction, the model cannot capture the response to both variables jointly.

[49] With symmetric trade barriers, the calibrated model violates triangular arbitrage in only one instant, which given the total number of triangular arbitrage permutations possible, is not statistically significant.

[50] The elasticity drops to 0.1177 (0.0093) when I add country population size to the regression, whose coefficient is in turn -0.0454 (0.0093).

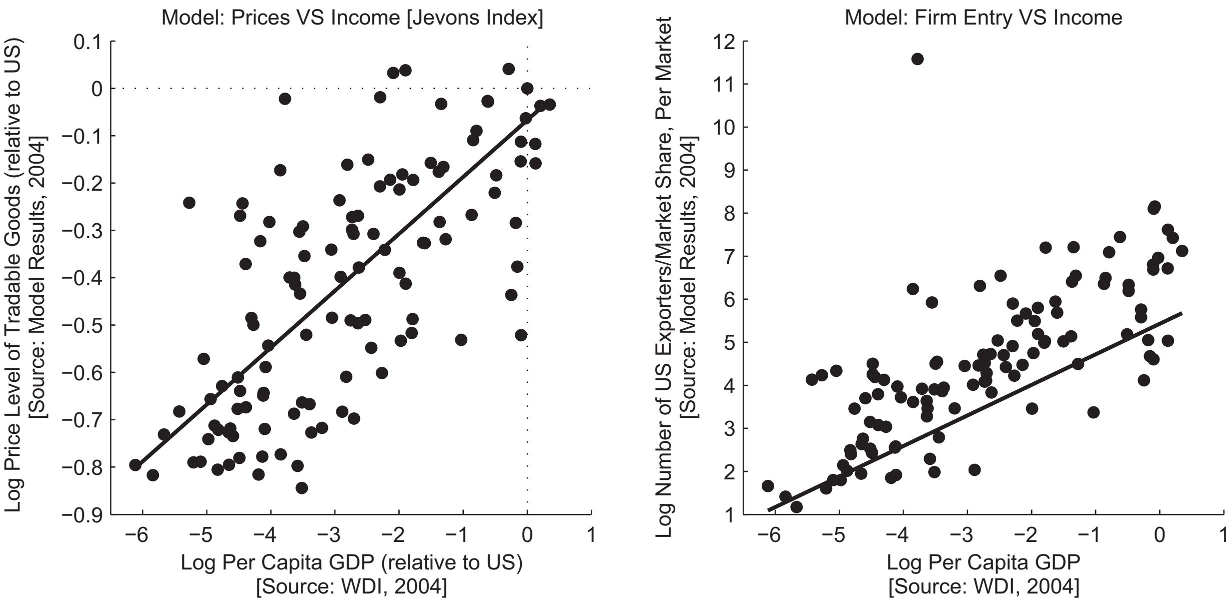

Figure 5: Prices, Firm Entry and Per-Capita Income

The quantitative success of the model reflects the choice of θ, which when lower, allows per-capita income to exert a greater force on prices of tradables, as illustrated in expression (26). Lower values of the elasticity of trade, θ, yield lower elasticities of substitution across goods, allowing firms to price-discriminate more heavily. A strong relationship between prices of tradables and per-capita income is a natural outcome.

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 model in which trade barriers segment international markets, allowing firms to exploit varying demand elasticities across countries with different income levels. Such behavior is apparent in a novel database I bring forward, which features a clothing manufacturer who supplies products at systematically higher prices to richer markets. Moreover, the mechanism I introduce in this paper further captures a documented empirical regularity that richer countries not only spend more per product, but also consume more diverse bundles of goods. Quantitatively, the model suggests that variable mark-ups can account for eighty percent of the observed positive relationship between prices of tradables and income across 123 countries.

On a broader scale, this paper emphasizes the role income differences play in shaping cross-country price variation in tradable consumption goods as well as 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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Appendix

A CES Model

This section outlines a variant of the CES model of Melitz (2003) and Chaney (2008).

The maximization problem of a consumer in country j buying goods from (potentially) all countries $\upsilon = 1, ..., I$ is:[51]

$$\max_{\{q^c_{\upsilon j}\}^I_{\upsilon=1} \geq 0} \left(\sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}} \left(q^c_{\upsilon j}(\omega) \right)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}$$
$$\text{s.t.} \quad \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}} p_{\upsilon j}(\omega) q^c_{\upsilon j}(\omega) d\omega \leq w_j.$$

I retain the market structure of the non-homothetic model in the text. Then, the demand for variety of type ϕ originating from country i consumed in a positive amount in country j, $q_{ij}(\phi) > 0$, is given by:[52]

$$q_{ij}(\phi) = w_j L_j \frac{p_{ij}(\phi)^{-\sigma}}{P_j^{1-\sigma}}, \tag{29}$$

where

$$P_j^{1-\sigma} = \sum_{\upsilon=1}^{I} N_{\upsilon j} \int_{\phi^*_{\upsilon j}}^{\infty} p_{\upsilon j}(\phi)^{1-\sigma} \mu_{\upsilon j}(\phi) d\phi, \qquad \sigma > 1. \tag{30}$$

From (29), notice that the productivity threshold in this economy cannot be determined using the demand for the cutoff variety. Instead, it is necessary to introduce fixed market access costs in order to bound the measure of firms that serve each market.

Using (29), the profit maximization problem of a firm with productivity draw ϕ originating in country i and considering to sell to country j is:

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

[51] CES utility constitutes a limiting case of the general utility function outlined earlier, with $\bar{q} \to 0$.

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

In the above problem, I assume that each firm incurs a fixed cost, $f > 0$, in order to sell to a particular market. Moreover, the fixed cost is paid in terms of labor units of the destination country.[53]

The optimal pricing rule of a firm with productivity draw $\phi \geq \phi^*_{ij}$ is given by a constant mark-up over marginal cost of production and delivery: $p_{ij}(\phi) = \frac{\sigma}{\sigma-1}\frac{\tau_{ij}w_i}{\phi}$.

B Price Levels of Final Tradable Goods

In this section, I describe the procedure used to derive the price level of final tradable goods in the data and the models analyzed in this paper.

I use data from the 2005 round of the International Comparison Program (ICP) at the basic heading level provided by the World Bank. According to the ICP Handbook[54], unit price data on goods with identical characteristics are collected across retail locations in the participating countries. The lowest level of aggregation is the basic heading (BH), which represents a narrowly-defined group of goods for which expenditure data are available. There are a total of 129 BHs in the data set. Each BH contains a certain number of products. Hence, the reported price of a BH is an aggregate price. An example of a basic heading is "1101111 Rice", which is made up of prices of different types of rice contained in specific packages.

In order to derive the price of a BH, the ICP uses a Jevons index.[55] For all N countries and I products within the basic heading, the ICP collects unit prices. The goal is to find the equivalent product in every country, thus washing away any quality differences. If an identical product is not found, the price entry is either left blank, resulting in missing observations, or a comparable product is found, ensuring that its specifications are carefully recorded so that quality adjustments can be made to the price entry.

A numeraire country is chosen, USA, and prices are expressed in 2005 US dollars. The Jevons index at the BH-level is a geometric average of relative prices of goods available in the US and another country. However, not all goods are found in all countries, resulting in price indices that are not transitive. Consequently, geometric averages are taken for every

[53]These two assumptions do not change the predictions of the model with respect to price levels, but they help the model generate the gravity equation in expression (27). Hence, I can use the same parameter estimates for the two models in the quantitative analysis of price levels.

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

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

pair of countries in the sample, and then prices relative to the US are computed using cross prices. The procedure, which yields transitive price indices, can be summarized as follows:

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

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

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

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

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

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

I use prices at the BH-level to arrive at the price level of final tradable goods by computing geometric averages across BHs that correspond to final tradable categories for 123 countries. Since there are no zero observations across these categories for the sample of countries I study, the price levels are transitive.

I now describe the Jevons index as it applies to the non-homothetic model. In this framework, a good is differentiated by the productivity of the firm producing it, as well as the source country of the firm. Hence, it is natural to think of goods produced by firms with identical productivities from different source countries as varieties. In a destination, a basic heading would then reflect the prices of the varieties produced with a particular productivity across all sources from which that destination imports. Hence, there would be a continuum of basic headings in each destination. As shown below, this is not a problem, since the relative (not absolute) price of a variety across destinations does not reflect the productivity of a firm producing it, hence all basic headings are identical.

First, I compute the Jevons index of a basic heading corresponding to productivity ϕ, based on the goods available in destinations j and k. Given source country υ, if $\phi_{\upsilon j}^* \neq \phi_{\upsilon k}^*$, then not all firms from country υ serve both destinations. Hence, only basic headings $\phi \geq \max[\phi_{\upsilon j}^*, \phi_{\upsilon k}^*]$ $(\forall \upsilon)$ are relevant in my comparison. The relative price of basic heading

$\phi \geq \max[\phi^*_{\upsilon j}, \phi^*_{\upsilon k}]$ $(\forall \upsilon)$ based on the goods available in destinations j and k is:

$$P^{j,k}_{jk} = \left[\prod_{\upsilon=1}^{M_{jk}} \frac{p_{\upsilon j}(\phi)}{p_{\upsilon k}(\phi)} \right]^{\frac{1}{M_{jk}}}, \tag{31}$$

where M_{jk} is the number of source countries that export to both j and k.

However, the relative price a given firm ϕ charges in two destinations is independent of the firm's productivity, and only reflects relative trade barriers and bilateral productivity cutoffs. Thus, (31) becomes:

$$P^{j,k}_{jk} = \left[\prod_{\upsilon=1}^{M_{jk}} \frac{\tau_{\upsilon j}}{\tau_{\upsilon k}} \left(\frac{\phi^*_{\upsilon j}}{\phi^*_{\upsilon k}} \right)^{-\frac{1}{2}} \right]^{\frac{1}{M_{jk}}}.$$

Using this expression in step 2 allows me to compute the Jevons index between countries j and k for this particular basic heading. Since the relative price of the basic heading does not depend on the productivity associated with producing varieties of this good, this statistic also represents the entire Jevons index between a pair of countries.

The procedure to compute Jevons indices for the CES model is identical. In this case, however, individual good prices simply reflect trade barriers and wages, since the model yields constant mark-ups.

C Consumer Problem, Firm Problem and Equilibrium

C.1 Deriving Consumer Demand

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

$$\max_{\{q^c_{\upsilon j}\}^I_{\upsilon=1} \geq 0} \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}} \log(q^c_{\upsilon j}(\omega) + \bar{q}) d\omega \quad \text{s.t.} \quad \lambda_j \left[\sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}} p_{\upsilon j}(\omega) q^c_{\upsilon j}(\omega) d\omega \leq w_j \right], \tag{32}$$

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

$$\lambda_j p_{ij}(\omega) = \frac{1}{q^c_{ij}(\omega) + \bar{q}}. \tag{33}$$

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

For any pair of goods $\omega_{ij}, \omega'_{\upsilon j} \in \Omega_j^*$, (33) gives:

$$p_{ij}(\omega)\left(q_{ij}^c(\omega) + \bar{q}\right) = p_{\upsilon j}(\omega')\, q_{\upsilon j}^c(\omega') + p_{\upsilon j}(\omega')\,\bar{q}. \tag{34}$$

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 $\omega_{ij} \in \Omega_j^*$:

$$\begin{aligned}
\int_{\Omega_j^*} \left[p_{ij}(\omega)\left(q_{ij}^c(\omega) + \bar{q}\right)\right] d\omega' &= \int_{\Omega_j^*} \left[p_{\upsilon j}(\omega')\, q_{\upsilon j}^c(\omega') + p_{\upsilon j}(\omega')\,\bar{q}\right] d\omega' \\
\Rightarrow \left[p_{ij}(\omega)\left(q_{ij}^c(\omega) + \bar{q}\right)\right] \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}^*} 1 d\omega' &= \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}^*} \left[p_{\upsilon j}(\omega')\, q_{\upsilon j}^c(\omega') + p_{\upsilon j}(\omega')\,\bar{q}\right] d\omega' \\
\Rightarrow \left[p_{ij}(\omega)\left(q_{ij}^c(\omega) + \bar{q}\right)\right] \sum_{\upsilon=1}^{I} N_{\upsilon j} &= w_j + \sum_{\upsilon=1}^{I} \int_{\Omega_{\upsilon j}^*} p_{\upsilon j}(\omega')\,\bar{q} d\omega' \\
\Rightarrow \left[p_{ij}(\omega)\left(q_{ij}^c(\omega) + \bar{q}\right)\right] N_j &= w_j + \bar{q} P_j \\
\Rightarrow q_{ij}^c(\omega) &= \frac{w_j + \bar{q} P_j}{N_j p_{ij}(\omega)} - \bar{q}
\end{aligned} \tag{35}$$

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:

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

C.2 Solving the Firm Problem

Recall (5), which gives the profit maximization problem of a firm with productivity draw ϕ originating in country i and considering to sell to country j. Since there is a continuum of firms, an individual monopolistic competitor does not view aggregate variables, P_j and N_j, as choices. Hence, the FOC of the firm's problem is:

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

which results in the optimal price of:

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

C.3 Solving for Equilibrium Objects

In this section, I 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 then derive a set of equations that solve for the wage rates of all countries simultaneously.

Straightforward algebraic manipulations allow me to obtain the aggregate price statistic P_j, the measure of firms serving each destination N_{ij}, and the productivity thresholds ϕ^*_{ij}, in terms of wages and measures of entrants for each country.

As described in section 2.4, to solve the model, it is necessary to jointly determine wages, w_i, and the measures of entrants, J_i, $\forall i$. The system of equilibrium equations consists of the free entry condition, (14), and the income/spending equality, (15), for each country.

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

$$w_i f_e=\sum_{\upsilon=1}^{I}\left(\frac{b_i}{\phi^*_{i\upsilon}}\right)^{\theta}\frac{\bar{q}\tau_{i\upsilon}w_iL_\upsilon}{\phi^*_{i\upsilon}(\theta+1)(2\theta+1)}. \tag{36}$$

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

$$L_iw_i=\sum_{\upsilon=1}^{I}J_i\frac{b_i^{\theta}}{{\phi^*_{i\upsilon}}^{\theta}}\frac{\bar{q}\tau_{i\upsilon}w_iL_\upsilon}{\phi^*_{i\upsilon}(2\theta+1)}. \tag{37}$$

Expressions (36) and (37) yield:

$$J_i=\frac{L_i}{(\theta+1)f_e}. \tag{38}$$

To characterize wages, I use import shares λ_{ij}, and the trade balance $\sum_j T_{ij}=\sum_j T_{ji}$, to arrive at:

$$\frac{w_i^{\theta+1}}{b_i^{\theta}}=\sum_{j=1}^{I}\left(\frac{L_jw_j}{{\tau_{ij}}^{\theta}\sum_{\upsilon=1}^{I}L_\upsilon b_\upsilon^{\theta}(\tau_{\upsilon j}w_\upsilon)^{-\theta}}\right). \tag{39}$$

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

D Calibration

Given a value of θ and bilateral trade barriers, estimated from the gravity equation of trade, I can compute all lower productivity bounds b_i using (39) and per-capita income (w_i) and population (L_i) data. Since the system in (39) is homogeneous in b, I choose to normalize b_{US}. This amounts to replacing the equation corresponding to $i = US$ in (39) with an expression that describes the moment in the data I choose in order to calibrate b_{US}. My moment of choice is average US firm sales in 2002, which amount to USD $11,161,200$. The corresponding expression for average sales of all US firms is: US sales home and abroad, divided by the measure of firms operating in the US (which implicitly includes US firms that sell at home and abroad, since the latter are a subset of the former as $\phi^*_{US,US} \leq \phi^*_{US,j} (\forall j)$):

$$11,161,200 = \frac{\sum_j T_{US,j}}{N_{US,US}}. \tag{40}$$

Next, I choose $\bar{q}$ to match average US firm size in 2002 of 41 workers. The corresponding expression of average US firm size is the ratio of the US population, which equals total number of workers in this model, to the measure of firms operating in the US:

$$41 = \frac{L_{US}}{N_{US,US}}. \tag{41}$$

Expressions (40) and (41) yield:

$$\begin{aligned} \frac{11,161,200}{41} &= \frac{\sum_j T_{US,j}}{L_{US}} \\ \Rightarrow \frac{11,161,200}{41}\frac{w_{US}^\theta}{b_{US}^\theta} &= \sum_j \left(\frac{L_j w_j}{{\tau_{US,j}}^\theta \sum_v L_v b_v^\theta (\tau_{vj} w_v)^{-\theta}} \right). \end{aligned} \tag{42}$$

Notice the resemblance between expression (42) and (39) for $i = US$. Indeed (42) serves the purpose of (39) under the proposed normalization. Hence, expression (39) for all $i \neq US$, together with (42) for the US, calibrate all lower-productivity bounds in this economy. Subsequently, the numerical value of $\bar{q}$ is computed from 42. Finally, to ensure that productivity cutoffs do not lie below calibrated productivity lower bounds, an adjustment to the fixed entry cost f_e is necessary. I choose f_e such that $\min_{i,j} \phi^*_{ij}/b_i = 1$, that is, the fixed entry cost is just low enough so that the lowest productivity cutoff is just equal to its corresponding lower bound. Thus, for at least one country, all potential producers end up producing in equilibrium.

E Extensive Margin of Imports

Hummels and Klenow (2005) define the extensive import margin for country j as follows:

$$EM_j = \frac{\sum_{i \neq j} \sum_{s \in M_{ijs}} m_{iWs}}{m_W},$$

where m_W is world imports, m_{iWs} is world imports from country i in category s, M_{ijs} is the set of source-categories (i, s) for which $m_{ijs} > 0$, and m_{ijs} is j's imports from i in category s. In the model, world imports are the total imports of all countries υ from all sources i, $\sum_\upsilon \sum_{i \neq \upsilon} T_{i\upsilon}$. A source-category pair in the model corresponds to a variety produced by firm with draw ϕ originating from country i. This variety is positively imported by j if and only if $\phi \geq \phi^*_{ij}$. Hence, M_{ijs} is the set containing all such varieties. Finally, for a given good $\phi \in M_{ij\phi}$, notice that $m_{iW\phi} = \sum_\upsilon p_{i\upsilon}(\phi) x_{i\upsilon}(\phi)$, where the entry is zero for those countries that do not import the good, $\phi < \phi^*_{i\upsilon}$. Thus, when computing world imports of all goods that belong to set $M_{ij\phi}$, I only need to account for goods produced by firms with productivity $\phi \geq \max(\phi^*_{i\upsilon}, \phi^*_{ij})(\forall i \neq j, \upsilon \neq j)$, as the remaining goods are either not positively-consumed by j, or not positively consumed by υ, or both.

With this in mind, the extensive margin of imports in the model is given by:

$$EM_j = \frac{\sum_\upsilon \sum_{i \neq \upsilon} \int_{\max(\phi^*_{ij}, \phi^*_{i\upsilon})}^{\infty} N_{i\upsilon} p_{i\upsilon}(\phi) x_{i\upsilon}(\phi) \mu_{i\upsilon}(\phi) d\phi}{\sum_\upsilon \sum_{i \neq \upsilon} \int_{\phi^*_{i\upsilon}}^{\infty} N_{i\upsilon} p_{i\upsilon}(\phi) x_{i\upsilon}(\phi) \mu_{i\upsilon}(\phi) d\phi}.$$

F Tables and Figures

This section contains all figures and tables referred to in the text.

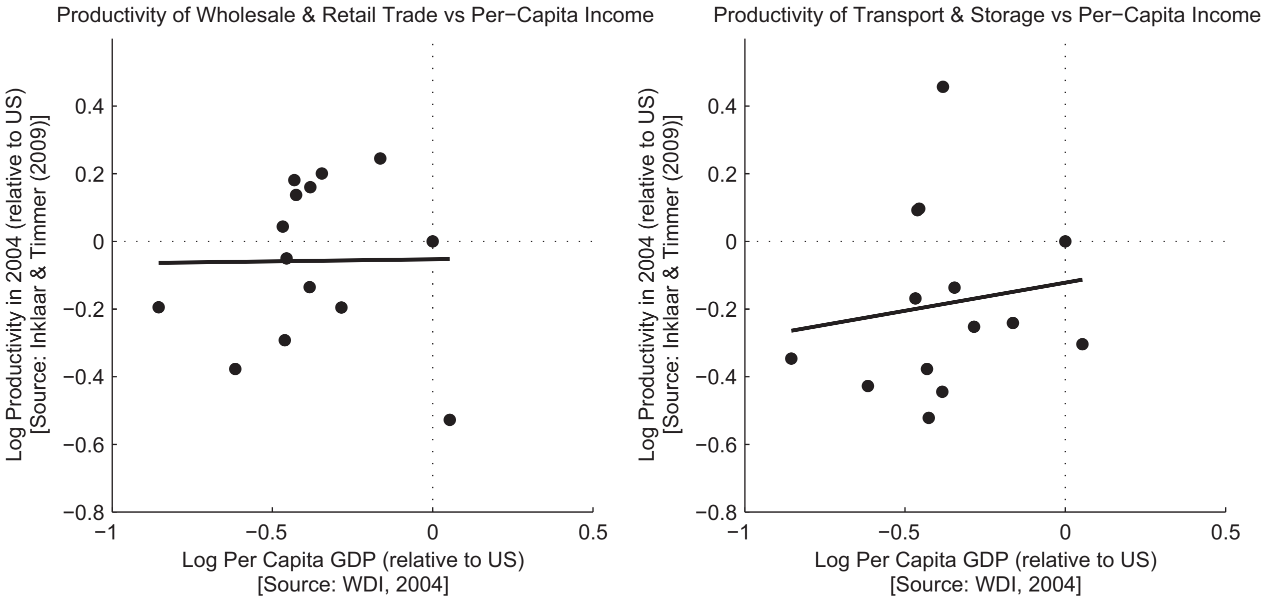

Figure 6: Productivity of Distribution Sectors and Per-Capita Income

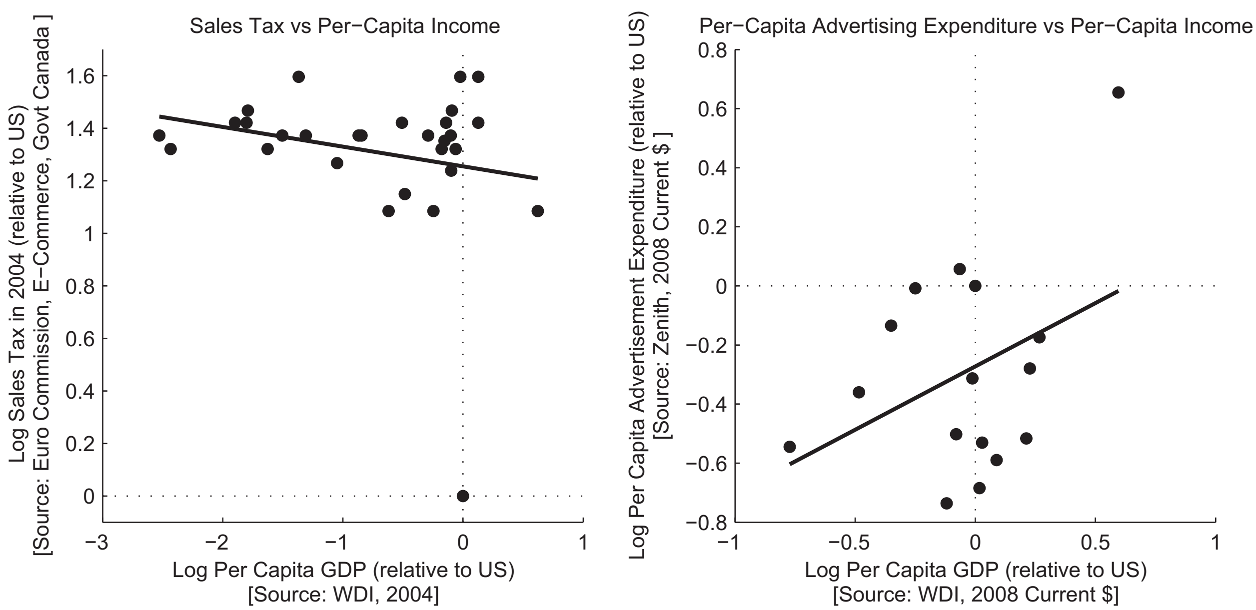

Figure 7: Sales Taxes, Advertising Expenditures and Per-Capita Income

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

Sample	Regression Included Variables —————— Coefficient (St. Error) *t-stat	(1) PCGDP DHL	(2) PCGDP DHL Region Stores Female Pop.	(3) PCGDP DHL Region Stores Female Pop. Gini	(4) PCGDP DHL Region Stores Female Pop. Gini Ad Cost
(A)	Log PCGDP	0.0761 (0.0023) *33.66	0.0750 (0.0043) *17.61	0.0736 (0.0076) *9.72	0.3701 (0.0123) *30.17
(B)	Log PCGDP	0.1204 (0.0027) *44.19	0.0663 (0.0032) *20.67	0.2172 (0.0092) *23.55	0.2120 (0.0099) *21.44

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

Sample (A)

All prices are converted to Euro using February/August 2008 average monthly exchange rates.
(1) 28 countries including: Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, UK.
(2) Regions: Mediterranean, Scandinavian, Eastern. Competitors: Zara, Miss Sixty, Bershka.
(3) Excludes Cyprus and Malta due to data limitations.
(4) Excludes Canada, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Luxembourg, Malta, Poland, Slovakia, Slovenia and Eastern dummy due to data limitations.

Sample (B)

All prices in Euro by default, since countries are members of Eurozone.
(1) 15 countries including: Austria, Belgium, Cyprus, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovenia, Spain.
(2) Regions: Mediterranean, Scandinavian, Eastern. Competitors: Zara, Miss Sixty, Bershka.
(3) Excludes Cyprus and Malta due to data limitations.
(4) Excludes Cyprus, Luxembourg, Malta, Slovenia and Eastern dummy due to data limitations.