

# International Pricing in a Generalized Model of Ideal Variety

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April 2008

**Abstract:** We examine international markups and pricing in a generalized version of an ‘ideal variety’ model. In this model, entry causes crowding in variety space, so that the marginal utility of new varieties falls as market size grows. Crowding is partially offset by income effects, as richer consumers will pay more for varieties closer matched to their ideal types. We show theoretically and confirm empirically that declining marginal utility of new varieties results in: a higher own-price elasticity of demand (and lower prices) in large countries and a lower own-price elasticity of demand (and higher prices) in rich countries. The model is also useful for generating facts from the literature regarding cross-country differences in the rate of variety expansion.

**JEL Classification:** F12, L11

**Acknowledgments:** For very helpful comments we thank two anonymous referees, Ken West, Marc Melitz, Kei-Mu Yi, participants at the EIT 2004 and NBER conferences, and seminar participants at the Universities of Purdue, Vanderbilt, Texas, Indiana and Illinois. Hummels thanks Purdue CIBER and NSF and Lugovskyy thanks Wang CIBER at the University of Memphis for financial support.

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## **I. Introduction**

The Dixit-Stiglitz (1977) model of monopolistic competition has become a workhorse model in many literatures that examine product differentiation in general equilibrium, including literatures on international trade, macroeconomics, and growth and development (see Gordon 1990 and Matsuyama 1995 for literature reviews). The model is widely used because it is tractable. In its most commonly used form the model assumes constant elasticity of substitution (CES) demand so that varieties are not assigned to any particular “address” and product space is effectively infinite. This implies that the elasticity of demand, markups and prices are invariant to market size and firm entry.

We examine an alternative model of horizontal product differentiation with richer implications for pricing. Lancaster (1979) originally developed a model of trade in ideal varieties in which variety space is finite, and varieties have unique addresses in product space. Firm entry causes “crowding” – varieties become more substitutable as more enter the market so that the own price elasticity of demand increases with market size, and prices fall.

We generalize the preferences in the ideal variety framework. Lancaster (1979) assumes that the equilibrium choice of variety is independent of consumption quantities, so that consumers get no closer to their ideal regardless of expenditures. We allow the opportunity cost of the ideal variety to depend on consumers’ individual consumption levels. When incomes rise, consumers increase the quantity consumed, but also place greater value on proximity to the ideal variety. The price elasticity of demand drops and prices rise. In equilibrium, the market responds by supplying more varieties, with lower

output per variety. Essentially, economies of scale forsaken are compensated for by the higher markups that consumers are now willing to pay.

We examine, and confirm, these implications in two exercises focusing on cross-country variation in trade goods prices and in the own-price elasticity of demand. We use Eurostats trade data for 1990-2003 that reports bilateral export prices for 11 EU exporters selling to all importers world-wide in roughly 11,000 products. Unlike many cross-country price studies that rely on domestic price data, our border prices are not contaminated by distribution markups within each country. We have many price observations for the same exporter-product over time, and this allows us to control for unobservables such as product quality that are outside of the model. We control for price levels that are specific to an importer-product, and price changes that are specific to an exporter-product. We can then relate over-time changes in prices for an importer-exporter-product to changes in importer characteristics. We find that price changes co-vary negatively with GDP growth and co-vary positively with growth in GDP per capita (conditioning on GDP growth), consistent with model predictions.

The generalized IV model implies that variation in the elasticity of demand generates cross-importer price differences. We use the TRAINS database on bilateral trade and trade costs to identify the own-price elasticity of demand and examine its co-variation with importer characteristics. We find that the own-price elasticity of demand is increasing in importer GDP and decreasing in importer GDP per capita, consistent with model predictions. The data reveal substantial variation in these elasticities across importers.

This paper relates, and adds to, several literatures. First, we contribute to a

literature in which market entry affects the elasticity of demand facing a firm. Most of the trade theory literature with this feature has emphasized oligopoly and homogeneous goods as in Brander and Krugman (1982).<sup>1</sup> The more sparse empirical literature has focused on plausibly homogeneous goods within a single country, such as the markets for gasoline, (Barron, Taylor, Umbeck 2005) and concrete, (Syverson 2004). In contrast, our model emphasizes free-entry monopolistic competition in a general equilibrium with multiple countries and differentiated goods.<sup>2</sup>

The model's predictions for import market size and the elasticity of demand are similar to quadratic utility models as in Ottaviano, Tabuchi, and Thisse (2003), and Melitz and Ottaviano (forthcoming). We are unaware of other papers that directly test this implication, and so to the extent that model predictions are similar, our empirical findings are consistent with the broader idea of market entry increasing substitutability across goods. However, we also allow for income effects operating through an intensity of preference for the ideal variety that can potentially counteract pure market size effects.<sup>3</sup> These income effects significantly improve our ability to fit the model to the data.

Second, this paper adds to the literature on price variation across markets. The literature on Balassa-Samuelson effects emphasizes the importance of nontraded good prices in explaining why price levels are higher in richer countries. We provide a theoretical explanation and empirical evidence supporting the idea that prices of traded

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<sup>1</sup> An exception here is Krugman (1979). However in his model the elasticity decreases in individual consumption *by assumption*, which i) significantly limits the set of suitable utility functions, ii) keeps the equilibrium value of elasticity invariant to changes in worker productivity.

<sup>2</sup> A similar prediction linking market size to markups is found in monopolistic competition models when the market equilibrium supports a sufficiently small number of firms. However, these strategic pricing effects are quantitatively much smaller than the effects we estimate.

<sup>3</sup> Perloff and Salop (1985) also include preference intensity but do not link it explicitly to observable characteristics of consumers, or consider a trading equilibrium.

goods are also higher in richer countries. A similar prediction using a different channel can be found in Alessandria and Kaboski (2004) who link larger markups in high income importers to consumers' opportunity cost of search.

The literature on pricing-to-market (see Goldberg and Knetter 1997 for an extensive review) has shown that the same goods are priced with different markups and thus have different price elasticities of demand across importing markets. We differ from, and add to, this literature in two ways. First, we show how markups systematically vary across importers depending on market characteristics. Second, we provide a complementary explanation for the variation in markups. The pricing-to-market literature focuses on movements along the *same*, non-CES, demand curves (e.g., Feenstra 1989, Knetter 1993) so that variation in quantities caused by tariff or exchange rate shocks yields variation in the elasticity of demand. We show that variation in market characteristics (size, income per capita), yields *different* demand curves and thus different price elasticities of demand across countries.

Third, we contribute to a relatively new but growing literature providing empirical evidence on models of product differentiation in trade. Most of these papers employ cross-exporter facts to understand Armington v. Krugman style horizontal differentiation as in Head and Ries (2001) and Acemoglu and Ventura (2002), or the importance of quality differentiation as in Schott (2003), Hallak (2004), and Hummels and Skiba (2004), or some combination of the two, as in Hummels and Klenow (2002, 2005). We emphasize cross-importer facts, and depart from the CES utility framework that dominates this literature.

In particular, our model provides a partial resolution to a puzzle about the rate of

variety expansion. Hummels and Klenow (2002) use cross-country data to examine how the variety and quantity per variety of imports co-vary with market size. They show that, while the number of imported varieties is greater in larger markets, variety differences are less than proportional to market size. That is, larger countries import more varieties, but also import higher quantity per variety.<sup>4</sup> The generalized ideal variety model generates this implication but the standard CES model does not. If entry does not “crowd” variety space, the own-price (and cross-price) elasticity of demand is the same regardless of market size. This implies that price and quantity per variety are the same in the two markets, and so there is a strict proportionality between number of varieties and market size.

The rest of the paper is organized as follows. Section II uses a simplified closed economy setting to motivate the generalization of Lancaster compensation function and to concentrate on the comparative statics in the model with a single differentiated product. Appendix 2 demonstrates that the key empirical predictions can also be derived in an open economy model. Sections III-IV provide empirical examinations of model implications for prices and the own-price elasticity of demand. Section V concludes.

## **II. Model**

### *A. Demand Functions*

Preferences of a consumer are defined over a differentiated product  $q$ , which is defined by a continuum of varieties indexed by  $\omega \in \Omega$ . Varieties can be distinguished by a single attribute. We assume that all varieties can be represented by points on the circumference

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<sup>4</sup> Hummels and Klenow (2002,2005) found a similar pattern for exports: variety and quantity per variety expands with exporter size, but less than proportionally. We focus on cross-importer facts in this paper.

of a circle, with the circumference being of unit length.

Each point of the circumference represents a different variety. Each consumer has his most preferred type, which we call his ‘ideal’ variety, and which we denote as  $\tilde{\omega}$ . It is ideal in the sense that given a choice between equal amounts of his ideal variety  $\tilde{\omega}$  and any other variety  $\omega$  consumer will always choose  $\tilde{\omega}$ . Moreover, utility is decreasing in distance from  $\tilde{\omega}$ : the further is the product from the ideal variety the less preferable it is for the consumer. These assumptions are usually incorporated in the formal model with a help of Lancaster’s compensation function  $h(v_{\omega, \tilde{\omega}})$ , defined for  $0 \leq v_{\omega, \tilde{\omega}} \leq 1$ . Lancaster’s compensation function is defined such that the consumer is indifferent between  $q$  units of his ideal variety  $\tilde{\omega}$  and  $h(v_{\omega, \tilde{\omega}})q$  units of some other variety  $\omega$ , where  $v_{\omega, \tilde{\omega}}$  is the shortest arc distance between  $\tilde{\omega}$  and  $\omega$ . It is assumed that:

$$(1) \quad h(0) = 1, \quad h'(0) = 0, \quad \text{and} \quad h'(v_{\omega, \tilde{\omega}}) > 0, \quad h''(v_{\omega, \tilde{\omega}}) < 0 \quad \text{for} \quad v_{\omega, \tilde{\omega}} > 0.$$

The subutility of variety  $\omega$  for consumer whose ideal variety is  $\tilde{\omega}$  is usually assumed to have the following separable form (e.g., Lancaster 1979, 1984, Helpman and Krugman 1985):

$$u(q_{\omega}, \omega, \tilde{\omega}) = \frac{q_{\omega}}{h(v_{\omega, \tilde{\omega}})}$$

The utility function, which includes all varieties  $\omega \in \Omega$ , can then be formulated as

$$(2) \quad u(q_{\omega} \mid \omega \in \Omega) = \max_{\omega \in \Omega} \left[ \frac{q_{\omega}}{h(v_{\omega, \tilde{\omega}})} \right]$$

The budget constraint is:

$$(3) \quad \int_{\omega \in \Omega} q_{\omega} p_{\omega} = I,$$

where  $p_\omega$  are the prices of the varieties being produced and  $I$  is income. We can maximize the utility subject to the budget constraint,  $I$ , and given the prices of differentiated varieties,  $p_\omega$ . The solution to this problem is:

$$(4) \quad q_{\omega'} = \frac{I}{p_{\omega'}}, \quad q_\omega = 0 \quad \text{for } \omega \neq \omega',$$

$$\text{where } \omega' = \arg \min [p_\omega h(v_{\omega, \tilde{\omega}}) \mid \omega \in \Omega].$$

In (4), the utility maximizing variety is independent of expenditures. For example, imagine that the consumer's ideal beverage is apple juice, the price of which is five times higher than the price of water:  $p_{AJ} = 5p_W$ . Equation (4) suggests that the consumer will buy  $\frac{I}{p_W}$  units of water if  $5 > h(v_{W, AJ})$ . This answer holds whether income allows him to buy five cups or fifty gallons of water.

Consider a more general formulation in which the strength of preference for the ideal variety depends on quantities consumed. Formally, we define a generalized compensation function,  $h(q_\omega, v_{\omega, \tilde{\omega}}; \gamma)$ , having the following properties:

$$(5) \quad h_2(q_\omega, v_{\omega, \tilde{\omega}}; \gamma) > 0 \text{ and } h_{22}(q_\omega, v_{\omega, \tilde{\omega}}; \gamma) > 0 \text{ for } v_{\omega, \tilde{\omega}} > 0$$

$$(6) \quad h(q_\omega, 0; \gamma) = 1, \quad h_2(q_\omega, 0; \gamma) = 0$$

$$(7) \quad h(0, v_{\omega, \tilde{\omega}}) = 1, \quad h_{12}(q_\omega, v_{\omega, \tilde{\omega}}; \gamma) > 0 \text{ for } q_\omega, \gamma, v_{\omega, \tilde{\omega}} > 0$$

$$(8) \quad h(q_\omega, v_{\omega, \tilde{\omega}}; 0) = h(v_{\omega, \tilde{\omega}})$$

where the parameter  $\gamma \geq 0$  defines the degree to which the consumer is "finicky", or willing to forego consumption to get closer to the ideal.

The standard properties associated with the distance from the ideal variety are

represented by (5) and (6). By (7) we assume that the consumer is not finicky at all at a zero consumption level, but when his consumption of a differentiated good increases he becomes increasingly finicky. Finally, (8) nests Lancaster's compensation function: if  $\gamma = 0$ , the compensation function does not depend on consumption volumes. An additional condition needs to be introduced to address the fact that in the generalized compensation function, the quantity of the chosen variety appears both in the nominator and in the denominator of the subutility function (2). Consequently, while the quantity consumed increases, the cost of being distanced from the ideal variety might increase so fast that it outweighs utility gains from the higher consumption level of this variety. This would contradict the standard assumption of the non-decreasing (in quantity) utility function. It is easy to show that the necessary and sufficient condition for utility to be increasing in the quantity consumed is:

$$(9) \quad h(q_\omega, v_{\omega, \tilde{\omega}}; \gamma) - q_\omega h_1(q_\omega, v_{\omega, \tilde{\omega}}; \gamma) > 0 \quad \forall \omega \in \Omega$$

The difference between the Lancaster and generalized compensation functions is illustrated by Figure 1.

In order to derive a closed form solution of the model, we chose a specific functional form of the generalized compensation function:

$$(10) \quad h(q_\omega^\gamma, v_{\omega, \tilde{\omega}}) = 1 + q_\omega^\gamma v_{\omega, \tilde{\omega}}^\beta \quad \beta > 1, 0 \leq \gamma \leq 1,$$

It is easy to verify that the restrictions imposed on the parameters  $\beta$  and  $\gamma$  in (10) are necessary and sufficient for properties (5) – (9) to hold. The corresponding utility function is then

$$(11) \quad u(q_\omega \mid \omega \in \Omega) = \max_{\omega \in \Omega} \left( \frac{q_\omega}{1 + q_\omega^\gamma v_{\omega, \tilde{\omega}}^\beta} \right).$$

Consumption of a differentiated variety  $\omega'$  is found by maximizing the utility

(11) subject to budget constraint (3):

$$(12) \quad q_{\omega'} = \frac{I}{p_{\omega'}}, \quad q_{\omega} = 0 \quad \text{for } \omega \neq \omega'$$

where  $\omega' = \arg \min \left[ p_{\omega} \left( 1 + q_{\omega}^{\gamma} v_{\omega, \tilde{\omega}}^{\beta} \right) \mid \omega \in \Omega \right]$ .

### B. Market Equilibrium

Each individual is endowed with  $z$  efficient units of labor, which he supplies inelastically in a perfectly competitive labor market. The wage per efficient unit of labor is normalized to one so that an individual's income is equal to his labor endowment:

$$(13) \quad I = z.$$

Varieties of the differentiated product are produced by monopolistically competitive firms, with identical technology. Production requires a fixed number of workers  $\alpha$ , payable in each period that the variety is produced, and marginal labor requirement  $c$ . Given that the wage equals one,  $\alpha$  and  $c$  are also interpreted as fixed and marginal costs.

The firms play a two-stage non-cooperative game under the assumption of perfect information. Each firm chooses a variety in the first stage and a price in the second stage. Each variety is produced by one firm, and firms are free to enter and exit. Finally, consumer preferences for ideal variety are uniformly distributed over the unit length circumference of the circle and the population density on the circumference is equal to  $L$ .

Under these assumptions, it is possible to show that *all* existing equilibria are zero-profit Nash equilibria. Moreover, there will exist symmetric Nash equilibria characterized by identical prices and output levels for the individual firms. In these

equilibria, the specification of the varieties produced will be evenly spaced along the spectrum.<sup>5</sup> In the following analysis, we will focus exclusively on such symmetric equilibria in which all varieties are equally priced and equally distributed on the circumference of the circle.

Next we solve for aggregate demand and the price elasticity of demand for variety  $\omega$ . The solution to this problem is described by Lancaster (1984) and Helpman and Krugman (1985), and for completeness is included in Appendix 1. In the symmetric equilibrium, in which the prices of all varieties are the same and all varieties are equally distanced from each other, the demand for any produced variety  $\omega \in \Omega$  is:

$$(14) \quad Q = \frac{dzL}{p},$$

where  $d$  is the shortest arc distance between any two available varieties, and  $p$  is the price of each available variety. The corresponding price elasticity of demand is:

$$(15) \quad \varepsilon = 1 + \frac{1}{2\beta} \left( \frac{p}{z} \right)^\gamma \left( \frac{2}{d} \right)^\beta + \frac{1-\gamma}{2\beta} > 1.$$

Knowing the cost structure and the price elasticity of demand, we can find the profit-maximizing price and zero-profit quantity for each produced variety:

$$(16) \quad p = \frac{c\varepsilon}{\varepsilon - 1} \quad Q = \frac{\alpha}{c} (\varepsilon - 1).$$

The equilibrium number of firms then can be found as the ratio of the aggregate income  $zL$  over the expenditure per variety  $pQ$ :

$$(17) \quad n = \frac{zL}{\alpha\varepsilon}.$$

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<sup>5</sup> The proof of existence and the detailed characterization of equilibria is provided by Lancaster (1979). An extension of Lancaster's proof for the form of the utility function in (11) is available upon request from the authors.

The circumference length is equal to one, so the distance between the closest varieties is:

$$(18) \quad d = \frac{1}{n} = \frac{\alpha\varepsilon}{zL}.$$

Now we can rewrite (15) using (16)–(18):

$$(19) \quad \varepsilon = 1 + \frac{1}{2\beta} \left[ \frac{c\varepsilon}{z(\varepsilon-1)} \right]^\gamma \left( \frac{2zL}{\alpha\varepsilon} \right)^\beta + \frac{1-\gamma}{2\beta}.$$

The equilibrium value of the price elasticity of demand is unique, since the LHS of (19) is increasing in  $\varepsilon$ , while the RHS is decreasing in  $\varepsilon$ . From (16) and (17) we can show that the equilibrium price, quantity per variety, and number of varieties are also unique.

### C. Comparative Statics

We examine changes in population density  $L$  and the individual labor endowment  $z$ , and their effect on the equilibrium price elasticity of demand, price, output per variety, and the number of varieties. By implicit derivation of (19) we get

$$(20) \quad \frac{\partial \varepsilon}{\partial L} \frac{L}{\varepsilon} = \left\{ 2\varepsilon \left[ \frac{z(\varepsilon-1)}{c\varepsilon} \right]^\gamma \left( \frac{2zL}{\alpha\varepsilon} \right)^{-\beta} + \frac{\gamma}{\beta(\varepsilon-1)} + 1 \right\}^{-1}.$$

The resulting expression is strictly positive and strictly less than one<sup>6</sup>; that is, the price elasticity of demand is *increasing* in population density at a *less* than proportional rate.

To explain this result we follow Lancaster (1979) in defining the *market width* of variety  $\omega$  as the portion of the total spectrum of consumers buying this variety rather than some other variety. The extreme values of market width in this model are one and

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<sup>6</sup> All addends in curly brackets are strictly positive and include the value 1, which makes their sum strictly greater than 1. The inverse of this sum is then between zero and one.

zero, which approximate pure monopoly and perfect competition. An increase in  $L$  increases purchasing power on each interval of the spectrum, and thus each firm needs a smaller interval to get the same total revenue. As a result, in the new zero-profit equilibrium, the market width for each produced variety shrinks. Consequently, the distance between the neighboring varieties decreases, thus making consumers more sensitive to the variation in price.

Equation (16) indicates that the increase in the price elasticity of demand leads to a decrease in the equilibrium price per variety, and an increase in the output per variety. The intuition is straightforward. Entry crowds variety space, driving up  $\varepsilon$  and lowering the markups firms can charge. Since prices are lower each firm must sell a higher quantity to break even. Consequently, growth in firm size uses resources that would otherwise have been used to expand variety; the number of varieties increases less than proportionally with labor force growth. This can also be seen in equation (17) which shows that a rising population leads directly to an increase in the number of varieties that is partially offset by the induced rise in  $\varepsilon$ .

These predictions are summarized in the last column of Table 1. The contrast with the standard constant elasticity model, as in Krugman (1980), is clear. If the price elasticity of demand is independent of market size, then prices and output per variety are also independent of market size, and the elasticity of  $n$  with respect to market size is one.

Next we examine changes in the individual labor endowment  $z$ , which can be interpreted both as an increase in productivity and in income per capita. By implicit derivation of (19) we can find:

$$(21) \quad \frac{\partial \varepsilon}{\partial z} \frac{z}{\varepsilon} = \left(1 - \frac{\gamma}{\beta}\right) \left\{ 2\varepsilon \left[ \frac{z(\varepsilon-1)}{c\varepsilon} \right]^\gamma \left( \frac{2zL}{\alpha\varepsilon} \right)^{-\beta} + \frac{\gamma}{\beta(\varepsilon-1)} + 1 \right\}^{-1},$$

$$0 < \frac{\partial \varepsilon}{\partial z} \frac{z}{\varepsilon} < 1.$$

An increase in  $z$  has two effects, raising  $\varepsilon$  through an increase in the aggregate labor endowment,  $zL$ , and lowering  $\varepsilon$  by raising income per worker. The effect on the aggregate labor endowment is captured by the inverse portion of (21). By comparing this expression with (20), we see that this channel yields the same changes in all variables of interest as an increase in population density.

The effect of rising income per worker, holding fixed aggregate output, is captured by the expression  $\frac{-\gamma}{\beta} \{\dots\}^{-1}$  in (21). Conceptually, compare two countries with the same GDP but differing labor productivity. Let country A have a smaller population and more productive (and therefore richer) workers than Country B. Then country A has a lower  $\varepsilon$ , higher prices, more firms, and lower output per firm.

This result is interesting because it indicates that, *ceteris paribus*, an identical variety produced using the same technology in both poor and rich countries will be priced higher in the rich country. As income rises, consumers place greater value on proximity to the ideal variety and are willing to pay a higher price for a larger degree of diversification. The market responds by supplying more varieties, even though economies of scale are utilized to a lesser degree for produced varieties.

These predictions are summarized in Table 1. Here, the contrast with the original Lancaster (1979) model is instructive. Since the Lancaster model is a special case of the generalized model, the predictions of the Lancaster model can be easily obtained from

(20) and (21) by setting  $\gamma$  equal to zero. Comparative statics with respect to market size are similar<sup>7</sup>, but the income effect is operative only in the generalized model. In Lancaster, an increase in worker productivity has no affect on model outcomes after controlling for market size.

#### *D. Open economy*

To this point, we have focused on closed economy comparative statics. In the closed economy, our predictions for the number of varieties, quantity per variety, price elasticity, and prices refer to domestic output, which is also domestic consumption. Unfortunately cross-country domestic data on prices and price elasticities are not available in sufficient detail for many countries to test the model.<sup>8</sup> Trade data are better in this regard, but to use them we must re-interpret the model in an open economy context. This extension is derived in detail in Appendix 2.

The model outlined in Appendix 2 nests the generalized ideal variety preferences into a simple general equilibrium model of trade between three countries. The variety space is segmented into subsets, and each country has a comparative advantage on a given subset. A key assumption which significantly changes the nature of the equilibrium compared to Lancaster (1984) is regarding the fixed labor requirement  $\alpha$ . We interpret  $\alpha$  not as the fixed cost of production, but as the fixed cost of adjustment to market. The fact, that  $\alpha$  is market specific ensures that in equilibrium all varieties in a particular

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<sup>7</sup> That is, the signs on the market size comparative statics are the same for the Lancaster and generalized ideal variety models are the same, but magnitudes differ.

<sup>8</sup> In a previous draft we used cross-country output data to show that the closed economy model's prediction for the number and size of firms is strongly confirmed. Looking within sectors across countries we found that the number of firms is rising in market size and income per capita, while the average size of firms is rising in market size and falling in income per capita.

segmented product subset are symmetric. We show that all our model predictions from the closed economy case extend to the open economy case, provided that we focus on the import or non-traded segments of the goods continuum. In this case, our comparative statics in equations (20) and (21) now can describe variation in the price elasticity of demand facing a common exporter when selling to importers who vary in market size (GDP) and per capita income (conditional on market size). The corresponding predictions for number of varieties, quantity per variety, and prices go through as in the closed economy case.

### **III. Empirics – Cross-Importer Variation in Prices**

The generalized ideal variety model predicts that markups and prices for the same goods will vary across markets as a function of market size and income. To get as close as possible to the spirit of the model we examine how prices for highly disaggregated products sold by the same exporting country vary with changing import market characteristics.

We employ bilateral export data from the Eurostats Trade Database for the period 1990-2003. These data report values and quantities (weight in kilograms) of trade for each of 11 EU exporters and over 200 importers worldwide, measured at the 8 digit level of the Harmonized System (roughly 11,000 categories). Because we have exporter-importer-product-time variation, we can control for many factors outside our model. Notably, we can control for importer-specific price variation, such as that arising from level differences in income and non-homothetic demand for quality, and we can control for differential growth rates in exporter prices due to changes in quality produced or

production costs. We can then relate changes in import prices at the border (i.e. prior to any value-added in distribution or retailing) to changes in importer characteristics.

We write export prices as

$$p_{ijt}^k = c_{jt}^k \alpha_{ij}^k m^k(a_i^k, Y_{it}, \frac{Y_{it}}{L_{it}}),$$

with indices j=exporter, i=importer, k = HS8 product, and t = time. The term  $c_{jt}^k$  captures influences that are specific to an exporter-product-time period. These include variation in marginal costs of production and product quality.<sup>9</sup> The term  $\alpha_{ij}^k$  captures time invariant influences specific to an importer-exporter-product. For example, Hummels-Skiba (2004) show that prices vary across bilateral pairs due to Alchian Allen effects, i.e. variation in tariffs and per unit transportation costs induce changes in the quality mix and observed prices. Similarly, for reasons outside the model Germany may happen to ship higher priced cars to the US than it does to France. To the extent that these effects change little over time, they are captured in  $\alpha_{ij}^k$ .

Finally,  $m()$  is a markup that depends on importer-commodity characteristics (such as market or regulatory structure not captured in our model), as well as market size and per capita income. For simplicity we approximate this markup rule as a separable log-linear function in its arguments,  $m_{it}^k = \exp(\alpha_i^k)(Y_{it})^{m_2} (Y_{it}/L_{it})^{m_3}$

This allows us to write log export prices as

$$\ln p_{ijt}^k = c_{jt}^k + \alpha_{ij}^k + a_i^k + m_2^k (\ln Y_{it}) + m_3^k (\ln \frac{Y_{it}}{L_{it}}).$$

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<sup>9</sup> Prices are the value of trade divided by weight.  $c_{jt}^k$  then also includes a conversion of a common price measure (value per kg) into commodity specific units.

In order to eliminate variation across importer-products  $a_i^k$  and bilateral pair-products  $\alpha_{ij}^k$  we take long differences of the data, examining changes in log export prices between the beginning and end of the sample. Using  $t = 0,1$ , we have<sup>10</sup>

$$\ln p_{ij,1}^k - \ln p_{ij,0}^k = (c_{j,1}^k - c_{j,0}^k) + m_2^k (\ln Y_{i,1} - \ln Y_{i,0}) + m_3^k \left( \ln \frac{Y_{i,1}}{L_{i,1}} - \ln \frac{Y_{i,0}}{L_{i,0}} \right)$$

Finally, to capture any evolution in product cost or quality that is specific to an exporter-product and constant across importers, we employ a vector of exporter-product fixed effects,  $a_j^k$ . This gives us a final estimating equation that allows us to relate changes in prices to changes in importer market size and per capita income.

$$(22) \quad \ln p_{ij,1}^k - \ln p_{ij,0}^k = a_j^k + \beta_1 (\ln Y_{i,1} - \ln Y_{i,0}) + \beta_2 \left( \ln \frac{Y_{i,1}}{L_{i,1}} - \ln \frac{Y_{i,0}}{L_{i,0}} \right) + e_{ij}^k$$

Initially, we pool over all commodities in our sample, which is equivalent to assuming that the effect of market size and income per capita is identical across products. The resulting estimate is<sup>11</sup>

$$\ln p_{ij,1}^k - \ln p_{ij,0}^k = a_j^k - .185_{(.009)} (\ln Y_{i,1} - \ln Y_{i,0}) + .251_{(.009)} \left( \ln \frac{Y_{i,1}}{L_{i,1}} - \ln \frac{Y_{i,0}}{L_{i,0}} \right) + e_{ij}^k$$

The results match our theoretical predictions in two respects. Prices fall for importers for whom GDP is growing, and rise for importers for whom income per capita is growing (conditional on GDP growth). However, we do not match a third model prediction.

Recall that rising worker productivity has two competing effects on markups on prices: raising total purchasing power within the economy (which lowers prices) and raising

<sup>10</sup> We experimented with using only end years 1990 and 2003, as well as constructing average prices over two and three year windows at the beginning and end of the sample. Results were unaffected.

<sup>11</sup> All coefficients are significant at 1% level. Number of observations is 1,043,566 and within-R<sup>2</sup>=0.01

household purchasing power and strength of preference for their ideal variety (which raises prices). In the theory, the former effect should dominate, but that is not the case in the estimates. The total effect of per capita GDP growth on prices is the sum of the coefficients on GDP and GDP per capita, and is positive.

Next, we estimate equation (22) by pooling over all HS8 commodities within each HS two-digit group and estimating effects for each HS2 group separately. While this eliminates many degrees of freedom it also relaxes the assumption of identical effects across all products. Results for each HS2 industry are reported in Table 2, along with counts of significant coefficients. For categories representing over 80 percent of trade by value, statistically significant coefficient estimates match the theory<sup>12</sup>. Conditioning on an exporter and product, prices are decreasing in importer's GDP growth, and increasing in importer's GDP per capita growth. The effects are not trivial in magnitude. Figure 2 is a histogram showing the distribution of coefficients over the HS2 groups. Because the value of trade differs dramatically across each HS2 group we weight the point estimates by that HS2 groups share in trade. For the median product, a 1% increase in GDP decreases prices by 0.5%, while a 1% increase in GDP per capita increases prices by 0.5%.

Of course, the impact of incomes on prices may be due in part to a rise in demand for quality as incomes increase. This is the interpretation of Hallak (2004) who shows that the demand for higher priced (presumably higher quality) goods rises with importer's income. Recall however that our estimates condition on the level of prices for an importer-exporter pair, and on growth in prices for an exporter-commodity. This sweeps

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<sup>12</sup> “Wrong-signed” and statistically significant estimates occur in categories representing only 2 percent of trade by value.

out much of the cross-exporter quality variation found, for example, in Schott (2003), Hallak (2004), and Hummels-Klenow (2005), and the cross-bilateral pair quality variation found in Hummels-Skiba (2004). It may be that exporters adjust their quality mix over time and direct changing quality differentially to specific importers depending on their changing characteristics. While we are unaware of any direct evidence on this point, this does provide a possible reason why the total derivative of prices with respect to per capita income is positive, rather than negative as the theory suggests.

### **III. Empirics – Own Price Elasticity of Demand**

In this section we examine the generalized ideal variety model's predictions for how the own-price elasticity of demand varies across markets. This is interesting empirical object in its own right, but also serves as an independent verification of the price findings in the preceding section. That is, we examine whether the elasticity of demand varies across import markets in the way necessary to generate the observed pattern of cross-importer variation in prices.

The generalized ideal variety model does not yield a convenient structural form for estimating the own-price elasticity. Our approach is to take as the null hypothesis that import demand is derived from a CES utility function with a common price-elasticity of demand across all markets. We then examine whether we can reject this null in favor of a model in which the elasticity varies systematically across markets. In particular, equations (20) and (21) predict that the own-price elasticity of demand is higher in large markets, and lower in rich markets (conditional on market size).

Our approach, detailed below, requires data on bilateral trade and bilateral trade

costs for many importers. Ideally, we would have those data in a panel in order to relate over-time changes in the price elasticity of demand within an importer to changes in that importer characteristics. Unfortunately, bilateral trade cost panel data are not available. Instead we use cross-sectional data from the TRAINS database, which reports bilateral trade values for many importers and exporters at the 6 digit level of the Harmonized System classification (roughly 5000 goods). Because we have multiple bilateral observations for each importer, we are able to difference out several important unobserved characteristics and identify the responsiveness of trade to trade cost shocks.

#### A. Methodology

We begin by constructing a test of the CES null hypothesis. The subutility function for product  $k$  ( $k = 6$  digit HS good), for importer  $i$ , facing  $j = 1 \dots J$  exporting sources for  $k$  is given by  $u_i^k = \left( \sum_{j=1}^J \lambda_j^k (q_{ij}^k)^{\theta^k} \right)^{1/\theta^k}$  where  $\theta^k = (\sigma_k - 1)/\sigma_k$ , and  $\lambda_j^k$  is a demand shifter, which could represent quality differences, or (unobserved) differences in the number of distinct varieties available from each exporter. As is well known, we can write the import demands as

$$(23) \quad q_{ij}^k = \frac{E_i^k}{\Pi_i^k} \left( \frac{p_{ij}^k}{\lambda_j^k} \right)^{-\sigma^k}$$

Where  $E_i^k$  denotes expenditures, and  $\Pi_i^k$  is the CES price index. Under the CES null, the price elasticity of demand is constant across all markets, so we can write the delivered price in market  $i$  as a function of the factory gate price at  $j$ , multiplied by ad-valorem trade costs,  $p_{ij}^k = p_j^k t_{ij}^k$ .

When estimating this for  $k = \text{HS 6 digit level of aggregation}$ , everything in (23) is unobservable except the nominal value of bilateral trade and trade costs. To isolate these terms, we multiply both sides of (23) by exporter prices, and sum over all importers  $g \neq i$  to get  $j$ 's exports to rest of the world,  $r$ .

$$(pq)_{rj}^k = \sum_{g \neq i} (pq)_{gj}^k = (\lambda_j^k)^{\sigma^k} (p_j^k)^{1-\sigma^k} \sum_{g \neq i} \frac{E_g^k}{\Pi_g^k} (t_{gj}^k)^{-\sigma^k}$$

Express  $i$ 's imports from  $j$  as a share of rest of world imports from  $j$ ,

$$(24) \quad \ln s_{ij}^k = \ln \frac{(pq)_{ij}^k}{(pq)_{rj}^k} = \ln \frac{E_i^k}{\Pi_i^k} - \sigma^k \ln t_{ij}^k - \ln \sum_{g \neq i} \frac{E_c^k}{\Pi_g^k} (t_{gj}^k)^{-\sigma^k}$$

Writing this in share terms eliminates unobserved price and quality (variety) shifters specific to  $j$ .<sup>13</sup> We assume trade costs take the form  $\ln t_{ij}^k = \ln(1 + \tau_i^k) + \delta_k \ln d_{ij}$ , where  $\tau_i^k$  is an MFN tariff facing all exporters in importer  $i$ , product  $k$ ,  $d_{ij}$  is the distance between countries, and  $\delta^k$  is the elasticity of trade costs with respect to distance.

To simplify this expression, we employ importer  $i$  – product  $k$  fixed effects  $\alpha_i^k$  (implemented by mean differencing) which eliminates the importer expenditure share, the CES price index, and MFN tariff rates. This leaves variation in bilateral distance to trace out the variation in trade costs. Note that any other unmeasured trade cost that is specific to an importer is swept out in this specification. Distance is commonly interpreted as a transportation cost measure. Were transportation costs subject to scale economies so that, for example, large importers enjoy lower transportation costs, these scale effects are eliminated in the differencing. Similarly, the specification eliminates variation due to

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<sup>13</sup> Alternatively, we could also write (24) by expressing  $i$ 's imports relative to any particular importer, or set of importers, rather than the world.

large or rich importers buying higher quality imports. The final term is exporter specific; we assume it to be orthogonal to the distance between bilateral pair  $ij$  and include it in the error.<sup>14</sup> We now have

$$(25) \quad \ln s_{ij}^k = \alpha_i^k - \sigma^k \delta^k \ln d_{ij} + e_{ij}^k$$

In the CES model, we can interpret the coefficient on distance as  $\beta^k = -\sigma^k \delta^k$ , which is invariant to the importer. We will test whether the constant elasticity is rejected by the data in favor of a form consistent with the generalized ideal variety model, by interacting distance with importer GDP and GDP per worker.

$$(26) \quad \ln s_{ij}^k = \alpha_i^k - \beta_1^k \ln d_{ij} + \beta_2^k \ln d_{ij} \ln Y_i + \beta_3^k \ln d_{ij} \ln \frac{Y_i}{L_i} + e_{ij}^k$$

Before proceeding to the results, a few notes regarding interpretation are in order. Ideally, we would estimate (26) separately for each exporter and commodity in order to examine how the own-price elasticity of demand varies across markets for the same product. However, in order to identify the importer-commodity fixed effects and generate sufficient data variation it is necessary to pool over multiple exporters. Pooling in this way is equivalent to restricting the own-price elasticity to be the same across all exporter and products over which we pool, i.e. imports of Japanese TVs respond to a change in the price of Japanese TVs in the same way that imports of Korean TVs respond to a change in the price of Korean TVs. In the estimates that follow, we employ several pooling strategies. For simplicity, we first pool over all exporters and 6 digit products.

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<sup>14</sup> Since we cannot measure the price indices or the elasticity of substitution it is difficult to include this last term explicitly. We cannot verify that trade costs between  $i$  and  $j$  are orthogonal to the real expenditure weighted sum of trade costs between  $j$  and all other countries. However, simple proxies for this term such as a sum over nominal GDP weighted distances are very weakly correlated with distances and tariffs between  $i$  and  $j$ . We show below that our results are robust to an alternative specification in which this omitted term does not appear.

Then, we pool over all exporters and 6 digit products within a particular 2 digit aggregate. In both cases, the importer fixed effects are still calculated with respect to the 6 digit product.

Second, the use of bilaterally varying trade costs exactly identifies price variation under the CES null, but imperfectly identifies price variation in the variable elasticity case. With variable elasticity preferences a rise in trade costs will be partially offset by a fall in the factory gate price so that only a part of the trade cost is passed through to the final price. That is, the true destination price includes a pricing-to-market adjustment, which is an omitted variable in our specification that is negatively correlated with trade costs. This omission will create a bias in the price elasticity toward zero. For a similar reason, if the interaction terms are significant, PTM will cause a bias in these estimates toward zero. This is problematic if we want to precisely identify the own-price elasticity of demand. It is less concerning if our primary interest lies in testing the CES null since we will be biased toward not finding a significant interaction between tariffs and importer characteristics.

### *B. Results*

We begin estimating equation (26) by pooling over all exporters and products. The resulting estimate is<sup>15</sup>

$$\ln s_{ij}^k = \alpha_i^k - \underset{(.027)}{.668} \ln d_{ij} - \underset{(.001)}{.057} \ln d_{ij} \ln Y_i + \underset{(.003)}{.101} \ln d_{ij} \ln \frac{Y_i}{L_i} + e_{ij}^k$$

We can immediately reject the hypothesis that the response of imports to price changes (via trade costs) is the same in all markets, as both interaction terms are significant, with

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<sup>15</sup> All coefficients are significant at 1% level. Number of observations is 1,183,696 and  $R^2=.17$ .

signs matching the theory. In large markets the effect of trade costs on trade are more pronounced, that is, demand becomes more elastic. In higher income markets, the effect of trade costs on trade are less pronounced, that is, demand becomes less elastic.<sup>16</sup>

Of course, not all products are likely to fit the model equally well, and the relevant pooling restrictions are unlikely to be met. Accordingly, we estimate equation (26) separately for each 2 digit HS product. Full details for each HS2 product are reported in Table 2, along with counts of significant coefficients. Figure 3 shows the distribution of coefficients across the HS2 products, weighted by their value in trade.

In HS2 categories representing 84 percent of trade by value we estimate significantly negative coefficients on the  $\ln d_{ij} \ln Y_{ij}$  interaction. Figure 3 shows that estimates of this interaction term lie primarily between 0 and -0.2. In HS2 categories representing 76 percent of trade we estimate significantly positive coefficients on the  $\ln d_{ij} \ln Y_{ij} / L_{ij}$  interaction, with most of these coefficients lying between 0 and 0.2. It is clear from these figures that, while the effect differs significantly across industries, the basic message of the interaction from the pooled regression comes through. The response of trade to trade costs (the price elasticity of demand) is greater in large markets and smaller in rich markets.

### C. Magnitudes implied by the elasticities

The model performs well on sign and significance, but does it imply significant differences in the price elasticity of demand across markets? A problem with interpreting

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<sup>16</sup> As in the price regressions above, we fail to match model predictions regarding the total derivative of the elasticity with respect to per capita income. The model predicts that the total derivative should include a negative effect (the Y/L effect on Y) and a positive effect (Y/L, conditional on Y), with the former dominating. However, in our estimates we find a positive total derivative.

these interaction terms is that we have a product of the price elasticity and an elasticity of trade costs with respect to distance.

$$(27) \quad \hat{\beta}_1^k \ln d + \hat{\beta}_2^k \ln d \ln Y + \hat{\beta}_3^k \ln d \ln(Y/L) = \delta^k (\sigma^k + \sigma_y^k \ln Y + \sigma_{y/l}^k \ln(Y/L))$$

To isolate the price elasticity, we can express the combined distance and interaction terms as a ratio for countries of different size and income. For countries 1 and 2, we have

$$(28) \quad \frac{\delta^k (\sigma^k + \sigma_y^k \ln Y_1 + \sigma_{y/l}^k \ln(Y/L)_1)}{\delta^k (\sigma^k + \sigma_y^k \ln Y_2 + \sigma_{y/l}^k \ln(Y/L)_2)}$$

Note that the elasticity of trade costs with respect to distance falls out, leaving only the elasticity of substitution and any interaction effects with importer Y and Y/L.

For each HS 2 product we take the regression point estimates, and combine them with importer data on Y and Y/L in order to calculate the combined interaction effects for each country in (27). We then rank them from most to least elastic, and express the elasticity ratio in (28) using the 90<sup>th</sup> percentile / 10<sup>th</sup> percentile country. This gives, for each HS 2 product, a measure of the range of elasticity over importers in the sample. For example, a value of two means that the price elasticity of demand for the 90<sup>th</sup> percentile country is twice that of the price elasticity for the 10<sup>th</sup> percentile country. In Figure 4 we plot a distribution of this statistic over all HS 2 products. Most of the distribution lies between 1.2 and 2.5.

Next we use our point estimates (26) to evaluate the variation in the number of imported varieties implied by our model and empirical estimates. Using our theoretical predictions (17) we can express the number of imported varieties as a function of population, income per capita, price elasticity and fixed cost of importing,

$$\ln n_i = \ln L_i + \ln(Y_i/L_i) - \ln \sigma_i - \ln \alpha_i.$$

Were  $\ln \sigma_i - \ln \alpha_i$  to be constant across importers, then the elasticity of varieties with respect to L and Y/L would be one. However, Hummels-Klenow (2002) estimate

$$\ln n_i = .22 \ln L_i + .45 \ln(Y_i/L_i)$$

How much of the difference between these estimates and unitary elasticities can we explain using our model? Our estimates of equation (26) using pooled data reveal this semi-log relationship.

$$|\delta \sigma_i| = .668 + .057 \ln Y_i - .101 \ln \frac{Y_i}{L_i},$$

Assuming the elasticity of trade costs with respect to distance  $\delta$  is a constant across importers we can calculate the elasticity of the price elasticity with respect to L and Y/L for comparability to Hummels-Klenow. We do this by calculating fitted values of the level of the price elasticity for each importer, taking logs and running the following regression.

$$(29) \quad \ln |\delta \sigma_i| = \underset{.001}{.076} \ln L_i - \underset{.003}{.050} \ln(Y_i/L_i)$$

Now, if the fixed cost of importing were constant, our estimates in (29) would imply

$$\ln n_i = .924 \ln L_i + 1.05 \ln(Y_i/L_i).$$

We generate some of the curvature between variety and population found in Hummels-Klenow but fall short in magnitude, while the curvature with respect to per capita income goes in the wrong direction. There are several possibilities for these differences. One we can address in the context of the simple model by letting the fixed cost of exporting

co-vary with L and Y/L. For our results to be consistent with the estimates of Hummels and Klenow (2008), the fixed cost of importing should be increasing in population and income in the following way:

$$\ln \alpha_i = .704 \ln(L_i) + .60 \ln(Y_i/L_i).$$

A second possibility would ascribe these differences to aggregation errors. Hummels-Klenow note that their approach is limited by the disaggregation of product categories, that is, there might be many more distinct varieties than are revealed by the trade statistics. If so, this will show up in a covariation between the intensive margin (or output per variety) and L and Y/L. With more granular data, the measured elasticities of variety with respect to L and Y/L they would have been much larger.

#### *D. Robustness: Product Composition.*

Even for the estimates where we provide separate estimates for each HS2 category there is likely to be heterogeneity across HS6 products in the price elasticity of demand. We might falsely reject the CES null if there is a systematic relationship between these elasticities and importer characteristics. For example, suppose the price elasticity of demand is constant across markets, but rich countries are more likely to purchase low elasticity HS6 products while poor countries purchase high elasticity HS6 products within the same HS2. This compositional effect would show up in our regression as a negative coefficient on the trade cost \* Y/L interaction.

To address this, we experimented with allowing a different coefficient on the trade cost variable for each HS6 product while still including the interaction terms with

importer Y and Y/L (common for all HS6 within an HS2). If the pure composition story is correct, we should find significant differences across HS6's within an HS2, and no significant interaction effect. We did not. The coefficients on the interaction terms were unaltered by this change.

Finally, one might argue that the ideal variety model is appropriate for consumer goods but not industrial inputs. We used Yeats (1998) classification to separate HS6 products into two groups: intermediate parts and components and all other goods. We then re-estimated equation (26) separately for each group, and found no significant differences between them. We do not view this result as necessarily problematic for the model. It is possible that differentiated consumer goods are formed from undifferentiated inputs with the differentiation coming entirely from assembly. However, we think a more likely model is that the inputs themselves are critical to differentiating ideal consumer varieties: wines becomes suited to particular consumer tastes in part because they use specialized grapes; laptop computers are customized by assembling differentiated components (screen, cpu, video chips) particularly desired by consumers.

## **VI. Conclusion**

We derive a generalized ideal variety model, in which entry leads to a “crowding” of variety space, so that larger markets exhibit a higher own-price elasticity of demand for differentiated goods, lower prices, and a larger average firm size. Working against this crowding is an income effect: as consumers grow rich and quantities consumed rise, their strength of preference for their ideal variety also rises. This gives firms greater pricing power over consumers. Conditioning on market size, richer markets see a lower

own-price elasticity, higher prices, and fewer firms.

We provide new evidence supporting the model's predictions. Conditioning on an exporter and product and exploiting cross-importer variation in bilateral trade shares, we find that the own-price elasticity of demand is higher in large markets, and lower in rich markets. Conditioning on an exporter and product and exploiting time series variation in importer characteristics, we find that prices of traded goods fall with importer GDP growth and rise with importer GDP per capita.

We see three implications of these findings. First, the theoretical and empirical literature on product differentiation in trade and in many other literatures has relied almost exclusively on constant-elasticity-of-substitution utility functions. While these models are highly tractable, they yield counter-factual implications on central empirical questions.

Second, as has been pointed out by Romer (1994) and Feenstra (1994) and the literature they have inspired, CES utility models imply potentially important welfare gains from trade in new varieties. Evaluating the welfare implication of new varieties in the generalized ideal variety model is beyond the scope of the current paper. However, our results suggest two qualifications for existing welfare studies. First, variety space does appear to fill up with entry, suggesting that the welfare gains from new variety may be substantially lower in large countries than in small.

Third, the model and the empirics suggest that income effects partially trump the crowding effect for some goods. Rich consumers want, and are willing to pay for, varieties closely matched to their ideal preferences. GDP growth that occurs primarily through growth in output per worker will still lead to substantial variety gains for some

goods, albeit at the cost of lowered economies of scale and higher prices.

Finally, we know that prices are systematically higher in rich than in poor countries, a fact that has typically been ascribed to cross-country differences in the prices of non-traded goods as in Balassa (1964) and Samuelson (1964). Our results show that the prices of traded goods are also systematically higher in rich countries because the price elasticity of demand is lower. This result is consistent with recent findings of Alessandria and Kaboski (2004) who attribute 62% of the relationship between national price level and income to pricing-to-market effect.

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Table 1. Predictions across Models.

Elasticity of	With Respect to	Models		
		<b>Krugman (1980)</b>	<b>Ideal Variety, Lancaster (1979)</b>	<b>Generalized Ideal Variety</b>
<b>Number of Varieties</b>	Market Size	1	$0 < X < 1$	$0 < X < 1$
	Income per worker <sup>1</sup>	0	0	$0 < X < 1$
<b>Output per Variety</b>	Market Size	0	$0 < X < 1$	$0 < X < 1$
	Income per worker <sup>1</sup>	0	0	$-1 < X < 0$
<b>Prices</b>	Market Size	0	$X < 0$	$X < 0$
	Income per worker <sup>1</sup>	0	0	$X > 0$
<b>Price Elasticity of Demand</b>	Market Size	0	$0 < X < 1$	$0 < X < 1$
	Income per worker <sup>1</sup>	0	0	$-1 < X < 0$

<sup>1</sup> Controlling for market size.

Table 2: Cross-Importer Variation in Prices and Price Elasticity

HS2	ABBREVIATION		Share of Trade	Price Regressions Eqn (22)		Distance Elasticity Regressions Eqn (26)	
				Y	Y/L	Y * Dist	Y/L * Dist
	Significant Coefficients with Signs matching Model Predictions	Simple Count		38	44	55	54
		Weighted by Share of Trade		82%	85%	84%	76%
	Significant Coefficients with Signs Different from Model Predictions	Simple Count		11	6	9	10
		Weighted by Share of Trade		2%	2%	5%	4%
	Mean of Significant Coefficients over HS 2	Simple Mean		-0.28	0.42	-0.06	0.10
		Weighted by Share of Trade		-0.47	0.54	-0.06	0.10
1	LIVE ANIMALS		0.12	-0.12	0.52	0.05	-0.18
2	MEAT AND EDIBLE MEAT OFFAL		0.42	.87***	-.62***	-.18***	.59***
3	FISH, CRUSTACEANS & AQUATIC INVERTEBRATES		1.07	-0.11	.24*	-0.02	-.33***
4	DAIRY PRODS; BIRDS EGGS; HONEY; ED ANIMAL PR NESOI		0.20	.23***	-.21***	-.06***	.16***
5	PRODUCTS OF ANIMAL ORIGIN, NESOI		0.09	0.12	-0.13	-0.03	0.1
6	LIVE TREES, PLANTS, BULBS ETC.; CUT FLOWERS ETC.		0.10	0.08	0.17	0	-.25***
7	EDIBLE VEGETABLES & CERTAIN ROOTS & TUBERS		0.30	.24**	-0.15	-.19***	.13**
8	EDIBLE FRUIT & NUTS; CITRUS FRUIT OR MELON PEEL		0.70	0.15	0.2	-.13***	.15***
9	COFFEE, TEA, MATE & SPICES		0.45	-0.02	0.11	0.02	-.14***
10	CEREALS		0.48	.7**	-0.46	-.12***	.27***
11	MILLING PRODUCTS; MALT; STARCH; INULIN; WHT GLUTEN		0.04	0.35	-0.3	-0.03	-0.09
12	OIL SEEDS ETC.; MISC GRAIN, SEED, FRUIT, PLANT ETC		0.44	0.12	0.13	-.1***	0.06
13	LAC; GUMS, RESINS & OTHER VEGETABLE SAP & EXTRACT		0.05	.54**	-0.4	0.04	.12*
14	VEGETABLE PLAITING MATERIALS & PRODUCTS NESOI		0.01	0.8	-0.65	-.09*	0.08
15	ANIMAL OR VEGETABLE FATS, OILS ETC. & WAXES		0.31	-0.07	.24*	-.03*	-0.04
16	EDIBLE PREPARATIONS OF MEAT, FISH, CRUSTACEANS ETC		0.31	.2*	-0.05	-0.01	-0.1
17	SUGARS AND SUGAR CONFECTIONARY		0.15	0	0.12	-.09***	0.08
18	COCOA AND COCOA PREPARATIONS		0.18	.21**	-0.14	-.1***	.11*
19	PREP CEREAL, FLOUR, STARCH OR MILK; BAKERS WARES		0.14	0.12	0.07	-.04**	.08*
20	PREP VEGETABLES, FRUIT, NUTS OR OTHER PLANT PARTS		0.33	-0.1	.24***	-.04***	-.06*
21	MISCELLANEOUS EDIBLE PREPARATIONS		0.23	0.12	-0.02	-0.02	.07*
22	BEVERAGES, SPIRITS AND VINEGAR		0.21	-.71***	.76***	-.03**	-.11**
23	FOOD INDUSTRY RESIDUES & WASTE; PREP ANIMAL FEED		0.38	0.36	-0.29	-.03*	.19***
24	TOBACCO AND MANUFACTURED TOBACCO SUBSTITUTES		0.14	.66*	-0.56	0.04	0.07
25	SALT; SULFUR; EARTH & STONE; LIME & CEMENT PLASTER		0.38	0.04	-0.09	-.1***	.08**
26	ORES, SLAG AND ASH		0.67	-1.06*	0.45	-0.02	0.01

HS2	ABBREVIATION	Share of Trade	Price Regressions Eqn (22)		Distance Elasticity Regressions Eqn (26)	
			Y	Y/L	Y * Dist	Y/L * Dist
27	MINERAL FUEL, OIL ETC.; BITUMIN SUBST; MINERAL WAX	8.03	-.53**	.52**	-.1***	0.02
28	INORG CHEM; PREC & RARE-EARTH MET & RADIOACT COMPD	0.73	0.17	-.21*	-.09***	.07***
29	ORGANIC CHEMICALS	2.51	-.21***	.27***	-.04***	.19***
30	PHARMACEUTICAL PRODUCTS	1.46	-.49***	.76***	0	.19***
31	FERTILIZERS	0.26	-0.15	.5*	-.11***	0.03
32	TANNING & DYE EXT ETC; DYE, PAINT, PUTTY ETC; INKS	0.51	-0.11	0.05	-.04***	.16***
33	ESSENTIAL OILS ETC; PERFUMERY, COSMETIC ETC PREPS	0.41	0.13	-0.03	0	.12***
34	SOAP ETC; WAXES, POLISH ETC; CANDLES; DENTAL PREPS	0.22	0.11	-0.04	-.07***	.17***
35	ALBUMINOIDAL SUBST; MODIFIED STARCH; GLUE; ENZYMES	0.14	.56***	-.52**	-.03**	.17***
36	EXPLOSIVES; PYROTECHNICS; MATCHES; PYRO ALLOYS ETC	0.04	1.27***	-1.18***	-0.03	0.14
37	PHOTOGRAPHIC OR CINEMATOGRAPHIC GOODS	0.31	-.42***	.61***	0	.19***
38	MISCELLANEOUS CHEMICAL PRODUCTS	0.81	-.22**	0.06	-.04***	.13***
39	PLASTICS AND ARTICLES THEREOF	2.55	-.23***	.27***	-.06***	.1***
40	RUBBER AND ARTICLES THEREOF	1.02	-.39***	.35***	-.07***	.12***
41	RAW HIDES AND SKINS (NO FURSKINS) AND LEATHER	0.32	-0.07	0.35	-.06***	0.02
42	LEATHER ART; SADDLERY ETC; HANDBAGS ETC; GUT ART	0.65	-.33***	.51***	0	.17***
43	FURSKINS AND ARTIFICIAL FUR; MANUFACTURES THEREOF	0.05	-0.18	0.62	-0.04	-0.18
44	WOOD AND ARTICLES OF WOOD; WOOD CHARCOAL	1.61	-0.21	.37**	-.08***	-.12***
45	CORK AND ARTICLES OF CORK	0.01	1.42	-1.01	-0.04	.54***
46	MFR OF STRAW, ESPARTO ETC.; BASKETWARE & WICKERWRK	0.03	-0.11	-0.46	-.09**	0.17
47	WOOD PULP ETC; RECOVD (WASTE & SCRAP) PPR & PPRBD	0.42	-1.08**	0.71	.06*	.15*
48	PAPER & PAPERBOARD & ARTICLES (INC PAPR PULP ARTL)	1.32	-.24***	.3***	-.07***	.08***
49	PRINTED BOOKS, NEWSPAPERS ETC; MANUSCRIPTS ETC	0.43	-1.04***	1.04***	0.01	.1***
50	SILK, INCLUDING YARNS AND WOVEN FABRIC THEREOF	0.04	0.22	0.05	0.02	.26**
51	WOOL & ANIMAL HAIR, INCLUDING YARN & WOVEN FABRIC	0.18	-0.23	0.27	-0.03	-.12**
52	COTTON, INCLUDING YARN AND WOVEN FABRIC THEREOF	0.60	-0.11	.3***	-.08***	.06***
53	VEG TEXT FIB NESOI; VEG FIB & PAPER YNS & WOV FAB	0.04	-.67**	.97***	-0.05	-.19*
54	MANMADE FILAMENTS, INCLUDING YARNS & WOVEN FABRICS	0.43	-.51***	.71***	-.06***	.04*
55	MANMADE STAPLE FIBERS, INCL YARNS & WOVEN FABRICS	0.35	-.15**	.32***	-.06***	.11***
56	WADDING, FELT ETC; SP YARN; TWINE, ROPES ETC.	0.12	-0.11	0.19	-.11***	.13***
57	CARPETS AND OTHER TEXTILE FLOOR COVERINGS	0.15	-1.1***	.98***	0	0.05
58	SPEC WOV FABRICS; TUFTED FAB; LACE; TAPESTRIES ETC	0.10	-0.16	0.2	.03*	.07*
59	IMPREGNATED ETC TEXT FABRICS; TEX ART FOR INDUSTRY	0.15	-0.14	.36***	-.1***	.15***
60	KNITTED OR CROCHETED FABRICS	0.18	0.11	0.02	-.09***	.16***
61	APPAREL ARTICLES AND ACCESSORIES, KNIT OR CROCHET	2.00	-.87***	1.09***	-.07***	.08***
62	APPAREL ARTICLES AND ACCESSORIES, NOT KNIT ETC.	2.48	-.38***	.7***	-.09***	.16***
63	TEXTILE ART NESOI; NEEDLECRAFT SETS; WORN TEXT ART	0.40	-0.05	.21**	-.04***	-0.01
64	FOOTWEAR, GAITERS ETC. AND PARTS THEREOF	1.08	-1.45***	1.45***	-.07***	.23***
65	HEADGEAR AND PARTS THEREOF	0.08	0.39	0	.09***	-0.1
66	UMBRELLAS, WALKING-STICKS, RIDING-CROPS ETC, PARTS	0.04	-0.04	0.02	0	.31***

HS2	ABBREVIATION	Share of Trade	Price Regressions Eqn (22)		Distance Elasticity Regressions Eqn (26)	
			Y	Y/L	Y * Dist	Y/L * Dist
67	PREP FEATHERS, DOWN ETC; ARTIF FLOWERS; H HAIR ART	0.08	-0.03	0.7	.18***	.32***
68	ART OF STONE, PLASTER, CEMENT, ASBESTOS, MICA ETC.	0.27	-.36***	.33***	-.04***	-0.01
69	CERAMIC PRODUCTS	0.32	-.35***	.4***	-.05***	.1***
70	GLASS AND GLASSWARE	0.46	0.06	-0.05	-.09***	.11***
71	NAT ETC PEARLS, PREC ETC STONES, PR MET ETC; COIN	2.73	-.62**	.58*	.08***	.11**
72	IRON AND STEEL	1.60	-0.07	0	-.18***	0
73	ARTICLES OF IRON OR STEEL	1.45	-.28***	.32***	-.09***	.07***
74	COPPER AND ARTICLES THEREOF	0.63	-.21*	0.12	-.13***	.12***
75	NICKEL AND ARTICLES THEREOF	0.15	-.78**	1.13***	0.07	0.13
76	ALUMINUM AND ARTICLES THEREOF	1.08	-.37***	.36***	-.14***	0.01
78	LEAD AND ARTICLES THEREOF	0.04	0.11	0.22	-.16***	0.03
79	ZINC AND ARTICLES THEREOF	0.10	-.88***	.96***	-.18***	.16*
80	TIN AND ARTICLES THEREOF	0.04	-.78**	1.06***	.15**	-0.21
81	BASE METALS NESOI; CERMETS; ARTICLES THEREOF	0.14	-1.37***	1.21***	0.02	-0.06
82	TOOLS, CUTLERY ETC. OF BASE METAL & PARTS THEREOF	0.45	-.36***	.5***	-0.01	.09***
83	MISCELLANEOUS ARTICLES OF BASE METAL	0.38	-.15*	0.08	-.04***	.05**
84	NUCLEAR REACTORS, BOILERS, MACHINERY ETC.; PARTS	16.27	-.51***	.58***	-.05***	.12***
85	ELECTRIC MACHINERY ETC; SOUND EQUIP; TV EQUIP; PTS	14.99	-.3***	.37***	-.02***	.06***
86	RAILWAY OR TRAMWAY STOCK ETC; TRAFFIC SIGNAL EQUIP	0.21	-0.4	0.25	-.15***	0.13
87	VEHICLES, EXCEPT RAILWAY OR TRAMWAY, AND PARTS ETC	8.82	-.83***	.98***	-.11***	.13***
88	AIRCRAFT, SPACECRAFT, AND PARTS THEREOF	1.93	-1.26***	1.41***	-0.04	0.07
89	SHIPS, BOATS AND FLOATING STRUCTURES	0.35	-0.18	0.26	-0.01	-0.03
90	OPTIC, PHOTO ETC, MEDIC OR SURGICAL INSTRMENTS ETC	3.52	-.24***	.31***	-.01*	.12***
91	CLOCKS AND WATCHES AND PARTS THEREOF	0.26	0.43	-0.26	.05***	-.11***
92	MUSICAL INSTRUMENTS; PARTS AND ACCESSORIES THEREOF	0.10	-0.44	.69**	.11***	0.06
93	ARMS AND AMMUNITION; PARTS AND ACCESSORIES THEREOF	0.06	0.37	-0.46	-0.02	-.36***
94	FURNITURE; BEDDING ETC; LAMPS NESOI ETC; PREFAB BD	1.56	0	.13**	-.03***	0.02
95	TOYS, GAMES & SPORT EQUIPMENT; PARTS & ACCESSORIES	1.33	-.16*	.28***	.03***	.15***
96	MISCELLANEOUS MANUFACTURED ARTICLES	0.27	-0.07	.18**	-0.01	.21***
97	WORKS OF ART, COLLECTORS' PIECES AND ANTIQUES	0.22	2.57***	-2.25***	0.05	-0.03

Notes:

1. Equations (22) and (26) separately estimated for each HS 2 category.
2. For equation (22) price regressions, table reports coefficients on log importer GDP (Y) and log importer GDP per capita (Y/L). For equation (26) distance elasticity regressions, table reports coefficient on interaction between logs of distance and logs of importer Y and Y/L.

*Opportunity cost of the ideal variety  $\bar{\omega}$  in terms of the non-ideal variety,  $\omega$*

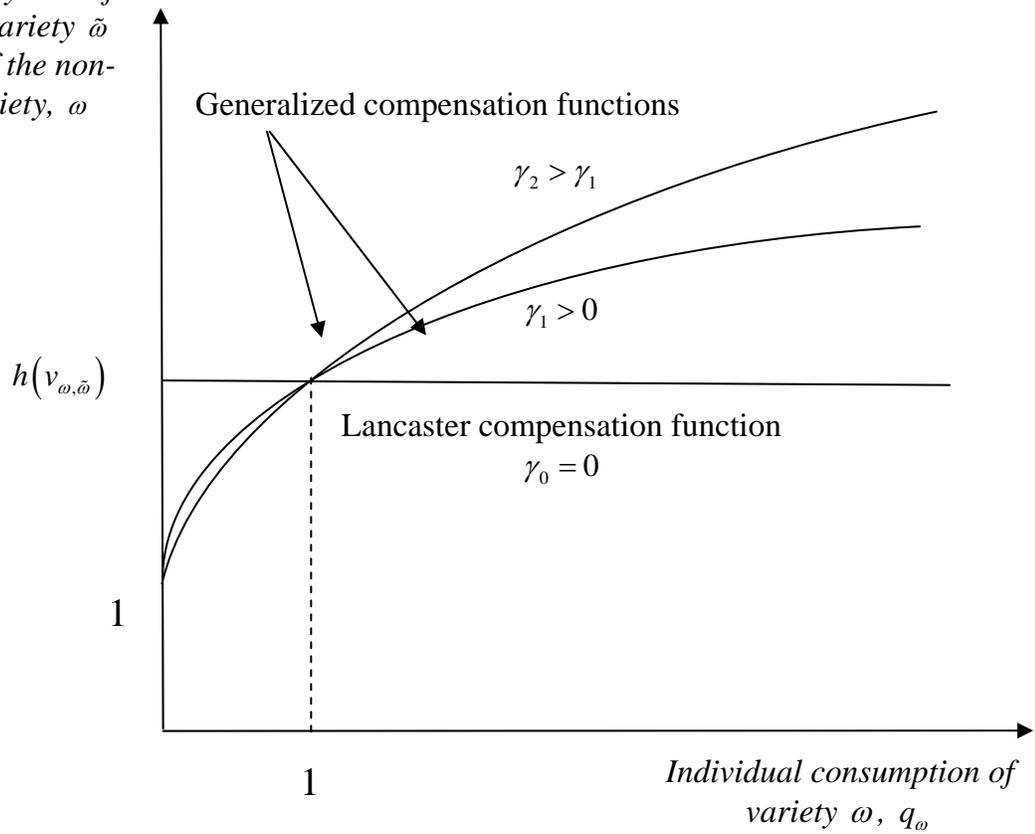
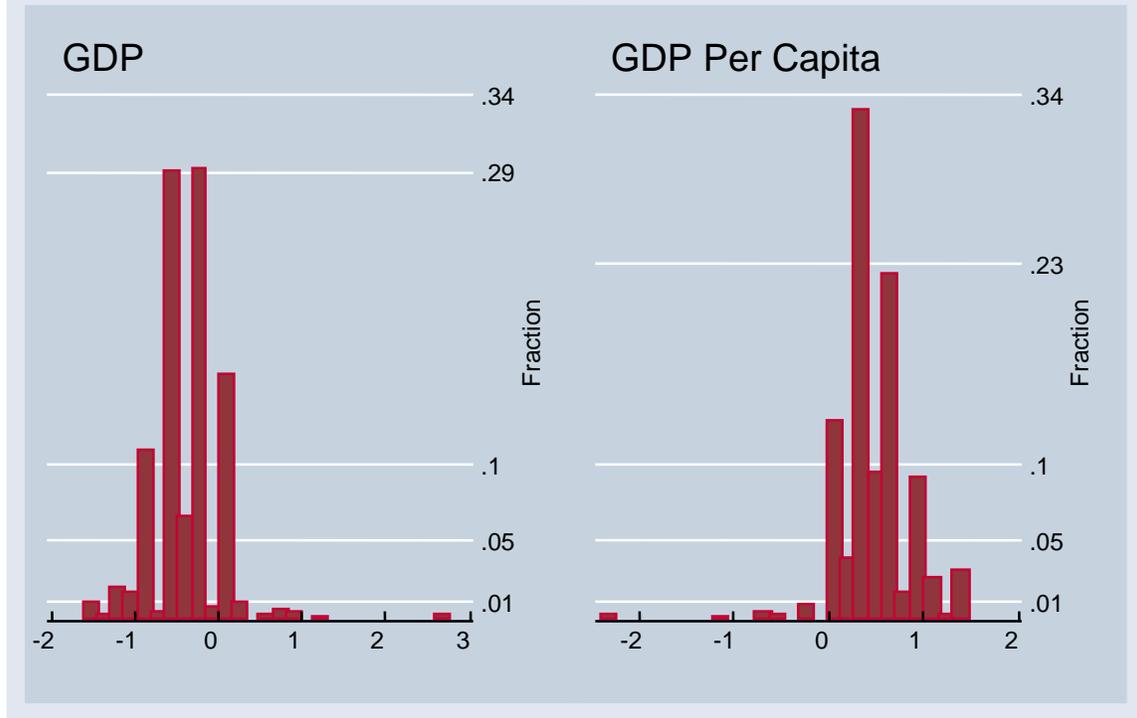


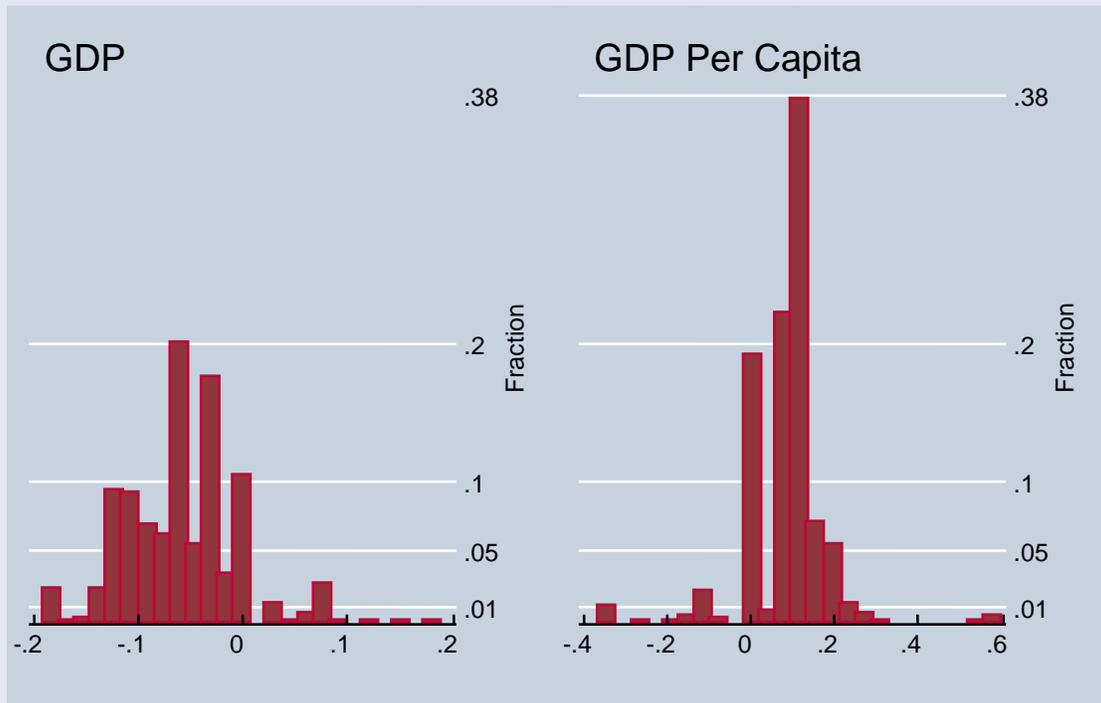
Figure 2. The Elasticity of Price with Respect to ...  
 Distribution of HS 2 point estimates, weighted by value



Notes:

1. From estimation of equation (22) on import prices from Eurostats trade database 1990-2003.
2. Full results in table 2.

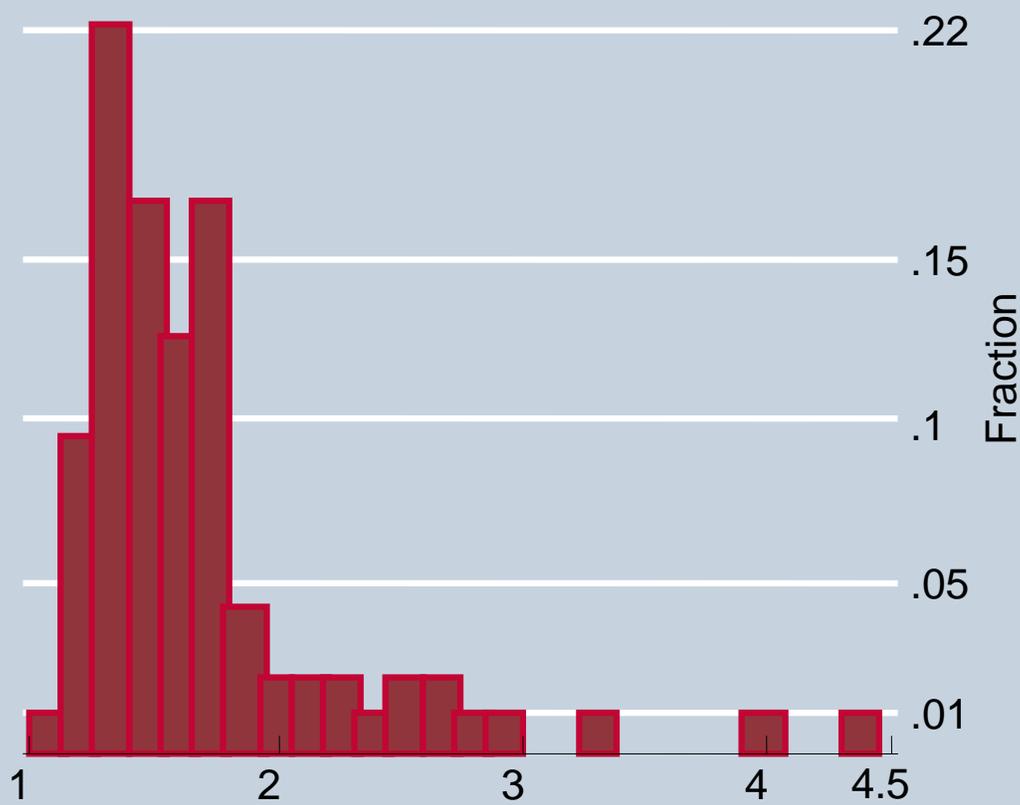
Figure 3. Importer Characteristics Interacted with Distance  
 Distribution of HS 2 point estimates, weighted by value



Notes:

1. From estimation of equation (26) on TRAINS bilateral trade data 1999.
2. Full results in table 2.

Figure 4. Implied Range of Elasticity Over Importers Varying both Y and Y/L



**Appendix 1. Derivation of the aggregate demand and price elasticity of demand for the differentiated varieties in the symmetric equilibrium.**

The derivation here is a slight modification of the corresponding derivations provided by Helpman and Krugman (1985, Chapter 6).

First we would like to find the aggregate demand function for variety  $\hat{\omega}$  given that its closest competitor to the left is variety  $\underline{\omega}$ , and its closest variety to the right is  $\bar{\omega}$ . The corresponding prices are denoted as  $p_{\underline{\omega}}$ ,  $p_{\hat{\omega}}$  and  $p_{\bar{\omega}}$ . Next let us choose the varieties  $\underline{\omega}, \bar{\omega} \in d^*(\underline{\omega}, \bar{\omega})$  such that

$$(A1) \quad \begin{aligned} p_{\underline{\omega}} \left(1 + q_{\underline{\omega}}^{\gamma} v_{\underline{\omega}, \underline{\omega}}^{\beta}\right) &= p_{\hat{\omega}} \left(1 + q_{\hat{\omega}}^{\gamma} v_{\hat{\omega}, \underline{\omega}}^{\beta}\right) \\ p_{\bar{\omega}} \left(1 + q_{\bar{\omega}}^{\gamma} v_{\bar{\omega}, \bar{\omega}}^{\beta}\right) &= p_{\hat{\omega}} \left(1 + q_{\hat{\omega}}^{\gamma} v_{\hat{\omega}, \bar{\omega}}^{\beta}\right), \end{aligned}$$

where  $d^*(\underline{\omega}, \bar{\omega})$  is the shortest arc between  $\underline{\omega}$  and  $\bar{\omega}$ . We focus on the symmetric equilibrium in which all prices are symmetric. Consequently, the market clientele for variety  $\hat{\omega}$  is a compact set of consumers whose ideal varieties range from  $\underline{\omega}$  to  $\bar{\omega}$ . Note that from the first stage of the two-stage budgeting procedure we know the individual consumption levels for each produced variety  $\hat{\omega}$ :

$$(A2) \quad q_{\hat{\omega}} = \frac{z}{p_{\hat{\omega}}}$$

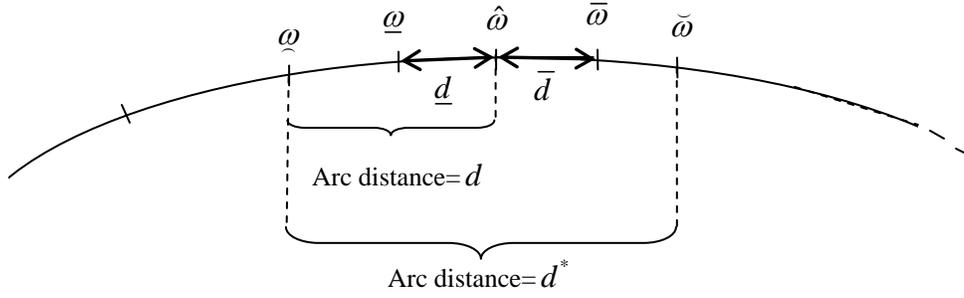


Figure A1.

In what follows, all varieties are identified by the shortest arc distance from variety  $\underline{\omega}$ : variety  $\hat{\omega}$  is represented by  $d$ , variety  $\underline{\omega}$  is represented by  $(d - \underline{d})$  where  $\underline{d} = v_{\underline{\omega}, \hat{\omega}}$ , and variety  $\bar{\omega}$  is represented by  $d + \bar{d} = v_{\underline{\omega}, \bar{\omega}}$  where  $\bar{d} = v_{\hat{\omega}, \bar{\omega}}$ . Figure A1 illustrates these identifications graphically. Now we can update our notation and substitute (A2) into (A1):

$$(A3) \quad \begin{aligned} p_{\underline{\omega}} \left[ 1 + (z)^\gamma p_{\underline{\omega}}^{-\gamma} (d - \underline{d})^\beta \right] &= p_{\hat{\omega}} \left( 1 + (z)^\gamma p_{\hat{\omega}}^{-\gamma} \underline{d}^\beta \right) \\ p_{\bar{\omega}} \left[ 1 + (z)^\gamma p_{\bar{\omega}}^{-\gamma} (d + \bar{d})^\beta \right] &= p_{\hat{\omega}} \left( 1 + (z)^\gamma p_{\hat{\omega}}^{-\gamma} \bar{d}^\beta \right) \end{aligned}$$

where  $p_{\underline{\omega}}$ ,  $p_{\bar{\omega}}$ , and  $p_{\hat{\omega}}$  denote the prices of the corresponding varieties.

From (A3) we can express the boundaries of the firm's clientele as a function of the distance between its closest competitors' varieties, their pricing ( $p_{\underline{\omega}}$  and  $p_{\bar{\omega}}$ ), the firm's own pricing ( $p_{\hat{\omega}}$ ) and variety choice (as measured by  $d$ ), and individual income spent on the differentiated good:

$$\begin{aligned} \underline{d} &= \underline{v} \left[ p_{\hat{\omega}}, d, p_{\omega}, p_{\bar{\omega}}, d^*, z \right] \\ \bar{d} &= \bar{v} \left[ p_{\hat{\omega}}, d, p_{\omega}, p_{\bar{\omega}}, d^*, z \right] \end{aligned} \quad (\text{A4})$$

Thus we can write the demand function faced by a firm producing variety  $\hat{\omega}$  as:

$$Q_{\hat{\omega}} = \frac{\left[ \underline{v}(\cdot) + \bar{v}(\cdot) \right] zL}{p_{\hat{\omega}}} \quad (\text{A5})$$

where  $zL$  is the aggregate expenditure on the differentiated varieties.

Next let us derive the price elasticity of demand function defined by (A5). To do it, we will first apply the implicit derivation to (A4) in order to find the response of the market width towards an increase in price:

$$\begin{aligned} \frac{\partial \underline{v}}{\partial p_{\hat{\omega}}} &= - \frac{(z)^{-\gamma} + (1-\gamma) p_{\hat{\omega}}^{-\gamma} \underline{d}^{\beta}}{p_{\omega} \beta p_{\omega}^{-\gamma} (d - \bar{d})^{\beta-1} + \beta p_{\hat{\omega}}^{1-\gamma} \underline{d}^{\beta-1}} < 0 \\ \frac{\partial \bar{v}}{\partial p_{\hat{\omega}}} &= - \frac{(z)^{-\gamma} + (1-\gamma) p_{\hat{\omega}}^{-\gamma} \bar{d}^{\beta}}{p_{\omega} \beta p_{\omega}^{-\gamma} (d^* - d - \bar{d})^{\beta-1} + \beta p_{\hat{\omega}}^{1-\gamma} \bar{d}^{\beta-1}} < 0 \end{aligned} \quad (\text{A6})$$

where the nominators of both fractions are strictly positive according to assumption (10).

Recall that we are focusing on the symmetric equilibria, and thus all prices are symmetric

and  $(d^* - d - \bar{d}) = (d - \underline{d}) = \underline{d} = \bar{d} = \frac{d}{2}$ . Combining this fact with (A6), we can derive the

price elasticity of demand from (A5):

$$\varepsilon = 1 + \frac{1}{2\beta} \left( \frac{p}{z} \right)^{\gamma} \left( \frac{2}{d} \right)^{\beta} + \frac{1-\gamma}{2\beta} > 1 \quad (\text{A7})$$

## Appendix 2. Open Economy

### A. Assumptions

The model outlined in this section nests the generalized ideal variety model into the Lancaster (1984) model of intra-industry trade. There are three countries, Home, France, and Germany, which are indexed by  $H$ ,  $F$ , and  $G$ , respectively. Consumer preferences are defined over a differentiated good  $q$ , which is defined by a continuum of varieties indexed by  $\omega \in \Omega$ :

$$(A8) \quad u(q_\omega \mid \omega \in \Omega) = \max_{\omega \in \Omega} \left( \frac{q_\omega}{1 + q_\omega^\gamma v_{\omega, \bar{\omega}}^\beta} \right),$$

As in the closed economy model, varieties can be distinguished by a single attribute, and all varieties can be represented by points on the circumference of a circle, with the circumference being of unit length. The budget constraint is

$$(A9) \quad \int_{\omega \in \Omega} q_\omega p_\omega = I_i, \quad i = \{H, F, G\}.$$

The consumer in country  $i = \{H, F, G\}$  is endowed with  $z_i$  efficient units of labor which he supplies inelastically. The wage per efficient unit of labor is denoted by  $w_i$ , so that the individual's budget is defined as:

$$(A10) \quad I_i = z_i w_i \quad i = \{H, F, G\}.$$

The wage in Home is normalized to one,  $w_H = 1$ .

The differentiated varieties are produced by monopolistically competitive firms. As in the closed economy model there are fixed and marginal labor requirements. We now interpret  $\alpha$  not as the fixed labor requirement of production, but as the labor requirement of adjustment to each market. Consequently, the fixed labor requirement is

incurred for each market the firm chooses to enter. The fixed labor requirement of market adjustment is assumed to be symmetric across the countries and varieties:

$$(A11) \quad \alpha_{i\omega} = \alpha \quad \forall \omega \in \Omega, i \in \{H, F, G\}.$$

In contrast, the marginal labor requirements are assumed to differ across countries and varieties. We split the variety space  $\Omega$  into four disjoint complementary subsets  $\Omega_0$ ,  $\Omega_H$ ,  $\Omega_F$ , and  $\Omega_G$  represented by arcs with the lengths  $S_0$ ,  $S_H$ ,  $S_F$ , and  $S_G$ , respectively. The marginal labor requirement of producing variety  $\omega \in \Omega_i$ ,  $i \in \{H, F, G\}$  is assumed to be  $c$  in country  $i$  and  $C > c$  in all other countries.

In other words each country has a Ricardian comparative advantage in the production of a certain subset of varieties. We assume that these subsets are proportional to the country endowments of the efficient units of labor:

$$(A12) \quad S_i = k \frac{L_i z_i}{L_H z_H + L_F z_F + L_G z_G} \quad 0 < k \leq 1, i \in \{H, F, G\}$$

The transportation cost  $\tau > 1$  is of ‘iceberg’ form, it is symmetric across varieties and countries, and is not prohibitive for trade,  $Cw_{-i} > \tau cw_i$  for any  $i \in \{H, F, G\}$ .

### *B. Market Equilibrium*

Following Lancaster (1984) we ignore boundary effects, that is, we focus on competition between varieties within each sub-interval of the circle. (This is similar in spirit to the empirical exercise, where we examine within country variation in prices as a function of market characteristics, and examine own- rather than cross-price effects in the elasticity of demand.) We show that there exists equilibrium such that each country completely specializes in varieties for which it has lower marginal labor requirement.

Can Home-produced varieties make positive profits on the interval  $\Omega_F$ ? Assume

that there exists a domestic firm producing variety  $\omega \in \Omega_F$  and earning nonnegative profit by selling the amount  $Q_\omega$  at price  $p_\omega$  in the Home's market. Given that France's marginal cost combined with trade cost is lower than Home's marginal cost,  $c\tau w_F < C$ , there exists a price,  $p < p_\omega$ , such that a French producer can sell the same amount  $Q_\omega$  of the identical product in Home's market at this price and earn a strictly positive profit. By undercutting the Home producer's price, French producer will crowd out Home's producer from the market. Indeed, because French firms have a marginal cost advantage and are free to produce anywhere they like on  $\Omega_F$ , none of Home's producers is able to earn nonnegative profit and all varieties will be produced by France on  $\Omega_F$ . In a similar fashion we can show that all varieties on  $\Omega_i$ ,  $i \in \{H, F, G\}$  will be produced by country  $i$  only.

Next, we need to find the equilibrium wages in France and Germany which would keep the current account balanced. If Home specializes on  $\Omega_H$ , France's expenditure on imports from Home are equal to the proportion of aggregate income spent on interval  $\Omega_H$ , i.e.,  $S_H L_F z_F w_F$ . Similarly, country  $i \in \{H, F, G\}$  will spend  $S_j L_i z_i w_i$  on products imported from country  $j \in \{H, F, G\}$ . As a result, the trade balance equation for each country can be written as:

$$\text{Home: } \frac{S_H L_F z_F w_F + S_H L_G z_G w_G}{\tau} = \frac{S_F L_H z_H w_H + S_G L_H z_H w_H}{\tau};$$

$$\text{France: } \frac{S_F L_H z_H w_H + S_F L_G z_G w_G}{\tau} = \frac{S_H L_F z_F w_F + S_G L_F z_F w_F}{\tau};$$

$$\text{Germany: } \frac{S_G L_F z_F w_F + S_G L_H z_H w_H}{\tau} = \frac{S_F L_G z_G w_G + S_H L_G z_G w_G}{\tau}.$$

Solving for the equilibrium wages, we get:

$$w_F = \frac{S_F L_H z_H}{S_H L_F z_F} \quad w_G = \frac{S_G L_H z_H}{S_H L_G z_G},$$

which after substituting for the arc lengths with (A12) results in

$$(A13) \quad w_F = w_G = 1$$

Next we focus on France's import from Home. The profit-maximizing price and zero-profit quantity for each produced variety are standard for this class of models:

$$(A14) \quad p_{FH} = \frac{c\tau\epsilon_{FH}}{\epsilon_{FH} - 1} \quad Q_{FH} = \frac{\alpha}{c\tau}(\epsilon_{FH} - 1),$$

from which the equilibrium number of firms is France's aggregate expenditure on Home's varieties  $S_H z_F L_F$  over the expenditure per variety  $p_{FH} Q_{FH}$ :

$$(A15) \quad n_{FH} = \frac{S_H z_F L_F}{\alpha \epsilon_{FH}}.$$

The distance between the closest varieties imported by France from Home is:

$$(A16) \quad d_{FH} = \frac{S_H}{n_{FH}} = \frac{\alpha \epsilon_{FH}}{z_F L_F}.$$

From (A7), the price elasticity of varieties imported by France from Home is,

$$\epsilon_{FH} = 1 + \frac{1}{2\beta} \left( \frac{p_{FH}}{z_F w_F} \right)^\gamma \left( \frac{2}{d_{FH}} \right)^\beta + \frac{1-\gamma}{2\beta},$$

which after substituting for price, wage and distance with (A13), (A14), and (A16) can be rewritten as:

$$(A17) \quad \epsilon_{FH} = 1 + \frac{1}{2\beta} \left[ \frac{c\epsilon_{FH}}{z_F (\epsilon_{FH} - 1)} \right]^\gamma \left( \frac{2z_F L_F}{\alpha \epsilon_{FH}} \right)^\beta + \frac{1-\gamma}{2\beta}.$$

As in the closed economy case, the equilibrium value of the price elasticity of demand is unique, since the LHS of (A17) is increasing in  $\varepsilon_{FH}$ , while the RHS is decreasing in  $\varepsilon_{FH}$ . Similarly, the price elasticity of demand for varieties imported by Germany from Home is

$$(A18) \quad \varepsilon_{GH} = 1 + \frac{1}{2\beta} \left[ \frac{c\varepsilon_{GH}}{z_G(\varepsilon_{GH} - 1)} \right]^\gamma \left( \frac{2z_G L_G}{\alpha\varepsilon_{GH}} \right)^\beta + \frac{1-\gamma}{2\beta}.$$

### C. Elasticities and Importer-Specific Characteristics

We can rearrange (A17) as

$$\left( \varepsilon_{FH} - 1 - \frac{1-\gamma}{2\beta} \right) (\varepsilon_{FH} - 1)^\gamma \varepsilon_{FH}^{\beta-\gamma} = \frac{1}{2\beta} \left[ \frac{c}{z_F} \right]^\gamma \left( \frac{2z_F L_F}{\alpha} \right)^\beta,$$

where the LHS is increasing in  $\varepsilon_{FH}$ . The corresponding function for  $\varepsilon_{GH}$  is

$$\left( \varepsilon_{GH} - 1 - \frac{1-\gamma}{2\beta} \right) (\varepsilon_{GH} - 1)^\gamma \varepsilon_{GH}^{\beta-\gamma} = \frac{1}{2\beta} \left[ \frac{c}{z_G} \right]^\gamma \left( \frac{2z_G L_G}{\alpha} \right)^\beta.$$

The ratio of the two expressions is

$$\frac{\left( \varepsilon_{FH} - 1 - \frac{1-\gamma}{2\beta} \right) (\varepsilon_{FH} - 1)^\gamma \varepsilon_{FH}^{\beta-\gamma}}{\left( \varepsilon_{GH} - 1 - \frac{1-\gamma}{2\beta} \right) (\varepsilon_{GH} - 1)^\gamma \varepsilon_{GH}^{\beta-\gamma}} = \left[ \frac{z_F}{z_G} \right]^{-\gamma} \left( \frac{z_F L_F}{z_G L_G} \right)^\beta,$$

and it is increasing in the ratio of aggregate incomes and decreasing (controlling for the ratio of GDPs) in the ratio of incomes. That is, controlling for exporter characteristics and other factors, a larger importer will have a higher elasticity, while a richer importer (controlling for the country size) – a smaller elasticity.