Trade in Ideal Varieties:

Theory and Evidence

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Abstract

Abstract: Models with constant-elasticity of substitution (CES) preferences are commonly employed in the international trade literature because they provide a tractable way to handle product differentiation in general equilibrium. However this tractability comes at the cost of generating a set of counter-factual predictions regarding cross-country variation in export and import variety, output per variety, and prices. We examine whether a generalized version of Lancaster's 'ideal variety' model can better match facts. 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. Model predictions about cross-country differences in the number and size of establishments are also empirically confirmed.

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I. Introduction

Beginning with Krugman (1979, 1980), the Dixit-Stiglitz (1977) framework of product differentiation has become a workhorse of the international trade literature. A short list of applications includes the literatures on intra-industry and north-north trade, economic geography, regional integration, gravity modeling of trade flows, and multinational firms.

The model is widely used because it is highly tractable. In its most commonly used form the model assumes constant elasticity of substitution (CES) demand, which has several important features. Varieties are not assigned to any particular "address" and product space is effectively infinite. As a consequence, differentiated varieties may exhibit a high or low degree of substitutability, but this is invariant to the number of products in the market. Further, consumers "love" variety, in the sense that increased variety improves welfare. Curiously, the marginal utility consumers derive from new variety is not declining in entry, whether new entrants represent the 20th or 200th variety on the market.

These assumptions carry pronounced normative implications. Trade economists are often bemused that the gains from trade in neoclassical models are small. However, as Romer (1994) demonstrates in a simple calibration, trade liberalization that increases the number of traded varieties can be a source of much larger welfare gains.[1] In a related empirical exercise, Feenstra (1994) shows that under a maintained hypothesis of CES demand, variety-corrected price indices for a set of US imports have fallen much lower than the uncorrected indices would seem to indicate.[2]

In sum, the CES model's core assumptions yield useful tractability, and the model's predictions about variety expansion imply tremendous welfare gains from trade in markets large

[1] Klenow and Rodriguez (1997) show that the welfare gains from new variety in Costa Rica are smaller than Romer suggests, but still larger than neoclassical gains.
[2] Broda and Weinstein (2004) extend the Feenstra calculations to a broader set of US import categories.

and small. But are the central empirical predictions of this structure correct? Consider a few stark implications of the model that can be shown by comparing, ceteris paribus, a large and a small closed economy. The larger country will enjoy entry of new varieties at a rate proportional to its country size. Because this entry does not "crowd" variety space, the own-price (and cross-price) elasticity of demand is the same as in the small country. This implies that prices, which depend only on marginal cost and the demand elasticity, are the same in the two markets. It also implies that the quantity per variety is the same in the two markets: fixed costs of entry are the same in the two markets, and markups are the same, so the same quantity per variety clears zero-profit conditions in both places. These predictions are not incidental. It is precisely this strong symmetry in prices and quantities, and the strict proportionality between number of varieties and market size which makes these models so tractable and widely-employed.

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.[3]

What could cause a less than proportional expansion of import varieties with respect to market size? Two candidates come to mind. Perhaps there are fixed costs of importing as modeled in Romer (1994), but these are rising in market size so that the cost of new varieties at the margin is higher for larger markets as in Klenow-Rodriguez Clare (1997). Alternatively, it may be that goods become more substitutable as more varieties enter the market, so that the marginal benefit of new varieties falls with market size. We emphasize the latter channel,

[3] 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.

examining the empirical implications of a generalized ‘ideal variety’ model.

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. This means that entry causes “crowding” – goods become more substitutable as more enter the market so that the own price elasticity of demand increases with market size. This has important implications for prices, the average size of firms and the rate of variety expansion.

Again consider a ceteris paribus comparison of a large and small country. In the large country, entry drives up the price elasticity of demand, leading to lower markups. Since firms in the large market must be able to recoup their fixed costs of entry despite lower markups, they must sell a larger quantity. This, in turn, implies that new variety expansion will be increasing in market size, but less than proportionally.

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 three exercises focusing on cross-country variation in average firm size, prices of traded goods, and the own-price elasticity of demand. First, we use the UNIDO Industrial Statistics Database to measure the average value added per firm for 152 3-digit ISIC sectors in 54 countries from 1990-2000. Controlling for country and industry effects so that we exploit purely time series variation, we show that average firm size co-varies positively with GDP, and negatively with GDP per worker (conditioning on GDP). This result is robust to alternative measures of firm and market size.

Next, we examine the model's predictions for prices. 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. This variation allows us to 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.

Finally, 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 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 (2005). We emphasize cross-importer facts, and depart from the CES utility framework that dominates this literature.

Second, we contribute to a literature in which market entry affects the elasticity of demand facing a firm. Most of the trade theory literature has emphasized oligopoly and homogeneous goods as in Brander and Krugman (1982). 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. The model's predictions for market size and the elasticity of demand are similar to quadratic utility models as in Ottaviano and Thisse (1999). 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.[4] These income effects significantly improve our ability to fit the model to the data.

Finally, 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 goods are also higher in richer countries.

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

[4] Perloff and Salop (1985) also include preference intensity but do not link it explicitly to observable characteristics of consumers, or consider a trading equilibrium.

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.

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 that nests the generalized ideal variety framework into a Ricardian continuum model in the manner of Dornbusch-Fischer-Samuelson (1977). Sections III-V provide empirical examinations of model implications for average firm sizes, prices, and the own-price elasticity of demand. Section VI concludes.

II. Model

A. Demand Functions

Preferences of a consumer are defined over a homogeneous numeraire product q_0, and a differentiated product q, which is defined by a continuum of varieties indexed by $\omega \in \Omega$:

(1) $$U = q_0^{1-\mu}\left[u\left(q_\omega \mid \omega \in \Omega\right)\right]^{\mu} \qquad 0 < \mu < 1,$$

where subutility $u\left(q_\omega \mid \omega \in \Omega\right)$ is defined later in this section. The budget constraint is:

(2) $$q_0 + \int_{\omega\in\Omega} q_\omega p_\omega = I,$$

where p_ω are the prices of the varieties being produced and I is income in terms of the numeraire.

Varieties can be distinguished by a single attribute. We assume that all varieties can be represented by points on the circumference 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 ω 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 $h\left(v_{\omega,\tilde{\omega}}\right)$, 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 $h\left(v_{\omega,\tilde{\omega}}\right)q$ units of some other variety ω, where $v_{\omega,\tilde{\omega}}$ is the shortest arc distance between $\tilde{\omega}$ and ω. It is assumed that:

(3) $h(0)=1$, $h'(0)=0$, and $h'\left(v_{\omega,\tilde{\omega}}\right)>0$, $h''\left(v_{\omega,\tilde{\omega}}\right)>0$ for $v_{\omega,\tilde{\omega}}>0$.

The subutility of variety ω 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):

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

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

$$u\left(q_{\omega} \mid \omega \in \Omega\right)=\max_{\omega\in\Omega}\left[\frac{q_{\omega}}{h\left(v_{\omega,\tilde{\omega}}\right)}\right] \tag{4}$$

Given the weak separability of the utility function (1), we can use a two-stage budgeting procedure. From the second stage we find that the consumer spends μI on the differentiated product. In the first stage, we can maximize the subutility subject to the budget constraint, μI, and given the prices of differentiated varieties, p_ω. The solution to this problem is:

$$
(5) \qquad \begin{aligned} & q_{\omega'} = \frac{\mu I}{p_{\omega'}}, \qquad q_\omega = 0 \quad \text{for } \omega \neq \omega', \\ & \text{where} \quad \omega' = \arg\min \left[p_\omega h\left(v_{\omega,\tilde{\omega}}\right) \mid \omega \in \Omega \right]. \end{aligned}
$$

In (5), 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: $p_{AJ} = 5 p_W$. Equation (5) suggests that the consumer will buy $\frac{\mu I}{p_W}$ units of water if $5 > h\left(v_{W,AJ}\right)$. 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, $h\left(q_\omega, v_{\omega,\tilde{\omega}}; \gamma\right)$, having the following properties:

$$
(6) \qquad h_2\left(q_\omega, v_{\omega,\tilde{\omega}}; \gamma\right) > 0 \text{ and } h_{22}\left(q_\omega, v_{\omega,\tilde{\omega}}; \gamma\right) > 0 \text{ for } v_{\omega,\tilde{\omega}} > 0
$$

$$
(7) \qquad h\left(q_\omega, 0; \gamma\right) = 1, \; h_2\left(q_\omega, 0; \gamma\right) = 0
$$

$$
(8) \qquad h\left(0, v_{\omega,\tilde{\omega}}\right) = 1, \; h_{12}\left(q_\omega, v_{\omega,\tilde{\omega}}; \gamma\right) > 0 \text{ for } q_\omega, \gamma, v_{\omega,\tilde{\omega}} > 0
$$

$$
(9) \qquad h\left(q_\omega, v_{\omega,\tilde{\omega}}; 0\right) = h\left(v_{\omega,\tilde{\omega}}\right)
$$

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 (6) and (7). By (8) 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, (9) 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 (4). 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:

$$(10) \qquad h\left(q_{\omega}, v_{\omega,\tilde{\omega}}; \gamma\right) - q_{\omega} h_1\left(q_{\omega}, v_{\omega,\tilde{\omega}}; \gamma\right) > 0 \qquad \forall \omega \in \Omega$$

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:

$$(11) \qquad h\left(q_{\omega}^{\gamma}, v_{\omega,\tilde{\omega}}\right) = 1 + q_{\omega}^{\gamma} v_{\omega,\tilde{\omega}}^{\beta} \qquad \beta > 1,\ 0 \le \gamma \le 1,$$

It is easy to verify that the restrictions imposed on the parameters β and γ in (11) are necessary and sufficient for properties (6) – (10) to hold. The corresponding subutility function is then

$$(12) \qquad u\left(q_{\omega} \mid \omega \in \Omega\right) = \max_{\omega \in \Omega} \left(\frac{q_{\omega}}{1 + q_{\omega}^{\gamma} v_{\omega,\tilde{\omega}}^{\beta}} \right).$$

Now we can apply the two-stage budgeting procedure in order to maximize (1) subject to (2) using a subutility function defined by (12). Given that the upper-case utility function is

Cobb-Douglas, the consumption of the homogeneous good and expenditure on the chosen differentiated varieties are:

(13) $$q_0 = (1-\mu) I ,$$

(14) $$\int_{\omega \in \Omega} q_\omega p_\omega = \mu I .$$

Consumption of a differentiated variety ω' is found by maximizing the subutility (12) subject to budget constraint (14):

(15) $$q_{\omega'} = \frac{\mu I}{p_{\omega'}}, \qquad q_\omega = 0 \quad \text{for} \ \ \omega \neq \omega'$$
$$\text{where} \quad \omega' = \arg\min \left[p_\omega \left(1 + q_\omega^\gamma v_{\omega,\tilde{\omega}}^\beta \right) | \, \omega \in \Omega \right].$$

B. Market Equilibrium

Each individual is endowed with z efficient units of labor, which he supplies inelastically in a perfectly competitive labor market. The homogeneous good is produced with constant returns to scale with labor requirement equal to one. Consequently, the wage is equal to one in terms of the numeraire and an individual's income is equal to his labor endowment:

(16) $$I = z .$$

Varieties of the differentiated product are produced by monopolistically competitive firms, with identical technology. Production requires a fixed number of workers α, payable in each period that the variety is produced, and marginal labor requirement c. Given that the wage equals one, α 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.[5] 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 ω. 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:

$$(17) \qquad Q = \frac{d\mu z L}{p},$$

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:

$$(18) \qquad \varepsilon = 1 + \frac{1}{2\beta}\left(\frac{p}{\mu z}\right)^{\gamma}\left(\frac{2}{d}\right)^{\beta} + \frac{1-\gamma}{2\beta} > 1.$$

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:

$$(19) \qquad p = \frac{c\varepsilon}{\varepsilon - 1} \qquad\qquad Q = \frac{\alpha}{c}\left(\varepsilon - 1\right).$$

[5] 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 (12) is available upon request from the authors.

Knowing the expenditure on each product from (14), and the size of firms from (19), we can find the equilibrium number of firms:

$$n = \frac{\mu z L}{\alpha \varepsilon}. \tag{20}$$

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

$$d = \frac{1}{n} = \frac{\alpha \varepsilon}{\mu z L}. \tag{21}$$

Now we can rewrite (18) using (19)–(21):

$$\varepsilon = 1 + \frac{1}{2\beta}\left[\frac{c\varepsilon}{\mu z(\varepsilon - 1)}\right]^{\gamma}\left(\frac{2\mu z L}{\alpha \varepsilon}\right)^{\beta} + \frac{1-\gamma}{2\beta}. \tag{22}$$

The equilibrium value of the price elasticity of demand is unique, since the LHS of (22) is increasing in ε, while the RHS is decreasing in ε. From (19) and (20) 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 (22) we get

$$\frac{\partial \varepsilon}{\partial L}\frac{L}{\varepsilon} = \left\{2\varepsilon\left[\frac{\mu z(\varepsilon - 1)}{c\varepsilon}\right]^{\gamma}\left(\frac{2\mu z L}{\alpha \varepsilon}\right)^{-\beta} + \frac{\gamma}{\beta(\varepsilon - 1)} + 1\right\}^{-1}. \tag{23}$$

The resulting expression is strictly positive and strictly less than one[6]; 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

[6] 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.

ω 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 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 (19) 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 ε 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 (20) 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 ε.

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 (22) we can find:

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

(24)

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

An increase in z has two effects, raising ε through an increase in the aggregate labor endowment, zL, and lowering ε by raising income per worker. The effect on the aggregate labor endowment is captured by the inverse portion of (24). By comparing this expression with (23), 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 $\frac{-\gamma}{\beta}\{...\}^{-1}$ in (24). 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 ε, 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 (1970) 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 (23) and

(24) by setting γ equal to zero. Comparative statics with respect to market size are similar[7], 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. Of these, data on the number of firms and output per firm are available from domestic data for many countries, and we test model predictions in section III. Unfortunately cross-country domestic data on prices and price elasticities are not available in sufficient detail for many countries to test the model. 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, and described briefly here.

Solving the ideal variety model required a symmetric equilibrium in which varieties on a circle are equally spaced and have the same prices. A trivial way to extend the model to the open economy is to maintain this symmetry for foreign and domestic firms. That is, foreign varieties pay some fixed cost to enter the market that is identical to that of domestic firms, and that the delivered marginal cost of foreign varieties (inclusive of production, tariffs or other trade costs) matches domestic production costs.

We rely on a more general solution that has been employed previously in the literature in a two-country setting by Dornbusch, Fischer, and Samuelson (1977), and in a multi-country setting by Eaton and Kortum (2002). In these models there is a continuum of homogeneous goods

[7] 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.

arranged according to strength of comparative advantage. At any point on the continuum we can compare the price of domestic goods to the delivered price of foreign goods and discern whether the products will be imported, exported, or neither.

We show in Appendix 2 that it is possible to nest the ideal variety framework into the continuum; each good is no longer a single point on the continuum, it is now a circle. The key features of the equilibrium are that, as in Dornbusch, Fischer, and Samuelson and Eaton and Kortum, each country will buy goods on a particular circle from only one supplier. This ensures that all varieties in a particular product space 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 (23) and (24) now 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 – The Number and Average Size of Firms

In this section we examine model predictions regarding the number and size of firms within a country. We can think of this either as a test of the closed economy version of the model, or as a test of the open economy version when focusing only on the non-traded segments of the goods continuum. In both cases, output characteristics within a country are determined by demand characteristics in that country not the world as a whole. Simply, the model predicts that the number of firms expands less than proportionally with market size so that the average size of firms is rising in market size. Conditioning on market size, growth in income per capita leads consumers to prefer a closer match to their ideal types which increases the number of firms, and lowers their average size.

To examine these predictions we employ data from the UNIDO Industrial Statistics Database. We have data on the number of establishments, total employment, value added, and gross output by 152 ISIC 3-digit industries for 54 countries from 1990-2000. There are undoubtedly important differences across countries and industries in industrial and government regulatory structure, as well as subtle differences in data definitions (e.g. what constitutes an "establishment"). As a consequence, cross-sectional differences in the number and size of firms are likely to be extremely noisy. Instead, we exploit the panel structure of the data to examine how changes in market size and income per capita affect changes in the number and size of establishments within a country.

Our estimating equations for number of establishments is

$$(25) \quad \ln N_{it}^k = \alpha_i^k + \beta_1 \ln \frac{Y_{it}}{L_{it}} + \beta_2 \ln SIZE_{it}^k + e_{it}^k$$

where the dependent variable N_i^k is the number of establishments in country i, industry k, at time t, $SIZE_{it}^k$ is the size of the industry (measured variously as total employment, gross output, or value added), $\frac{Y_{it}}{L_{it}}$ is real GDP per capita taken from the World Bank's World Development Indicators, and α_i^k is a country-industry fixed effect.

We also examine average establishment size,

$$(26) \quad \ln\left(\frac{SIZE_{it}^k}{N_{it}^k}\right) = \alpha_i^k + \beta_1 \ln \frac{Y_{it}}{L_{it}} + \beta_2 \ln SIZE_{it}^k + e_{it}^k$$

where $SIZE_{it}^k$ is again measured variously as employment, gross output, or value added. We also employ total market size for all sectors (ln GDP from the World Bank WDI) in place of sector specific measures on the right hand side.

Results are reported in Table 2. In the first 3 columns we see that the prediction of the generalized ideal variety model for number of establishments is borne out. Conditioning on a country and industry, growth in the total size of an industry leads to a less than proportional expansion in the number of establishments. This holds for all three measures of industry size. The number of establishments is also rising in income per capita.

The next six columns examine the average size of firms. Regardless of the measure employed, we see that average size of establishments is increasing in industry size and decreasing in income per capita. The same holds true when we employ GDP instead of sector specific measures, though the regression fits are much lower in this case.

IV. Empirics – Cross-Importer Variation in Prices

Next, we empirically examine the theoretical predictions regarding cross-importer prices: prices should be lower in large markets and higher in rich markets after conditioning on market size. 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, and 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.[8] The term α_{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 α_{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, $m_{it}^{k} = \exp\left(\alpha_{i}^{k}\right)\left(Y_{it}\right)^{m_{2}^{k}}\left(Y_{it}/L_{it}\right)^{m_{3}^{k}}$

This allows us to write log export prices as

$$\ln p_{ijt}^{k} = c_{jt}^{k} + \alpha_{ij}^{k} + a_{i}^{k} + m_{2}^{k}(\ln Y_{it}) + m_{3}^{k}(\ln \frac{Y_{it}}{L_{it}}).$$

In order to eliminate variation across importer-products a_{i}^{k} and bilateral pair-products α_{ij}^{k} we take long differences of the data, examining changes in log export prices between the

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[8] 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.

beginning and end of the sample. Using t = 0,1, we have[9]

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

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.

$$(27) \quad \ln p_{ij,1}^{k} - \ln p_{ij,0}^{k} = a_j^k + \beta_1(\ln Y_{i,1} - \ln Y_{i,0}) + \beta_2\left(\ln\frac{Y_{i,1}}{L_{i,1}} - \ln\frac{Y_{i,0}}{L_{i,0}}\right) + e_{ij}^k$$

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[10]

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

The results match our theoretical predictions. Prices fall for importers for whom GDP is growing, and rise for importers for whom income per capita is growing.

Next, we estimate equation (27) 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 3, along with counts of significant coefficients. For categories representing over 80 percent of trade by value, statistically

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[9] 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.
[10] All coefficients are significant at 1% level. Number of observations is 1,043,566 and within-R^2=.001

significant coefficient estimates match the theory[11]. 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. 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 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. However, we are unaware of any direct evidence on this point.

IV. 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. Unfortunately, this 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

[11] "Wrong-signed" and statistically significant estimates occur in categories representing only 2 percent of trade by value.

favor of a model in which the elasticity varies systematically across markets. In particular, equations (23) and (24) 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 and tariffs for many importers and exporters at the 6 digit level of the Harmonized System classification (roughly 5000 goods). While we are not able to use the time series to difference out unobserved characteristics as in the firm size and price regressions above, we can still use multiple bilateral observations for each importer to similar effect.

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…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 λ_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

$$(28) \quad q_{ij}^k = \frac{E_i^k}{\Pi_i^k} \left(\frac{p_{ij}^k}{\lambda_j^k} \right)^{-\sigma^k}$$

Where E_i^k denotes expenditures, and Π_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 = HS 6 digit level of aggregation, everything in (28) is unobservable except the nominal value of bilateral trade and trade costs. To isolate these terms, we multiply both sides of (28) by exporter prices, and sum over all importers $c \neq i$ to get j's exports to rest of the world, r.

$$(pq)_{rj}^k = \sum_{c\neq i}(pq)_{cj}^k = \left(\lambda_j^k\right)^{\sigma^k}\left(p_j^k\right)^{1-\sigma^k}\sum_{c\neq i}\frac{E_c^k}{\Pi_c^k}\left(t_{cj}^k\right)^{-\sigma^k}$$

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

$$(29) \quad \ln s_{ij}^k = \ln\frac{(pq)_{ij}^k}{(pq)_{rj}^k} = \ln\frac{E_i^k}{\Pi_i^k} - \sigma^k \ln t_{ij}^k - \ln\sum_{c\neq i}\frac{E_c^k}{\Pi_c^k}\left(t_{cj}^k\right)^{-\sigma^k}$$

Writing this in share terms eliminates unobserved price and quality (variety) shifters specific to j.[12] We assume trade costs take the form $\ln t_{ij}^k = \ln(1+\tau_i^k) + \delta_k \ln d_{ij}$, where τ_i^k is an MFN tariff facing all exporters in importer i, product k, d_{ij} is the distance between countries, and δ^k is the elasticity of trade costs with respect to distance.

To simplify this expression, we employ importer i – product k fixed effects α_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. 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.[13] We now have

[12] Alternatively, we could also write (29) by expressing i's imports relative to any particular importer, or set of importers, rather than the world.

[13] 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

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

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.

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

Before proceeding to the results, a few notes regarding interpretation are in order. Ideally, we would estimate (31) 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 two pooling strategies. For simplicity, we first pool over all exporters and 6 digit products. 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

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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.

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 (31) by pooling over all exporters and products. The resulting estimate is[14]

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

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 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.

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 (31) separately for each 2 digit HS product. Full details for each HS2 product are reported in Table 3, along

[14] All coefficients are significant at 1% level. Number of observations is 1,183,696 and R^2=.17.

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.

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

$$(32) \quad \hat{\beta}_1^k \ln d + \hat{\beta}_2^k \ln d \ln Y + \hat{\beta}_3^k \ln d \ln\left(Y/L\right) = \delta^k (\sigma^k + \sigma_y^k \ln Y + \sigma_{y/l}^k \ln\left(Y/L\right))$$

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

$$(33) \quad \frac{\delta^k}{\delta^k} \frac{(\sigma^k + \sigma_y^k \ln Y_1 + \sigma_{y/l}^k \ln\left(Y/L\right)_1)}{(\sigma^k + \sigma_y^k \ln Y_2 + \sigma_{y/l}^k \ln\left(Y/L\right)_2)}$$

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 (32). We then rank them from most to least elastic, and express the elasticity ratio in (33) using the 90th percentile / 10th 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 90th percentile country is twice that of the price elasticity for the 10th 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.

C. Robustness: tariffs as an alternative trade cost measure

Ideally we would have data on bilaterally varying ad-valorem trade costs, rather than using a distance proxy for them. Our TRAINS also includes tariff rates for each trade observation, but has insufficient variation across exporters for a given importer-product for us to use this variable in estimating (31). There is some variation in the tariff *schedule* across export sources for a given importer and six digit HS, but most of the high tariff observations correspond to zero trade values. Of the pairs where trade is observed, in about 90 percent of the cases $TAR_{ij}^{k} = \text{median}(TAR_{i}^{k})$. This means that tariffs in the data can reasonably be treated as identical across exporters as we model above, in which case employing importer-product (ik) fixed effects eliminates tariffs as a useful source of variation for trade costs

We experimented with an alternative specification that allowed us to exploit cross-importer variation in tariffs. Starting from (28), we multiply both sides by exporter prices to get (observable) nominal values for bilateral trade. We include exporter j – commodity k fixed effects, α_j^k, to eliminate all exporter-specific effects, including the last term in (29) which we had omitted as unmeasurable in our primary specification. Finally, we proxy for real expenditures in equation (29) using importer GDP and GDP per capita so that the estimating equation becomes

$$\ln pq_{ij}^k = \alpha_j^k + \gamma_1 \ln Y_i + \gamma_1 \ln \frac{Y_i}{L_i} + \beta_4^k \ln d_{ij} + \beta_1^k \ln\left(1+\tau_i^k\right) + \beta_2^k \ln\left(1+\tau_i^k\right) \ln Y_i + \beta_3^k \ln\left(1+\tau_i^k\right) \ln \frac{Y_i}{L_i} + e_{ij}^k \tag{34}$$

Here, the elasticity is identified using cross-importer variation in tariffs within a particular good. The advantage of this specification is that one can read the coefficients on tariffs and its interactions directly in terms of a price elasticity σ^k, rather than as the product of two elasticities $\sigma^k \delta^k$. The disadvantage is that we omit the importer price index, which could plausibly affect our estimated interaction terms.[15]

We estimate (34) by pooling over all exporters and HS6 products within an HS2 aggregate. Table 3 reports full results, and Figure 5 reports the distribution over the HS2 products of coefficients on the interaction terms. The same basic message from Figure 3 goes through. For 75 percent of trade by value, the signs match the predictions of the generalized ideal variety model. Larger countries exhibit a higher price elasticity of demand. Conditioning on size, richer countries exhibit a lower price elasticity of demand.

Unlike the specification employing distance as a measure of trade costs, here we can directly interpret the interaction coefficients in terms of their impact on the absolute price elasticity. A coefficient of -0.5 on the GDP x tariff term implies that doubling GDP yields demand that is 0.5 percentage points more elastic. Given the range of GDP variation in the world, this represents substantial variation in the price elasticity across countries.

D. Robustness: Product Composition.

[15] To explain, large countries are likely to have larger domestic industries. If we believe the CES null, this translates into a lower price index due to the value of greater variety (see Feenstra 1994).

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 (31) 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 version of the Lancaster (1979) ideal variety model. In this model, 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 country and industry and exploiting time series variation, we find that average firm size is rising for countries with rising GDP, and falling for countries with rising GDP per capita. 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. Finally, 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.

We see three implications of these findings. First, the theoretical and empirical literature on product differentiation in trade 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 substantial 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 important 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. Second, the news is not all bad in the sense 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. Whether these traded goods price differences are a significant contributor to national price levels as a whole, and constitute a challenge to the centrality of non-traded goods in explaining them, we leave for subsequent work.

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Table 1. Predictions across Models.

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

[1] Controlling for market size.

Table 2: The Number and Size of Firms

	Number of Establishments			Average Establishment Size: Employment		Average Establishment Size: Gross Output		Average Establishment Size: Value Added	
GDP per capita	1.279	0.774	0.864	-1.631	-1.264	-0.134	-0.703	-0.256	-0.804
	(0.037)	(0.040)	(0.040)	(0.050)	(0.036)	(0.049)	(0.039)	(0.052)	(0.040)
GDP				0.246		0.040		0.110	
				(0.019)		(0.015)		(0.016)	
Industry Total Employment	0.669				0.300				
	(0.009)				(0.009)				
Industry Total Gross Output		0.449					0.531		
		(0.008)					(0.008)		
Industry Total Value Added			0.367						0.605
			(0.008)						(0.008)
Constant	-0.044	-0.037	-0.037	0.038	0.039	0.023	0.038	0.025	0.038
	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Observations	21983	21014	21043	21983	21983	21014	21014	21043	21043
R2	0.229	0.163	0.131	0.053	0.090	0.000	0.166	0.002	0.213

Notes:

1. Panel regression of equations 25 and 26 includes country-ISIC3 industry fixed effects
2. All variables are in logs, standard errors are in parentheses.
3. Regression R2 are net of fixed effects

Table 3: Cross-Importer Variation in Prices and Price Elasticity

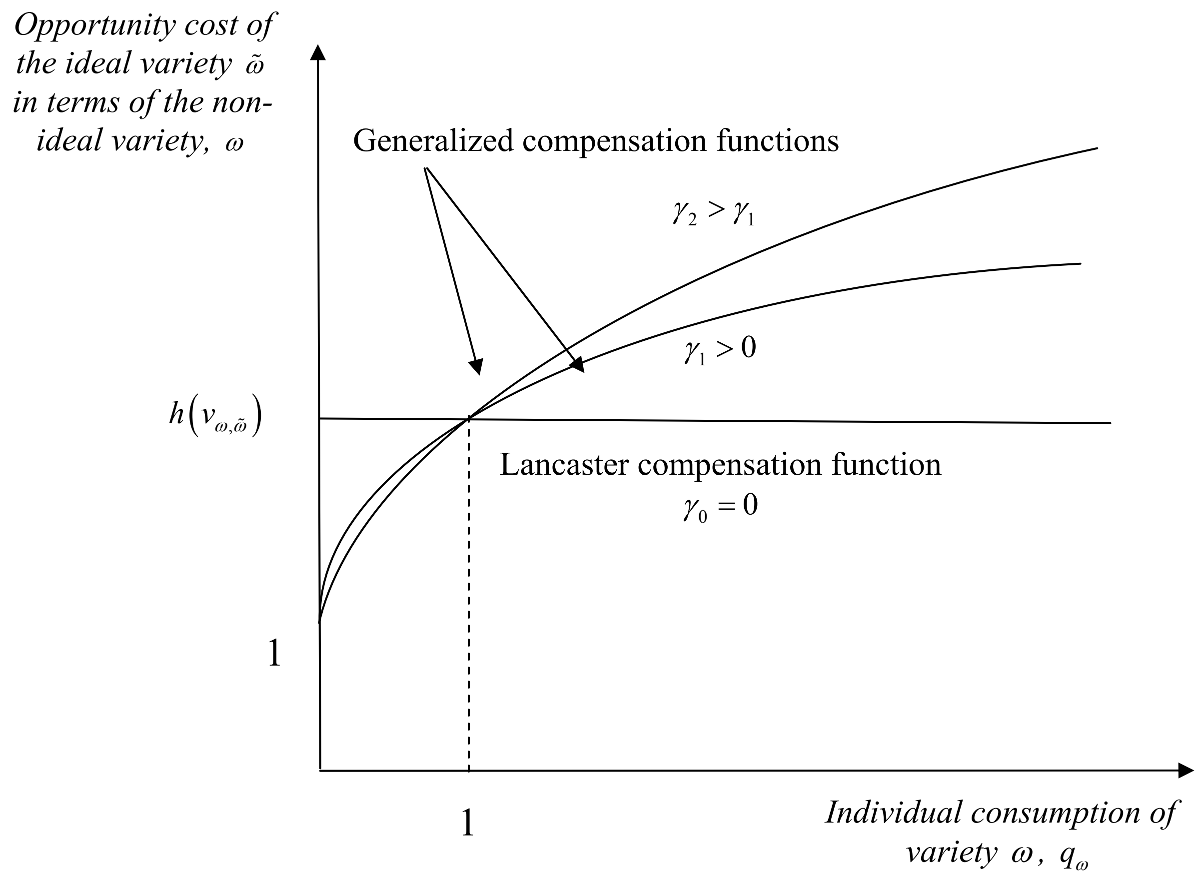
HS2	ABBREVIATION		Share of Trade	Price Regressions Eqn (27)		Distance Elasticity Regressions Eqn (31)		Tariff Elasticity Regressions Eqn (34)	
				Y	Y/L	Y * Dist	Y/L * Dist	Y* tar	Y/L * tar
	Significant Coefficients with Signs matching Model Predictions	Simple Count		38	44	55	54	60	43
		Weighted by Share of Trade		82%	85%	84%	76%	76%	74%
	Significant Coefficients with Signs Different from Model Predictions	Simple Count		11	6	9	10	8	15
		Weighted by Share of Trade		2%	2%	5%	4%	7%	11%
	Mean of Significant Coefficients over HS 2	Simple Mean		-0.28	0.42	-0.06	0.10	-0.84	0.46
		Weighted by Share of Trade		-0.47	0.54	-0.06	0.10	-0.60	1.00
1	LIVE ANIMALS		0.12	-0.12	0.52	0.05	-0.18	-0.14	-1.68
2	MEAT AND EDIBLE MEAT OFFAL		0.42	.87***	-.62***	-.18***	.59***	.45*	1.97**
3	FISH, CRUSTACEANS & AQUATIC INVERTEBRATES		1.07	-0.11	.24*	-0.02	-.33***	-1.01***	0.44
4	DAIRY PRODS; BIRDS EGGS; HONEY; ED ANIMAL PR NESOI		0.20	.23***	-.21***	-.06***	.16***	.77***	0.22
5	PRODUCTS OF ANIMAL ORIGIN, NESOI		0.09	0.12	-0.13	-0.03	0.1	-1.38	6.92***
6	LIVE TREES, PLANTS, BULBS ETC.; CUT FLOWERS ETC.		0.10	0.08	0.17	0	-.25***	-1.23***	3.24***
7	EDIBLE VEGETABLES & CERTAIN ROOTS & TUBERS		0.30	.24**	-0.15	-.19***	.13**	-.96***	1.34**
8	EDIBLE FRUIT & NUTS; CITRUS FRUIT OR MELON PEEL		0.70	0.15	0.2	-.13***	.15***	0.05	-1.05**
9	COFFEE, TEA, MATE & SPICES		0.45	-0.02	0.11	0.02	-.14***	-.54***	-1.46***
10	CEREALS		0.48	.7**	-0.46	-.12***	.27***	-0.72	-0.87
11	MILLING PRODUCTS; MALT; STARCH; INULIN; WHT GLUTEN		0.04	0.35	-0.3	-0.03	-0.09	-0.08	1.43
12	OIL SEEDS ETC.; MISC GRAIN, SEED, FRUIT, PLANT ETC		0.44	0.12	0.13	-.1***	0.06	-0.39	1.9***
13	LAC; GUMS, RESINS & OTHER VEGETABLE SAP & EXTRACT		0.05	.54**	-0.4	0.04	.12*	0.29	2.75***
14	VEGETABLE PLAITING MATERIALS & PRODUCTS NESOI		0.01	0.8	-0.65	-.09*	0.08	2.25	-2.37
15	ANIMAL OR VEGETABLE FATS, OILS ETC. & WAXES		0.31	-0.07	.24*	-.03*	-0.04	-1.07***	-1.4**
16	EDIBLE PREPARATIONS OF MEAT, FISH, CRUSTACEANS ETC		0.31	.2*	-0.05	-0.01	-0.1	-.54*	-0.33
17	SUGARS AND SUGAR CONFECTIONARY		0.15	0	0.12	-.09***	0.08	-.7***	0
18	COCOA AND COCOA PREPARATIONS		0.18	.21**	-0.14	-.1***	.11*	-.59**	3.44***
19	PREP CEREAL, FLOUR, STARCH OR MILK; BAKERS WARES		0.14	0.12	0.07	-.04**	.08*	-.37*	1.44***
20	PREP VEGETABLES, FRUIT, NUTS OR OTHER PLANT PARTS		0.33	-0.1	.24***	-.04***	-.06*	-.75***	1.07**
21	MISCELLANEOUS EDIBLE PREPARATIONS		0.23	0.12	-0.02	-0.02	.07*	-0.1	0.46
22	BEVERAGES, SPIRITS AND VINEGAR		0.21	-.71***	.76***	-.03**	-.11**	-0.07	.82**
23	FOOD INDUSTRY RESIDUES & WASTE; PREP ANIMAL FEED		0.38	0.36	-0.29	-.03*	.19***	0	-0.39
24	TOBACCO AND MANUFACTURED TOBACCO SUBSTITUTES		0.14	.66*	-0.56	0.04	0.07	-.54**	0.79
25	SALT; SULFUR; EARTH & STONE; LIME & CEMENT PLASTER		0.38	0.04	-0.09	-.1***	.08**	-1.13***	-0.02
26	ORES, SLAG AND ASH		0.67	-1.06*	0.45	-0.02	0.01	-0.29	10.28

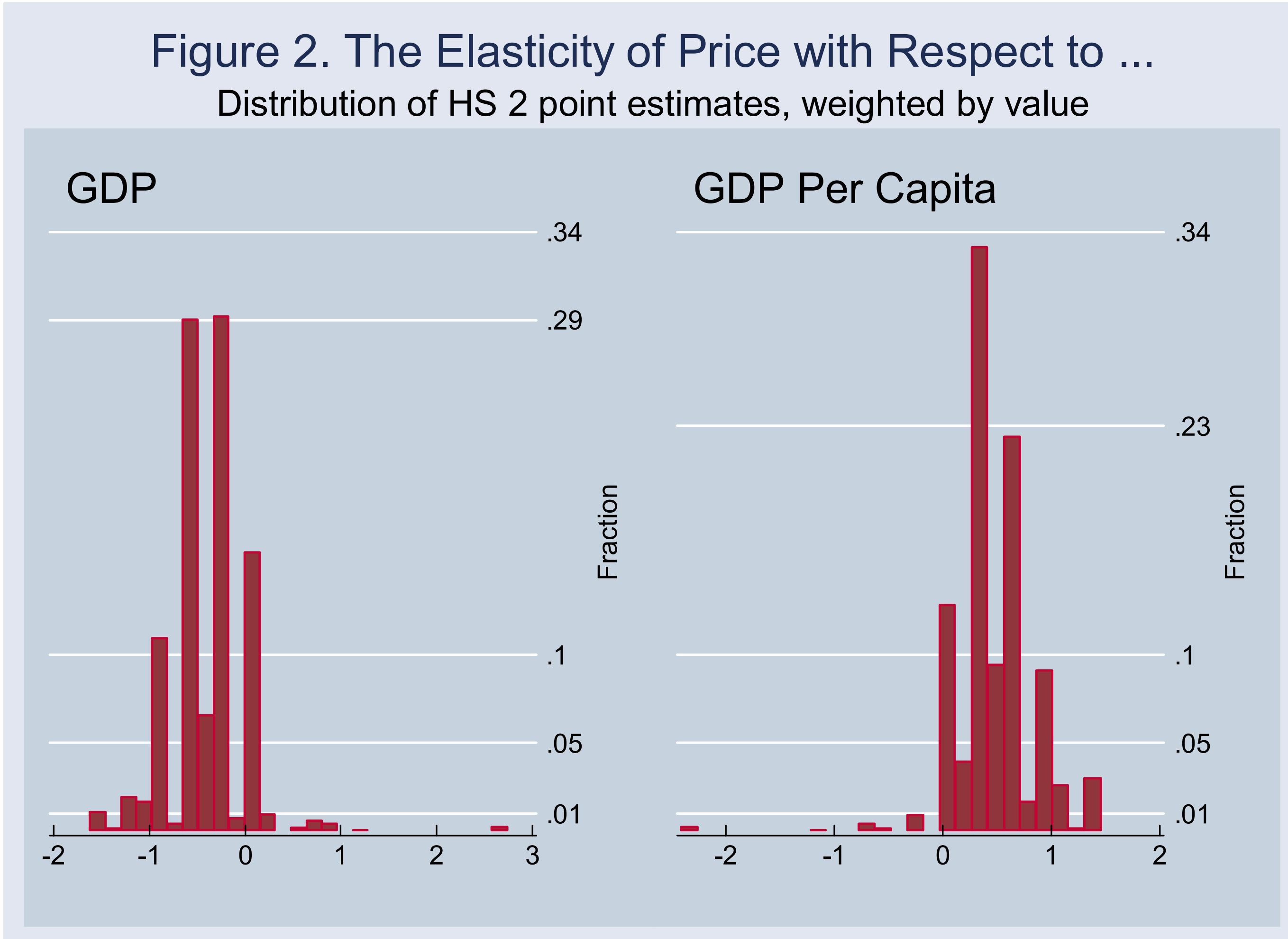
HS2	ABBREVIATION	Share of Trade	Price Regressions Eqn (27)		Distance Elasticity Regressions Eqn (31)		Tariff Elasticity Regressions Eqn (34)	
			Y	Y/L	Y * Dist	Y/L * Dist	Y* tar	Y/L * tar
27	MINERAL FUEL, OIL ETC.; BITUMIN SUBST; MINERAL WAX	8.03	-.53**	.52**	-.1***	0.02	0.03	4.5***
28	INORG CHEM; PREC & RARE-EARTH MET & RADIOACT COMPD	0.73	0.17	-.21*	-.09***	.07***	-.84***	-0.11
29	ORGANIC CHEMICALS	2.51	-.21***	.27***	-.04***	.19***	.48***	.69***
30	PHARMACEUTICAL PRODUCTS	1.46	-.49***	.76***	0	.19***	-0.02	2.23***
31	FERTILIZERS	0.26	-0.15	.5*	-.11***	0.03	-0.55	-6.55***
32	TANNING & DYE EXT ETC; DYE, PAINT, PUTTY ETC; INKS	0.51	-0.11	0.05	-.04***	.16***	-0.18	1.66***
33	ESSENTIAL OILS ETC; PERFUMERY, COSMETIC ETC PREPS	0.41	0.13	-0.03	0	.12***	.22**	-0.14
34	SOAP ETC; WAXES, POLISH ETC; CANDLES; DENTAL PREPS	0.22	0.11	-0.04	-.07***	.17***	0	2.25***
35	ALBUMINOIDAL SUBST; MODIFIED STARCH; GLUE; ENZYMES	0.14	.56***	-.52**	-.03**	.17***	-0.24	3.19***
36	EXPLOSIVES; PYROTECHNICS; MATCHES; PYRO ALLOYS ETC	0.04	1.27***	-1.18***	-0.03	0.14	-1.25**	-0.88
37	PHOTOGRAPHIC OR CINEMATOGRAPHIC GOODS	0.31	-.42***	.61***	0	.19***	0.26	-2.08***
38	MISCELLANEOUS CHEMICAL PRODUCTS	0.81	-.22**	0.06	-.04***	.13***	-1.04***	.87**
39	PLASTICS AND ARTICLES THEREOF	2.55	-.23***	.27***	-.06***	.1***	-.61***	.33*
40	RUBBER AND ARTICLES THEREOF	1.02	-.39***	.35***	-.07***	.12***	-.22***	2.19***
41	RAW HIDES AND SKINS (NO FURSKINS) AND LEATHER	0.32	-0.07	0.35	-.06***	0.02	-0.2	-0.68
42	LEATHER ART; SADDLERY ETC; HANDBAGS ETC; GUT ART	0.65	-.33***	.51***	0	.17***	-1.68***	.79**
43	FURSKINS AND ARTIFICIAL FUR; MANUFACTURES THEREOF	0.05	-0.18	0.62	-0.04	-0.18	1.66***	2.57*
44	WOOD AND ARTICLES OF WOOD; WOOD CHARCOAL	1.61	-0.21	.37**	-.08***	-.12***	-1.65***	-1.05**
45	CORK AND ARTICLES OF CORK	0.01	1.42	-1.01	-0.04	.54***	1.91***	3.88**
46	MFR OF STRAW, ESPARTO ETC.; BASKETWARE & WICKERWRK	0.03	-0.11	-0.46	-.09**	0.17	-2.3***	2.01
47	WOOD PULP ETC; RECOVD (WASTE & SCRAP) PPR & PPRBD	0.42	-1.08**	0.71	.06*	.15*	0.46	-12.42***
48	PAPER & PAPERBOARD & ARTICLES (INC PAPR PULP ARTL)	1.32	-.24***	.3***	-.07***	.08***	-.61***	.78***
49	PRINTED BOOKS, NEWSPAPERS ETC; MANUSCRIPTS ETC	0.43	-1.04***	1.04***	0.01	.1***	-.66***	0.15
50	SILK, INCLUDING YARNS AND WOVEN FABRIC THEREOF	0.04	0.22	0.05	0.02	.26**	-0.25	0.49
51	WOOL & ANIMAL HAIR, INCLUDING YARN & WOVEN FABRIC	0.18	-0.23	0.27	-0.03	-.12**	-1.26***	0.43
52	COTTON, INCLUDING YARN AND WOVEN FABRIC THEREOF	0.60	-0.11	.3***	-.08***	.06***	-1.84***	.47*
53	VEG TEXT FIB NESOI; VEG FIB & PAPER YNS & WOV FAB	0.04	-.67**	.97***	-0.05	-.19*	-1.37***	-1.09
54	MANMADE FILAMENTS, INCLUDING YARNS & WOVEN FABRICS	0.43	-.51***	.71***	-.06***	.04*	-1.43***	1.81***
55	MANMADE STAPLE FIBERS, INCL YARNS & WOVEN FABRICS	0.35	-.15**	.32***	-.06***	.11***	-1.37***	.9***
56	WADDING, FELT ETC; SP YARN; TWINE, ROPES ETC.	0.12	-0.11	0.19	-.11***	.13***	-.99***	0.44
57	CARPETS AND OTHER TEXTILE FLOOR COVERINGS	0.15	-1.1***	.98***	0	0.05	-.81***	0.14
58	SPEC WOV FABRICS; TUFTED FAB; LACE; TAPESTRIES ETC	0.10	-0.16	0.2	.03*	.07*	-1.14***	1.65***
59	IMPREGNATED ETC TEXT FABRICS; TEX ART FOR INDUSTRY	0.15	-0.14	.36***	-.1***	.15***	-.45***	.69*
60	KNITTED OR CROCHETED FABRICS	0.18	0.11	0.02	-.09***	.16***	-1.64***	2.36***
61	APPAREL ARTICLES AND ACCESSORIES, KNIT OR CROCHET	2.00	-.87***	1.09***	-.07***	.08***	-1.6***	2.14***
62	APPAREL ARTICLES AND ACCESSORIES, NOT KNIT ETC.	2.48	-.38***	.7***	-.09***	.16***	-1.94***	.55**
63	TEXTILE ART NESOI; NEEDLECRAFT SETS; WORN TEXT ART	0.40	-0.05	.21**	-.04***	-0.01	-1.86***	0.43
64	FOOTWEAR, GAITERS ETC. AND PARTS THEREOF	1.08	-1.45***	1.45***	-.07***	.23***	-1.06***	2.99***
65	HEADGEAR AND PARTS THEREOF	0.08	0.39	0	.09***	-0.1	-1.72***	0.46
66	UMBRELLAS, WALKING-STICKS, RIDING-CROPS ETC, PARTS	0.04	-0.04	0.02	0	.31***	-1.46***	0.15

HS2	ABBREVIATION	Share of Trade	Price Regressions Eqn (27)		Distance Elasticity Regressions Eqn (31)		Tariff Elasticity Regressions Eqn (34)	
			Y	Y/L	Y * Dist	Y/L * Dist	Y* tar	Y/L * tar
67	PREP FEATHERS, DOWN ETC; ARTIF FLOWERS; H HAIR ART	0.08	-0.03	0.7	.18***	.32***	-2.61***	0.95
68	ART OF STONE, PLASTER, CEMENT, ASBESTOS, MICA ETC.	0.27	-.36***	.33***	-.04***	-0.01	-.57***	1.61***
69	CERAMIC PRODUCTS	0.32	-.35***	.4***	-.05***	.1***	-1.19***	.59*
70	GLASS AND GLASSWARE	0.46	0.06	-0.05	-.09***	.11***	-.43***	1.58***
71	NAT ETC PEARLS, PREC ETC STONES, PR MET ETC; COIN	2.73	-.62**	.58*	.08***	.11**	-1.38***	-5.13***
72	IRON AND STEEL	1.60	-0.07	0	-.18***	0	-1.09***	0.57
73	ARTICLES OF IRON OR STEEL	1.45	-.28***	.32***	-.09***	.07***	-.66***	1.73***
74	COPPER AND ARTICLES THEREOF	0.63	-.21*	0.12	-.13***	.12***	0.08	-.97*
75	NICKEL AND ARTICLES THEREOF	0.15	-.78**	1.13***	0.07	0.13	1.84***	-5.35***
76	ALUMINUM AND ARTICLES THEREOF	1.08	-.37***	.36***	-.14***	0.01	-.93***	-1.85***
78	LEAD AND ARTICLES THEREOF	0.04	0.11	0.22	-.16***	0.03	1.13	1.99
79	ZINC AND ARTICLES THEREOF	0.10	-.88***	.96***	-.18***	.16*	-0.36	-1.67
80	TIN AND ARTICLES THEREOF	0.04	-.78**	1.06***	.15**	-0.21	0.84	-1.06
81	BASE METALS NESOI; CERMETS; ARTICLES THEREOF	0.14	-1.37***	1.21***	0.02	-0.06	0.11	-0.6
82	TOOLS, CUTLERY ETC. OF BASE METAL & PARTS THEREOF	0.45	-.36***	.5***	-0.01	.09***	-.23***	1.59***
83	MISCELLANEOUS ARTICLES OF BASE METAL	0.38	-.15*	0.08	-.04***	.05**	-.47***	2.68***
84	NUCLEAR REACTORS, BOILERS, MACHINERY ETC.; PARTS	16.27	-.51***	.58***	-.05***	.12***	-.27***	2***
85	ELECTRIC MACHINERY ETC; SOUND EQUIP; TV EQUIP; PTS	14.99	-.3***	.37***	-.02***	.06***	-.08**	.96***
86	RAILWAY OR TRAMWAY STOCK ETC; TRAFFIC SIGNAL EQUIP	0.21	-0.4	0.25	-.15***	0.13	-2.02***	-2.25**
87	VEHICLES, EXCEPT RAILWAY OR TRAMWAY, AND PARTS ETC	8.82	-.83***	.98***	-.11***	.13***	-.52***	1.13***
88	AIRCRAFT, SPACECRAFT, AND PARTS THEREOF	1.93	-1.26***	1.41***	-0.04	0.07	-1.56**	-6.21***
89	SHIPS, BOATS AND FLOATING STRUCTURES	0.35	-0.18	0.26	-0.01	-0.03	-.91***	0.66
90	OPTIC, PHOTO ETC, MEDIC OR SURGICAL INSTRMENTS ETC	3.52	-.24***	.31***	-.01*	.12***	.14**	-0.02
91	CLOCKS AND WATCHES AND PARTS THEREOF	0.26	0.43	-0.26	.05***	-.11***	-0.2	-1.23***
92	MUSICAL INSTRUMENTS; PARTS AND ACCESSORIES THEREOF	0.10	-0.44	.69**	.11***	0.06	-2.15***	2.63***
93	ARMS AND AMMUNITION; PARTS AND ACCESSORIES THEREOF	0.06	0.37	-0.46	-0.02	-.36***	-.43**	-0.69
94	FURNITURE; BEDDING ETC; LAMPS NESOI ETC; PREFAB BD	1.56	0	.13**	-.03***	0.02	-1.6***	-0.16
95	TOYS, GAMES & SPORT EQUIPMENT; PARTS & ACCESSORIES	1.33	-.16*	.28***	.03***	.15***	-1.41***	.52*
96	MISCELLANEOUS MANUFACTURED ARTICLES	0.27	-0.07	.18**	-0.01	.21***	-.61***	-0.26
97	WORKS OF ART, COLLECTORS' PIECES AND ANTIQUES	0.22	2.57***	-2.25***	0.05	-0.03	-.9**	-5.62***

Notes:
1. Equations (27), (31), and (34) separately estimated for each HS 2 category.
2. For equation (27) price regressions, table reports coefficients on log importer GDP (Y) and log importer GDP per capita (Y/L). For equation (31) distance elasticity regressions, table reports coefficient on interaction between logs of distance and logs of importer Y and Y/L. For equation (34) tariff elasticity regressions table reports coefficient on interaction between log (1 + tariff) and logs of importer Y and Y/L.

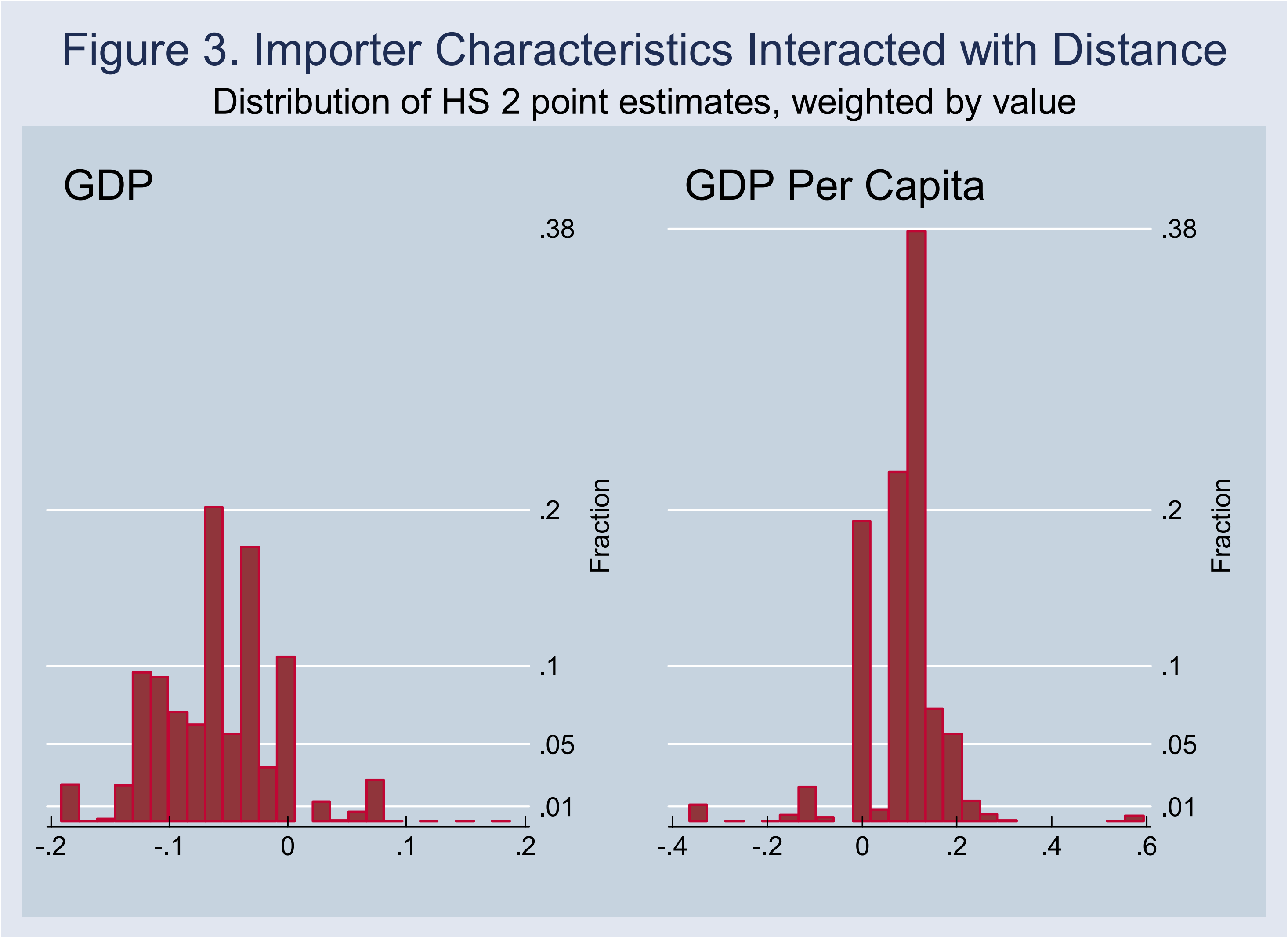
Figure 1. Lancaster and generalized compensation functions.





Notes:

1. From estimation of equation (27) on import prices from Eurostats trade database 1990-2003.
2. Full results in appendix table 2.



Notes:
1. From estimation of equation (31) on TRAINS bilateral trade data 1999.
2. Full results in appendix table 2.

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

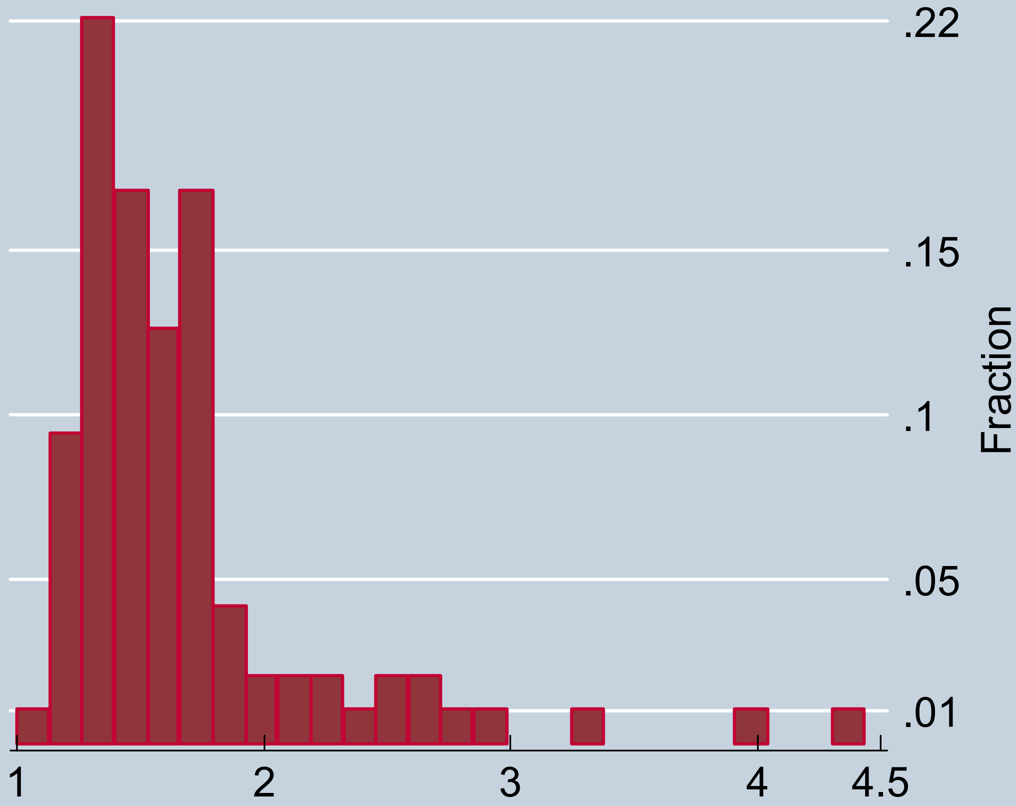
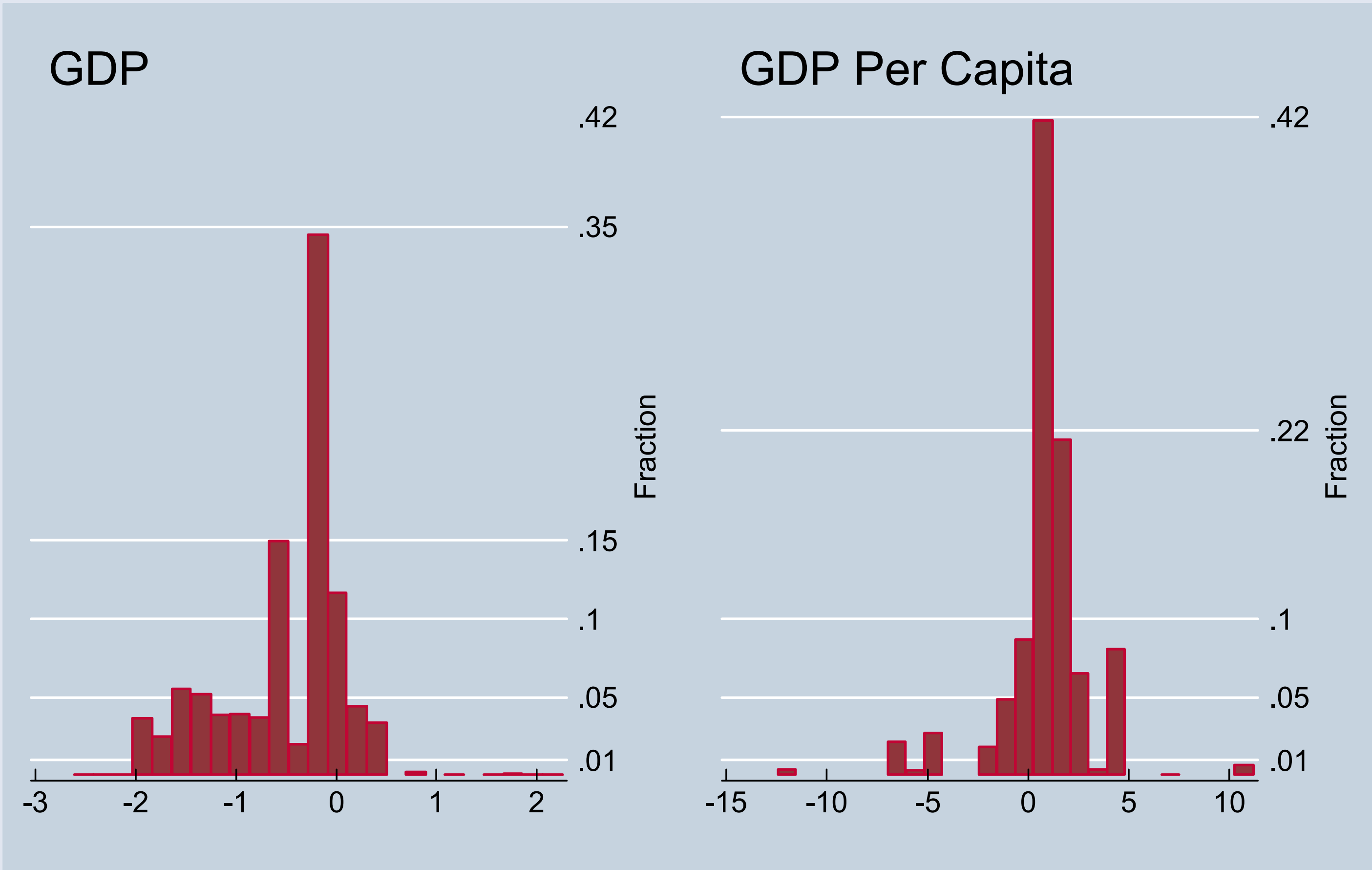


Figure 5. Importer Characteristics Interacted with Tariff

Distribution of HS 2 point estimates, weighted by value



Notes:

1. From estimation of equation (34) on TRAINS bilateral trade data 1999.
2. Full results in appendix table 2.

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 $\underset{\smile}{\omega}$, and its closest variety to the right is $\breve{\omega}$. The corresponding prices are denoted as $p_{\underset{\smile}{\omega}}$, $p_{\hat{\omega}}$ and $p_{\breve{\omega}}$. Next let us choose the varieties $\underline{\omega}, \bar{\omega} \in d^*\left(\underset{\smile}{\omega}, \breve{\omega}\right)$ such that

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

where $d^*\left(\underset{\smile}{\omega}, \breve{\omega}\right)$ is the shortest arc between $\underset{\smile}{\omega}$ and $\breve{\omega}$. 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 $\widehat{\omega}$:

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

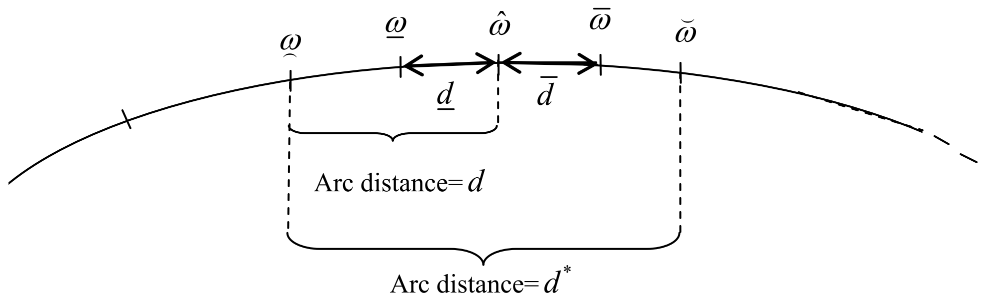


Figure A1.

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

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

where $p_{\underset{\frown}{\omega}}$, $p_{\breve{\omega}}$, 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 $\left(p_{\underset{\frown}{\omega}} \text{ and } p_{\breve{\omega}}\right)$, the firm's own pricing $\left(p_{\hat{\omega}}\right)$ and variety choice (as measured by d), and individual income spent on the differentiated good:

$$\underline{d} = \underline{v}\left[p_{\hat{\omega}}, d, p_{\underline{\omega}}, p_{\bar{\omega}}, d^*, \mu z\right]$$

(A4)

$$\bar{d} = \bar{v}\left[p_{\hat{\omega}}, d, p_{\underline{\omega}}, p_{\bar{\omega}}, d^*, \mu z\right]$$

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

(A5) $$Q_{\hat{\omega}} = \frac{\left[\underline{v}(.) + \bar{v}(.)\right]\mu z L}{p_{\hat{\omega}}}$$

where μIL 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:

$$\frac{\partial \underline{v}}{\partial p_{\hat{\omega}}} = -\frac{(\mu z)^{-\gamma} + (1-\gamma) p_{\hat{\omega}}^{-\gamma} \underline{d}^{\beta}}{p_{\underline{\omega}} \beta p_{\underline{\omega}}^{-\gamma} \left(d - \bar{d}\right)^{\beta-1} + \beta p_{\hat{\omega}}^{1-\gamma} \underline{d}^{\beta-1}} < 0$$

(A6)

$$\frac{\partial \bar{v}}{\partial p_{\hat{\omega}}} = -\frac{(\mu z)^{-\gamma} + (1-\gamma) p_{\hat{\omega}}^{-\gamma} \bar{d}^{\beta}}{p_{\bar{\omega}} \beta p_{\bar{\omega}}^{-\gamma} \left(d^* - d - \bar{d}\right)^{\beta-1} + \beta p_{\hat{\omega}}^{1-\gamma} \bar{d}^{\beta-1}} < 0$$

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 $\left(d^* - d - \bar{d}\right) = \left(d - \underline{d}\right) = \underline{d} = \bar{d} = \frac{d}{2}$. Combining this fact with (A6), we can derive the price elasticity of demand from (A5):

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

Appendix 2. Open Economy

The model outlined in this section nests the generalized ideal variety model into the Dornbusch-Fischer-Samuelson (1977) continuum of comparative advantage model. There are two countries, Home and Foreign, which are indexed by superscripts H and F, respectively. Consumer preferences are defined over a homogeneous product q_0 and over M differentiated products q_k, $k = 1, 2, ..., M$, where each of the differentiated products is defined by a continuum of varieties indexed by $\omega \in \Omega_k$:

$$\text{(A8)} \quad U = q_0^{1-\mu} \prod_{k=1}^{M} \left[u_k \left(q_{i\omega} \mid \omega \in \Omega_k \right) \right]^{\frac{\mu}{M}} \qquad 0 < \mu < 1,$$

where subutility $u_k \left(q_{k\omega} \mid \omega \in \Omega_k \right)$ is defined as

$$\text{(A9)} \quad u_k \left(q_{k\omega} \mid \omega \in \Omega_k \right) = \max_{\omega \in \Omega_k} \left(\frac{q_{k\omega}}{1 + q_{k\omega}^{\gamma} v_{\omega,\tilde{\omega}}^{\beta}} \right),$$

and the budget constraint is

$$\text{(A10)} \quad q_0 + \sum_{k=1}^{M} \int_{\omega \in \Omega_k} q_{k\omega} p_{k\omega} = I .$$

The differentiated varieties are produced by monopolistically competitive firms, with identical technologies. As in the closed economy model there are fixed and marginal labor requirements. We now interpret α not as the fixed cost of production, but as the cost of adjustment to each market. Consequently, the fixed cost is incurred for each market the firm chooses to enter. The fixed cost of market adjustment is assumed to be symmetric across the countries, products, and varieties:

$$\text{(A11)} \quad \alpha_{k\omega}^{H} = \alpha_{k\omega}^{F} = \alpha \qquad \forall \omega \in \Omega_k, \ k = 1, 2, ..., M .$$

In contrast, the marginal costs are assumed to differ across products and countries, while remaining the same for all varieties of a given product and country.

In particular, we assume that the Home's marginal cost is increasing in the index of the product:

(A12) $c_k^H < c_{k+1}^H$ $\qquad k = 1, 2, ..., (M-1)$,

while, for Foreign, the order of marginal costs across products is the reverse:

(A13) $c_k^F > c_{k+1}^F$ $\qquad k = 1, 2, ..., (M-1)$.

We assume that the parameters of the model are such that each country has a Ricardian comparative advantage in the production of a certain subset of products, which stimulates inter-product trade. The degree of comparative advantage differs across products: it is decreasing in k for Home and increasing in k for Foreign.

The transportation costs for the differentiated goods are of the 'iceberg' form, and they are identical for all varieties of all the products and for both directions of trade:

(A14) $t_{k\omega}^{HF} = t_{k\omega}^{FH} = t \geq 1$ $\qquad$ for any $\omega \in \Omega_k$, $k = 1, 2, ..., M$.

The homogeneous good can be traded at no cost. It is included in the model to guarantee balanced trade and equality of wages across countries: the numeraire sector is assumed to be large enough for each country to produce homogenous product under free trade.

B. Market Equilibrium

Consumers can potentially access both domestic and imported varieties. Hence, our first step is to find out which varieties will be traded internationally. Consider a single product $l \in \{1, 2, ..., M\}$. We analyze whether consumption of product l in Home consists of only domestic varieties, of only imported varieties, or both.

First, consider the case when $c_l^H > tc_l^F$. Assume that there exists a domestic firm producing variety $\omega \in \Omega_l$ and earning nonnegative profit by selling the amount $Q_{l\omega}$ at price $p_{l\omega}$ in the Home's market. Then there exists $p < p_{l\omega}$ such that a Foreign's producer can sell the same amount $Q_{l\omega}$ of the identical product in Home's market at price p and earn a strictly positive profit. By undercutting the Home producer's price, Foreign's producer will crowd out Home's producer from the market. Indeed, because Foreign firms have a marginal cost advantage and are free to produce anywhere they like on the product circle, none of Home's producers is able to earn nonnegative profit at Home's market of product l. All varieties of this product in the Home's market will be imported from Foreign.

In a similar fashion, it is possible to show that, if $c_l^H < tc_l^F$, no varieties of product l will be imported from Foreign by Home. Finally, if $c_l^H = tc_l^F$, the varieties of product l consumed at Home, can be produced both in Home and in Foreign. In this manner, we guarantee that all varieties of a particular product within a market will be symmetric. Similar analysis for Foreign can be conducted to determine the production location for each good l consumed in Foreign.

C. Comparative Statics

How does a change in z or L affect the equilibrium? Because we have pinned down the wage with the numeraire sector, cross-country differences in production costs $\left(c_l^H, c_l^F\right)$ for a given product are robust to changes in *z, L*. As a result, changes to *z, L* do not affect the division of products into imported, exported, and nontraded segments, and are instead absorbed entirely through changes in variety within a given product circle.[1]

In the closed economy equilibrium defined by equations (17)-(22), zL defines a country's resource availability and income constraints. In the multi-good open economy setting, the resource constraints can obviously not bind for each of the M products. However, if we focus on products that fall in the non-traded or import segments of the continuum, we can apply the closed economy solutions separately for each product. Now, μzL in (16) becomes $\mu zL/M$, and defines total expenditures on each product. This income constraint limits entry of firms, whether domestic firms for non-traded goods or foreign firms for imports, in precisely the same way as before.

Our comparative statics can now be interpreted as a cross-importer comparison: how is the market for a particular exporter's variety different in import markets with differing z and L? Given the Cobb-Douglas upper level utility, expenditure shares are fixed across countries, while total expenditures will vary across importers due to variation in z and L. As a result, the comparative statics within each product category with respect to z and L will be the same in both closed and open economy settings.

[1] This is in contrast to the standard DFS model where changes in L lead to wage changes and can affect the set of traded goods.