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How Strong is the Love of Variety?

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Abstract

Models with monopolistic competition and constant elasticity of substitution (CES) preferences have become a mainstay of theoretical and empirical work in international trade. However, the standard model yields contrafactual predictions on the number of varieties, prices and output per variety that are traded. In particular the model predicts a rate of variety growth that is faster than that observed in the data. This paper develops and tests a model with a more general, but still tractable, CES preference structure that nests Krugman (1980) and Armington (1969) style models. With limited love of variety the consumer faces a trade-off between buying more varieties or higher quantities per variety and in equilibrium the model yields a variety growth rate consistent with the data. The empirics confirm that consumer's *"love of variety"* is 42 percent lower than is assumed in Krugman's model. One implication is that existing studies overstate the variety gains from trade liberalization. Another is that the impact of product variety on economic growth and the strength of industrial agglomerations is smaller than is typically assumed.

I. Introduction

First introduced in international trade theory by Krugman (1980), Dixit-Stiglitz (1977) monopolistic competition model is widely used in general equilibrium modeling of trade flows with product differentiation. In its standard form, the model employs constant elasticity of substitution (CES) preferences to gain tractability in a general equilibrium framework. Consequently, it exhibits stark predictions on the number of varieties, prices and output per variety.

Krugman's monopolistic competition model assumes each country specializes in a number of varieties that is proportional to market size. It predicts that the rate of variety expansion is proportional to the growth in country size while output and prices per variety remain constant. The prediction implies that larger economies export more only on the extensive margin (a greater range of varieties) which it is at odds with empirical evidence. Hummels and Klenow (2002, 2005) empirically exploited exporter variation and examined the relationship between the number of exported varieties and exporter's country size. They found that the number of exported varieties represents only 59 percent of a larger country's exports. Thus, the rate of variety growth seems to be lower than that predicted by the theory.

Alternatively, Armignton's (1969) model, which dominates Computable General Equilibrium (CGE) analyses of trade policy, assumes varieties are differentiated by country of origin. In contrast with Krugman's model, the number of varieties is fixed. The Armington model shuts down the variety expansion channel of larger countries. Thus, a country grows only through the intensive margin in the sense that it produces higher quantities of its variety sold at lower prices on the world market.

These predictions have important welfare implications. In Krugman's model, greater variety represents the only source of gains from trade liberalization. In Armington's model, unilateral trade liberalization can yield unfavorable terms of trade effects since the number of varieties cannot adjust (Brown - 1987). However both terms of trade and variety gains are important consequences of trade liberalization. Thus, Armington's model may understate the gains from trade because it lacks the variety adjustment margin and Krugman's model may overstate them because it features no terms of trade effects.

This paper develops a model that can generate the slower rate of variety growth seen in the data. It incorporates a more general CES preference structure[1] that nests Krugman's and Armington's model. In both models, varieties are differentiated by country of origin. In Krugman's model the consumer also regards varieties as differentiated within a given country. Any two varieties originating from an exporter are equally substitutable as any two varieties from different exporters. In Armington's model, each country produces one variety or the consumer perceives varieties originating from the same country as perfect substitutes. The general CES structure generalizes the elasticity of substitution across varieties within a given exporter. Its lower and upper bounds are the elasticity of substitution in Krugman's and Armington's model. Intuitively, the consumer regards same country's varieties as more substitutable than varieties originating from different countries. Thus, the consumer has decreasing marginal valuation for varieties originating from the same country. Put it another

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[1] In the working paper of their seminal work, Dixit and Stiglitz(1975) proposed a general CES utility function that allows for different degrees of love of variety by introducing product diversity multiplicatively as an externality into the CES preference structure. In their specification the love of variety parameter could take positive and negative values and it could be interpreted as product diversity being a positive (public good) and negative externality (public bad) respectively. Other theoretical work used different forms of the general CES (Either – 1982, Benassy – 1996 and Montagna -1999). The specification of the general CES preference structure of this paper was inspired by Brown, Deardorff and Stern(1995).

way, the general CES preference allows the consumer's love of variety to be lower than is assumed by Krugman's preference structure.

To give intuition for this preference structure, consider two examples. The CAMIP survey[2] asks car buying consumers for their second choice. It shows that conditional on buying a Japanese car, consumers' most common second choice was also buying a Japanese car. Similarly, conditional on buying an American car, consumers' most common second choice was also an American car (Berry, Levinshon and Pakes - 2004)[3]. This suggests that consumers perceive within country varieties as more similar and better substitutes. Why are varieties more similar within a country? It could be country specific comparative advantage that makes a country's varieties more alike. For instance, Japanese car varieties might be more similar to each other than to American car varieties because of country specific technology in producing fuel efficient vehicles. French wine varieties might be more similar to each other than to Chilean wine varieties because of country specific climate, grape cultivation techniques, or methods of fermentation and ageing.

A simple trade model shows that consumer's limited love of variety can slow down the rate of variety growth. On the demand side, the consumer faces a trade-off between buying more varieties or higher quantities per variety. The elasticity of imports with respect to the number of varieties equals consumer's love of variety. In equilibrium, without factor price equalization, larger countries produce and export higher number of varieties but also higher quantities per variety sold at lower prices. Intuitively, any level of consumer's love of variety lower than in Krugman's model limits the extent to which larger economies allocate their additional resources towards producing new varieties and thus they also produce and export

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[2] Survey conducted on behalf of General Motors for 1993
[3] See Table 4

higher quantities per variety at lower prices. But, for any level of consumer's love of variety higher than in Armington's model, the terms of trade effects are less adverse.

In the empirics, this paper exploits a different source of variation than Hummels and Klenow (2002, 2005) to understand whether consumer's limited love of variety explains the empirical facts. Conditional on an exporter, I exploit cross-importer variation and structurally identify consumer's love of variety as the elasticity of imports with respect to the extensive margin. To do this I first derive a measure of variety that is consistent with the underlying utility structure. The extensive margin represents the cross-section equivalent of the variety growth measure derived by Feenstra (1994) extended to the general CES case. The general CES variety adjusted price index nests Feenstra's price index when love of variety is the highest.

I employ UN's COMTRADE data for 1999 that reports trade for many bilateral pairs and more than 5000 6 digit Harmonized System categories. I estimate that consumer love of variety is, on average, lower by 42 percent than is assumed in Krugman's model. The estimates reinforce Hummels and Klenow (2002, 2005)'s results and suggest that consumer's limited love of variety could explain the number of traded varieties patterns observed in the data.

This work relates and adds to three lines of research. First, it relates to the literature that develops richer models of product differentiation that predict a slower rate of variety growth. The literature employs two preference structures characterized by variable price elasticity of demand: quadratic utility function (Ottaviano and Thisse - 1999, Ottaviano et. all - 2000) and the ideal variety approach (Lancaster- 1979, Hummels and Lugovskyy - 2005). A monopolistic competition model with variable price elasticity of demand predicts that the variety price decreases and the variety output increases in importer's market size. Thus, the economy

expansion takes place not only on the extensive margin, but also on the intensive margin yielding a less than proportional relationship between the number of varieties and country size. Variable price elasticity of demand makes these models harder to work with in a general equilibrium framework or in empirical applications, and as a result there are only a few trade applications of these models.

Despite its stark features, CGE and economic geography models widely employ CES preference structure to gain tractability in general equilibrium framework. By incorporating the general CES utility, this paper's approach maintains the tractability of CES preferences and generates qualitatively the same predictions on the number of traded varieties, prices and output per variety as the models with variable price elasticity of demand do.

Second, my work builds on and adds to the literature that calibrates or estimates the welfare impact of traded varieties in the CES framework. Romer (1994), in a simple calibration, shows that trade liberalization that increases the number of traded varieties yields large welfare gains. Feenstra (1994) also shows that the consumer perceives the introduction of new varieties as a decrease in prices and thus the variety adjusted import price indexes are lower than the traditional price indexes. Furthermore Broda and Weinstein (2004) applies Feenstra(1994)'s method to a larger set of commodities to estimate the impact of new imported varieties on U.S. welfare and finds that greater product variety increased U.S. consumer's welfare by 3% of U.S. GDP from 1972 to 2001.

Third, Head and Ries (2001) investigate whether the relationship between a country's share of production is more or less than proportional to its share of demand in order to empirically distinguish increasing returns (Krugman) and national product differentiation (Armington) models. They found that the evidence for U.S. and Canada is mostly consistent to

Armington's model. This paper proposes an alternative structural test to home market effects and the findings reject both models and provide evidence for a model that blends together features of both Krugman and Armington.

These welfare results hinge heavily on modeling consumers' preferences using CES utility as in Krugman's model. This preference structure introduces instability into CGE models. If product varieties are industrial inputs, then trade liberalization increases the number of input varieties which increases the demand for the product which increases further the demand for input varieties (Brown, Deardorff and Stern - 1995). The result is that these CGE models generate far greater specialization than we see in actual output patterns.

The rest of the paper is organized as follows. Section II describes a simple trade model to illustrate how consumer's limited love of variety can explain the slower rate of variety growth observed in the data. Section III builds on Feenstra(1994)'s method and derives the relative general CES demand to identify and estimate consumer's love of variety in section IV. Section V provides some robustness check exercises and section VI concludes.

II. Diminishing returns to national varieties

This section describes a simple open economy model to illustrate how consumer's love of variety can explain the slower rate of variety growth observed in the data. The model nests Krugman's and Armington's models as two extreme versions of trade models, and predicts that growing economies expand the production of new varieties at a rate equal to the consumer's love of variety.

2.1. Preference structure

The representative consumer's preferences are identical across all M countries and are represented by a nested general CES utility function:

$$(1) \quad U_i = \left[\sum_{j=1}^{M} n_j^{\frac{\beta-1}{\sigma}} \left(\sum_{l=1}^{n_j} x_{jl}^{\frac{\sigma-1}{\sigma}} \right) \right]^{\frac{\sigma}{\sigma-1}}$$

subject to $\sum_{j=1}^{M} \sum_{l=1}^{n_j} p_{jl} x_{jl} = w_i L_i = Y_i$; where w_i is workers' wage and L_i is the size of the labor force in country i.

The parameter $\sigma > 1$ represents the elasticity of substitution across exporters j; x_{jl}, p_{jl} and n_j denote the quantity, prices per variety and number of varieties bought from country j (including from country i). The parameter $\beta \in [0,1]$ represents the consumer's *love of variety* – the marginal valuation of a variety. At $\beta = 1$ (Krugman) a consumer enjoys variety growth equally regardless of its source. At $\beta = 0$ (Armington) a consumer values adding a new exporter to the consumption bundle but places no value on additional varieties produced by an existing exporter. That is, it regards all varieties within the same exporter as identical[4]:

Krugman: $U_i = \left[\sum_{j=1}^{M} n_j x_j^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \overset{x_j = x}{=} (Mn)^{\frac{\sigma}{\sigma-1}} x$;

Armington: $U_i = \left[\sum_{j=1}^{M} \left(n_j x_j \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \overset{x_j = x}{=} M^{\frac{\sigma}{\sigma-1}} (nx)$.

The general CES demand for exporter j's variety is[5]:

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[4] To illustrate better how the general CES nests Krugman's and Armington's preference structure, I assume that varieties originating from the same country are symmetric in quantities: $x_{jl} = x_j$

[5] In the rest of section 1, I drop the importer subscript i.

$$(2) \quad x_{jl} = \frac{p_{jl}^{-\sigma} n_j^{\beta-1}}{\sum_{j=1}^{M} n_j^{\beta-1} \left(\sum_{l=1}^{n_j} p_{jl}^{1-\sigma} \right)} Y_i.$$

For $\beta = 1$ the demand becomes the CES demand. For any values of $\beta < 1$, the consumer faces a trade-off between the quantity per variety and the number of varieties imported. In other words, as an exporter's varieties become less valuable at the margin than in the CES framework, the consumer would rather buy a higher quantity per variety than more varieties. For $\beta = 0$ an increase in the number of varieties is exactly offset by a decrease in the quantity per variety. That is, the consumer becomes indifferent between buying more varieties or more per variety from an exporter as long as the total quantity stays the same.

Taking sum across all varieties exported by country j in (2) and rearranging, I obtain the relative imports from exporter j:

$$(3) \quad \frac{M_j}{M_k} = \left(\frac{n_j^{\frac{\beta-1}{1-\sigma}} \left(\sum_{l=1}^{n_j} p_{jl}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}}{n_k^{\frac{\beta-1}{1-\sigma}} \left(\sum_{l=1}^{n_k} p_{kl}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}} \right)^{1-\sigma}.$$

To build intuition, assume all varieties originating from a country are symmetric in prices. Then the relative total demand for exporter j's varieties relative to exporter k's varieties becomes:

$$(4) \quad \frac{M_j}{M_k} = \left(\frac{p_j}{p_k} \right)^{1-\sigma} \left(\frac{n_j}{n_k} \right)^{\beta}.$$

The elasticity of relative imports with respect to the relative number of varieties equals the consumer's love of variety. An increase in the number of varieties exported by j, ceteris paribus, yields a less than proportional increase in relative imports for any $\beta < 1$.

2.2. Market equilibrium

Each firm incurs a marginal cost of production in terms of wage (w_j) and a fixed cost of production ($\alpha > 0$). Workers' efficiency in producing one unit of a variety (A_j) varies across countries. Each firm has monopoly power in its own market and the firm's profit maximization problem yields the standard solution for the price of each variety as a constant markup over marginal cost:

$$(5) \quad p_j = \frac{\sigma}{\sigma - 1} \frac{w_j}{A_j}.$$

For simplicity, I assume symmetry in prices of an exporter's varieties and no transport costs or fixed costs of exporting; and thus the *zero-profit condition* for each exporter yields the quantity supplied per variety:

$$(6) \quad q_j = \frac{\alpha(\sigma - 1)}{w_j / A_j}.$$

From (5) and (2) it follows:

$$(7) \quad \frac{p_j}{p_k} = \frac{w_j / A_j}{w_k / A_k} \quad ; \quad (8)\frac{x_j}{x_k} = \left(\frac{p_j}{p_k}\right)^{-\sigma} \left(\frac{n_j}{n_k}\right)^{\beta - 1}.$$

Equation (8) represents the relative general CES demand for each country's variety. For $\beta = 1$, the relative quantities demanded depend only on variety prices, and the general relative demand collapses to relative CES demand. For any value of $\beta < 1$, the relative

quantities demanded depend on variety prices but also on the number of varieties in the market. Everything else equal, the relationship reflects the trade-off the consumer faces between buying higher quantities per variety or more varieties. The trade-off represents the novelty introduced in the model by the general CES.

Using (7) and (8), the *market clearing for each variety* $\left(x_j/x_k = q_i/q_k\right)$ gives:

(9) $$\left(\frac{n_j}{n_k}\right)^{1-\beta} = \left(\frac{w_j}{w_k}\right)^{1-\sigma}\left(\frac{A_j}{A_k}\right)^{\sigma-1}.$$

Intuitively, as the number of varieties increases the quantity demanded per variety decreases at a rate depending on consumer's love of variety but the quantity supplied per variety has to satisfy the zero profit condition. Thus, new varieties enter until the quantity demanded equals quantity supplied. For higher values of β, the quantity demanded per variety decreases at a lower pace and thus more varieties enter until it equals the zero-profit quantity threshold.

The *labor market clearing* yields the inverse labor demand equation:

(10) $$\frac{w_j}{w_k} = \left(\frac{L_j}{L_k}\right)^{-\frac{1-\beta}{\sigma-\beta}}\left(\frac{A_j}{A_k}\right)^{\frac{\sigma-1}{\sigma-\beta}}.$$

Equation (10) suggests that the slope of the relative labor demand is increasing in β. In a comparison between a large and a small country, for $\beta = 1$, the relative wage reflects only their productivity differences and not their labor force sizes: $w_j/w_k = A_j/A_k$. For $\beta = 0$ it depends both on productivity differences and labor force sizes: $w_j/w_k = \left(L_j/L_k\right)^{-\frac{1}{\sigma}}\left(A_j/A_k\right)^{\frac{\sigma-1}{\sigma}}$. Figure 1 illustrates the relative wage determination as a function of love of variety. Everything else constant, for a lower consumer's love of variety the wage becomes lower. Intuitively, lower β

slows down the rate of variety growth and increases the equilibrium quantity per variety.

Higher quantities can be sold at lower prices and thus the value of marginal product of labor

decreases, yielding lower wages.

The terms of trade is a crucial mechanism in this model. Acemoglu and Ventura(2002)

use the same mechanism in a model with $\beta = 1$, endogenous capital accumulation and fixed

labor endowment. In their model, the production of each variety uses a fixed labor requirement

and it features constant returns to capital. Since the fixed cost of production is in terms of the

scarce factor, as countries accumulate more capital, the number of varieties is proportional and

bounded above by the labor endowment. Thus, countries with higher income per capita

produce also higher quantities per variety and they face adverse terms of trade effects. In the

limited love of variety model the number of varieties is bounded above by consumer's

marginal valuation for an exporter's variety and as countries grow in size they also produce

higher quantities per variety sold at lower prices.

Figure 1: Relative wage determination

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The relative number of varieties as a function of labor force size is:

$$(11) \frac{n_j}{n_k} = \left(\frac{L_j}{L_k}\right)^{\frac{\sigma-1}{\sigma-\beta}} \left(\frac{A_j}{A_k}\right)^{\frac{\sigma-1}{\sigma-\beta}}.$$

The elasticity of relative number of varieties with respect to country size is increasing in β:

$$(12) \quad \frac{d \, n_j/n_k}{d \, L_j/L_i} \frac{L_j/L_i}{n_j/n_k} = \frac{\sigma-1}{\sigma-\beta}$$

For $\beta=1$, as in Krugman's model, the variety growth rate is proportional to country size. For any values of β lower than one, the rate of variety growth is less than proportional and a larger country produces more varieties but also higher quantities per variety sold at lower prices (see Figure 2).

Figure 2: *The relative country size and number of produced (exported) varieties*

The relative GDPs are:

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$$(13)\frac{Y_j}{Y_i} = \frac{w_j L_j}{w_i L_i} = \left(\frac{A_j}{A_i}\right)^{\frac{\sigma-1}{\sigma-\beta}} \left(\frac{L_j}{L_i}\right)^{\frac{\sigma-1}{\sigma-\beta}}.$$

Using (10) and (13) into (7), the relative variety prices and quantities as a function of GDP are:

$$(14)\frac{p_j}{p_i} = \left(\frac{Y_j}{Y_i}\right)^{\frac{\beta-1}{\sigma-1}} ; \quad \frac{x_j}{x_i} = \left(\frac{Y_j}{Y_i}\right)^{\frac{(1-\beta)}{\sigma-1}}$$

That is, a country with higher GDP produces and exports higher quantities at lower prices with an elasticity increasing in β. The relative number of varieties remains proportional to a

country's GDP: $\dfrac{n_j}{n_i} = \dfrac{Y_j}{Y_i}$.

The limited love of variety model's predictions match several features of the data[6]. It predicts a less than proportional export extensive margin with respect to labor force size. Larger economies export higher quantities per variety but with a lower elasticity with respect to labor force size and GDP than in Armington's model. This paper's model fails to explain the variety price facts observed in the data. The model can match these facts if larger countries improve their technologies for producing each variety (the model assumes that a country's technology level is exogenous) and consequently larger countries export at no lower prices per variety than small countries do. Moreover, the model lacks the import extensive margin, but introducing fixed costs of exporting together with variable trade costs could easily generate it. Acemoglu and Ventura (2002)'s model features also only an export extensive margin. It has qualitatively the same predictions on the intensive margin but it predicts that the number of varieties is proportional to the country's employment and constant with respect to its GDP.

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[6] Empirical facts estimated by Hummels and Klenow (2002, 2005)

Thus, the limited love of variety model can match better the empirical facts on the export extensive margin.

III. Empirics

Next, I structurally identify and estimate consumer's love of variety and test whether it is lower than that implicitly assumed in Krugman's model. Following the model described in the previous section, an obvious identification would relate the relative number of exported varieties to the relative exporter's country size. Hummels and Klenow (2002, 2005) exploited exporter variation and empirically examined the relationship between the number of exported varieties and exporter's country size. They found that the number of exported varieties represent 59 percent of a larger country's exports. This paper exploits a different source of variation to understand whether the limited love of variety explains the empirical facts. Conditional on an exporter, I exploit cross-importer variation to estimate equation (3). The logarithm of relative import demand as given (3) is non-linear in the number of varieties and thus requires burdensome estimation techniques. The next section extends Feenstra (1994)'s method to derive the relative import demand by decomposing the relative general CES price index into a price and a number of varieties component.

3.1. General CES price index decomposition

The CES price index P_{jk} (i.e. variety-adjusted price index) can be decomposed into the traditional price index $\widetilde{P}_{jk}$ and extensive margin (i.e. a weighted count of the number of varieties) following Feenstra (1994)'s method. The methodology separates the extensive margin and the traditional price index without assuming that an exporter's varieties have equal

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prices and quantities. Feenstra (1994) shows the consumer perceives the introduction of new varieties as a decrease in prices such that the CES price index decreases in the number of varieties. If varieties are more substitutable they have a lower impact on the price index and the variety adjusted price index becomes closer to the traditional price index.

If the set of varieties is the same across exporters (j and k), the cross section equivalent of the CES price index equals the traditional price index and can be written as[7]:

$$(15) \qquad \widetilde{P}_{jk} = \prod_{l \in I} \left(\frac{p_{jl}}{p_{kl}} \right)^{\omega_{jl}(I)}$$

$$\text{where} \quad s_{rl}(I) \equiv \frac{p_{rl} x_{rl}}{\sum_{l \in I} p_{rl} x_{rl}} \; for \; r = j, k \; ; \qquad \omega_{jl}(I) \equiv \frac{\left(\dfrac{s_{jl}(I) - s_{kl}(I)}{\ln s_{jl}(I) - \ln s_{kl}(I)} \right)}{\sum_{l \in I} \left(\dfrac{s_{jl}(I) - s_{kl}(I)}{\ln s_{jl}(I) - \ln s_{kl}(I)} \right)} .$$

The weights used in constructing the price index are the logarithmic mean of the cost shares of each variety l in country j's exports. But, the traditional price index is not appropriately defined if the set of varieties varies across exporters. For a pair of countries, some varieties are in the common set (I) and some varieties are outside the common set. In this case, the traditional price index needs to be adjusted by the relative share of varieties outside the common set. The construction of the variety-adjusted price index requires two conditions. First, exporter j and k should export at least one common variety ($I \neq \varnothing$). Second, the varieties in the common set should be identical such that the relative variety prices in (15) are meaningful. That is, any demand shifter should affect proportionally the varieties originating from different countries in the common set.

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[7] Sato(1976) and Vartia(1976)

Proposition 1 formalizes the extension of Feenstra (1994)'s method for decomposing the general CES price index.

Proposition 1:[8] If $b_{jl} = b_{kl}$ for $l \in I \subseteq (I_j \cap I_k)$, $I \neq \varnothing$, then the general CES price index can

be written as $P_{jk} = \widetilde{P}_{jk} \left(\dfrac{\lambda_j}{\lambda_k} \right)^{\frac{\beta}{1-\sigma}}$

where b_{jl}, b_{kl} - unobservable demand shifters and

$$(16) \quad \lambda_r \equiv \frac{\sum\limits_{l \in I} p_{rl} x_{rl}}{\sum\limits_{l \in I_r} p_{rl} x_{rl}} \quad for \quad r = j, k \ \square$$

I define the extensive margin as:

$$(17) \quad EM_{jk} \equiv \frac{\lambda_j}{\lambda_k} = \frac{\sum\limits_{l \in I_j} p_{jl} x_{jl} \Big/ \sum\limits_{l \in I} p_{jl} x_{jl}}{\sum\limits_{l \in I_k} p_{kl} x_{kl} \Big/ \sum\limits_{l \in I} p_{kl} x_{kl}}.$$

If the set of varieties imported from j is a subset of the set of varieties imported from k ($I = I_j$), then the extensive margin simplifies to:

$$(18) \quad EM_{jk} = \frac{\sum\limits_{l \in I_j} p_{kl} x_{kl}}{\sum\limits_{l \in I_k} p_{kl} x_{kl}}.$$

The extensive margin of country j represents the weighted count of varieties relative to exporter k's varieties. The varieties are weighted by their importance in k's exports. If I assign equal weight to each variety, the extensive margin represents the simple count of varieties exported by j to an importer as a share of the number of varieties exported by k.

And, the variety-adjusted price index can be written as follows:

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[8] The proof of the proposition can be found in appendix 1.

(19) $\quad P_{jk} = \left(EM_{jk} \right)^{\frac{\beta}{1-\sigma}} \widetilde{P}_{jk}$.

In the extension, the new varieties lower the price index at a rate that depends on both σ and β. A lower love of variety, ceteris paribus, dampens the effect of new varieties on the price index. That is, if the consumer values new varieties less at the margin, they have a lesser effect on the price index.

3.2. Relative import demand with asymmetric varieties

Using decomposition (19) I can re-write equation (3) as:

(20) $\quad \dfrac{M_{j}}{M_{k}} = \left(EM_{jk} \right)^{\beta} \left(\widetilde{P}_{jk} \right)^{1-\sigma}$.

The observed relative bilateral imports are a function of relative bilateral variety-adjusted price indexes. Equation (20) is the asymmetric equivalent of (4). An increase in the number of imported varieties acts in the same way as a decrease in prices: it will draw resources towards the exporter's products and the higher is the love of variety the larger will be the shift.

The love of variety parameter represents the elasticity of relative imports with respect to extensive margin:

(21) $\dfrac{\partial M_{j}/M_{k}}{\partial EM_{jk}} \dfrac{EM_{jk}}{M_{j}/M_{k}} = \beta$.

The price elasticity of demand remains $1-\sigma$ as in the standard CES framework. The empirical analysis structurally identifies and estimates the love of variety parameter by taking (20) to the data.

IV. Cross – importer love of variety

In this section I structurally identify consumer's love of variety by estimating (20) for each product.

4.1. Data

I employ data from UN's COMTRADE data for 1999. The COMTRADE data was obtained through UNCTAD/ World Bank WITS data system, which yields bilateral import data collected by the national statistical agencies of 143 importing countries, covering 224 exporters and 5015 6 digit level Harmonized System (HS) classification categories. After merging it with great circle distance data, I obtain a dataset covering 132 importers and 185 exporters for a total of 4,328,408 data points.

I define a product as a 2 digit level HS category (denoted by h) and a variety as a 6 digit level HS category (denoted by l) within a 2 digit level HS category[9]. For each bilateral pair in each HS 2 category, I construct the relative imports, extensive margin and prices according to the decomposition methodology outlined in section 3.1.

4.2. Estimation and results

Since detailed data on trade costs is not readily available for many importers, I use great circle bilateral distance as a crude proxy for trade costs. I model trade costs as (where i indexes importers):

$$(22) \quad \tau_{ijl} = t_{il} * \left(d_{ij} \right)^{\gamma}.$$

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[9] For instance, HS 04 category represents 'Dairy products' with HS 6 varieties such as: different types of milk and cream, yogurt, buttermilk, different type of cheeses etc.

where t_{il} represents the ad-valorem tariff , d_{ij} represents the distance between the pair of countries i and j and γ represents the elasticity of transport costs with respect to distance. Conditional on an importer, the ad-valorem tariff for a variety can be safely assumed to be equal across exporting countries (Hummels and Lugovskyy - 2005). The price index becomes:

$$(23) \quad \widetilde{P}_{ijk} = \prod_{l \in I_{ij}} \left(\frac{d_{ij}}{d_{ik}} \right)^{\omega_{ijl}(I_{ij})\gamma} \underbrace{\prod_{l \in I} \left(\frac{p_{jl}}{p_{kl}} \right)^{\omega_{ijl}(I_{ij})}}_{\widetilde{P}_{jk}^{FOB}} .$$

where d_{ik} represents the weighted average distance of ROW exports to country i, the weights being the share of each trade partner in world trade; and the fob exporter's prices per variety are equal across importers.

I choose the ROW (rest-of-the-world) as the comparison country k. That is to say, the comparison country consists of all the exporters other than j taken together that have positive exports to importer i. The ROW is a convenient comparison country because I can exploit all the information available in the data. An additional advantage of using ROW is that, conditional on an importer, the common set of varieties between any exporter j and ROW is the set of HS 6 categories exported by j. This property allows a more intuitive construction of the extensive margin (i.e. a weighted count of varieties) as in (18) which weighs each variety with its ROW trade value.

The estimating equation becomes:

$$(24) \quad \log IMPSHR_{ijk}^{h} = \delta_{j}^{h} + \beta_{h} \log EM_{ijk}^{h} + \gamma(1-\sigma_{h})\log d_{ijk}^{h} + \varepsilon_{ijk}^{h} .$$

The extensive margin varies across exporters because of exporter's size (as shown in the model described in section II). For a given exporter, the extensive margin varies across importers because of other reasons outside the model such as trade costs combined with fixed

costs of exporting. The specification includes exporter fixed effects (δ_j^h) common to all importers that capture the exporters' fob variety prices. Note that importer specific factors common to all exporters such as market size and income are differenced out by estimating a specification in relative terms. Conditional on an exporter, the love of variety estimation exploits variation across importers in the extensive margin. The love of variety parameter measures the degree to which importers value an exporter's varieties.

I estimate specification (24) for each product. Pooling across products restricts the elasticity of substitution to be equal across products which based on the estimates in the literature is clearly a strong assumption (Hummels -1999 and Broda and Weinstein- 2004). Thus, I consider product regressions results more reliable.

All $\widehat{\beta_h}$ are significantly lower than that assumed in Krugman's model and significantly higher than assumed by Armington's model. The simple average consumer love of variety equals 0.58. All the price elasticity of demand estimates ($(1-\widehat{\sigma}_h)\widehat{\gamma}$) are negative and significant at 5 percent level. Moreover, the average of $\widehat{\sigma}_h$ [10]'s is 3.79. The results are summarized by figure 3 and figure 4. Table 1 and 2 provide summary statistics of the estimates.

V. Robustness check

5.1. U.S. love of variety

In this section I structurally identify U.S.'s love of variety by estimating (20) for each product. Identifying and estimating the love of variety by exploiting the time series variation in

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[10] calculated using $\widehat{\gamma} = 0.26$ (Hummels - 2001)

the U.S. data has some advantages. The U.S. data is more disaggregated at the commodity level which allows a finer measurement of "unique" products. Also, it provides detailed information on trade costs.

5.1.1. Data

I employ U.S. data from the "U.S. Imports of Merchandise" CD-ROM for the period 1991-2004, published by the U.S. Bureau of the Census. The dataset contains U.S. imports collected from electronically submitted Customs forms, covering an average of 223 exporters and commodity detail at 10 digit level Harmonized System (HS) classification. The data includes country of origin, value, quantity, freight and duties paid.

The empirical implementation defines a product as a 2 digit level HS category (denoted by *h*) and a variety as a 10 digit level HS category (denoted by *l*) within a 2 digit level HS category. For each U.S. – trade partner data point in a HS 2 category for a year, I construct the relative imports, extensive margin and prices according to the decomposition methodology outlined in section 3.1.

5.1.2. Estimation and results

The price index $\widetilde{P}_{jkt}$ can be written as (where *t* indexes time periods):

$$(25)\ \widetilde{P}_{jkt} = \underbrace{\prod_{l \in I_{jt}} \left(\frac{\tau_{jtl}}{\tau_{ktl}} \right)^{\omega_{jtl}(I_{jt})}}_{\tau_{jkt}} \underbrace{\prod_{l \in I_{jt}} \left(\frac{p_{jl}}{p_{kl}} \right)^{\omega_{jtl}(I_{jt})}}_{\widetilde{P}_{jk}^{FOB}}.$$

I measure the relative trade costs (τ_{jkt}) using ad-valorem trade costs (i.e. one plus the share of duties and freight paid in the import value) for each HS 10. For each HS 2 product, the ROW trade costs represent a weighted average of trade costs, where the weights are the share of each exporter's variety into the ROW exports to U.S. for each time period.

Thus, the estimating equation for each product h becomes:

$$(26) \quad \log IMPSHR_{jkt}^h = \delta_j^h + \beta_h \log EM_{jkt}^h + (1 - \sigma_h) \log \tau_{jkt}^h + \varepsilon_{jkt}^h.$$

I include an exporter fixed effect (implemented by mean-differencing) to capture the relative

fob variety prices. By estimating a specification in relative terms, the time-shifters common to

all exporters such as importer's market size are differenced out. Conditional on an exporter, the

love of variety estimation exploits variation across time in the extensive margin. The love of

variety estimate measures the degree to which the U.S. values new varieties and the elasticity

of substitution should be greater than one ($\sigma_h > 1$).

All U.S. $\widehat{\beta}_h$ are significantly lower than that assumed by Krugman's model. The

average of U.S. consumer's love of variety equals 0.41. The time series variation in extensive

margin is noisier than the variation in cross-section thus the U.S. love of variety point estimates

are lower than cross-importer estimates. 99 percent of $\widehat{\sigma}_h$ are significantly different than unity

at 5 percent level with a weighted average of 5.33. The results by product are summarized by

figure 5 and 6. Table 1 and 2 provides a summary of the estimates.

5.2. Hidden variety

The decomposition of the variety-adjusted price indexes into extensive margin and

price index requires the existence of a common set of varieties between exporter j and k.

Theoretically a variety in the common set features an equal unobservable demand shifter for

both exporters which can be interpreted as the same number of hidden varieties, the same

quality or taste parameter. Previous studies (Hummels-Klenow- 2005, Broda and Weinstein -

2004) have empirical defined variety at different level of data aggregation imposed by data

availability. In the cross-importer estimation, I define the common set of varieties as the set of

HS 6 categories within a HS 2 category in which both exporters have positive exports to a given importer.

This issue could represent a mis-measurement problem if there are multiple hidden varieties within each HS 6 category. But, in the paper's specification, it is not a concern if the relative number of hidden varieties is proportional to the relative number of observed varieties. However, I can use the U.S. data to test the statement. Consider that HS 10 categories represent the hidden varieties within an observed HS 6 category. For each HS 2 category, the following is true:

$$(27)\ \frac{n^j_{HS10}}{n^k_{HS10}} = \frac{n^j_{HS10/HS6}}{n^k_{HS10/HS6}} * \frac{N^j_{HS6}}{N^k_{HS6}}.$$

where n^j_{HS10}, $n^j_{HS10/HS6}$ and N^j_{HS6} represent the number of HS 10 categories within an HS 2, the number of HS 10 categories within an HS 6 category and the number of HS 6 category within an HS 2 exported for each j.

Testing whether varieties defined at HS 6 level in the common set feature the same number of hidden varieties for exporter j and k (i.e. $n^j_{HS10/HS6}/n^k_{HS10/HS6} = 1$) is equivalent to testing whether the relative number of hidden varieties (n^j_{HS10}/n^k_{HS10}) is proportional to relative number of observed varieties (N^j_{HS6}/N^k_{HS6}). Figure 7 confirms that hidden varieties do not represent problem in the specification in relative terms and the deviations from the 45 degree line are captured by exporter fixed effects.

An alternative hidden variety robustness check is to re-estimate the U.S. love of variety by defining a variety at HS 6 commodity level and compare the estimates to the ones obtained by defining a variety at HS 10 level. The point estimates differ on average by .06 but the mean

of the estimates distribution is preserved. Figure 8 and 9 shows the distribution of the love of variety and elasticity of substitution estimates when variety is defined at HS 6 level.

VI. Conclusion

This paper describes a simple trade model which incorporates a more general CES preference structure that nests Krugman's and Armington's model. The model illustrates how consumer's limited love of variety can explain the slower variety growth rate observed in the data. The general CES introduces a trade-off that the consumer faces between buying more varieties or higher quantities per variety. In equilibrium, without factor price equalization, a larger country exports more varieties but also higher quantities per variety sold at lower prices on the world markets. For any values of the love of variety lower than in Krugman's model, the variety expansion is less than proportional to country size as observed in the data. Introducing a more general CES preference structure in a monopolistic competition model matches better the empirical facts while still remaining tractable in general equilibrium.

The empirics structurally identify and estimate consumer's love of variety as the elasticity of relative imports to extensive margin and find that it is lower than it is assumed in Krugman's model. Consumer's limited love of variety has important implications for welfare calculations. A simple calibration in Appendix 2 shows that a love of variety estimate of 0.6, ceteris paribus, reduces the variety gains from trade liberalization by 40%. Moreover, the impact of product variety on economic growth and the strength of industrial agglomerations is smaller than is typically assumed.

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Cross-importer Love of Variety and Elasticity of Substitution Estimates across Products

Figure 3: Love of Variety Estimates across HS2
- weighted by value-

Figure 4: Elasticity of Substitution Estimates across HS2
- weighted by value -

U.S. Love of Variety and Elasticity of Substitution Estimates across Products

Figure 5: U.S. Love of Variety Estimates across HS2
- weighted by value -

Figure 6: U.S. Elasticity of Substitution Estimates across HS2
- weighted by value -

Note: The weight represents the average HS 2 import value across 1991-2004.

Table 1. Love of Variety Estimates by HS 2
Summary Statistics

Specification	Weighted Mean	Simple Mean	Std. Deviation	Min.	Max.
Cross-importer	0.56	0.58	0.13	0.21	0.91
U.S.	0.4	0.41	0.14	0.12	0.78

Notes: 1.The cross-importer estimates are weighted by the world trade value of each HS 2 category
2. The U.S.estimates are weighted by the average HS 2 trade value across 1991-2004
3. All estimates significantly different from one.

Table 2. Elasticity of Substitution Estimates by HS 2
Summary Statistics

Specification	Weighted Mean	Simple Mean	Std. Deviation	Min.	Max.
Cross-importer *(using distance)*	3.79	3.42	0.58	1.9	4.5
U.S. *(using trade costs)*	5.33	4.68	1.7	1.2	8.88

Notes: 1. The cross-importer estimates are weighted by the world trade value of each HS 2 category
2. The U.S. estimates are weighted by the average HS 2 trade value across 1991-2004
3. 99% of U.S. estimates are significantly different from one at 5% level
4. The cross-importer estimates are calculated using the estimate of elasticity of transport costs
with respect to distance of 0.26 (Hummels - 2001)

Table 3: Love of Variety Estimates

HS 2	Description	LoV Coeff.	s.e.	Nobs	R2
01	LIVE ANIMALS	0.80	(0.04)	2,490	0.30
02	MEAT AND EDIBLE MEAT OFFAL	0.58	(0.03)	2,335	0.28
03	FISH, CRUSTACEANS & AQUATIC INVERTEBRATES	0.65	(0.02)	4,409	0.36
04	DAIRY PRODS; BIRDS EGGS; HONEY; ED ANIMAL PR NESOI	0.65	(0.03)	3,558	0.33
05	PRODUCTS OF ANIMAL ORIGIN, NESOI	0.47	(0.02)	2,427	0.26
06	LIVE TREES, PLANTS, BULBS ETC.; CUT FLOWERS ETC.	0.39	(0.03)	2,850	0.30
07	EDIBLE VEGETABLES & CERTAIN ROOTS & TUBERS	0.62	(0.02)	4,133	0.35
08	EDIBLE FRUIT & NUTS; CITRUS FRUIT OR MELON PEEL	0.61	(0.02)	4,747	0.31
09	COFFEE, TEA, MATE & SPICES	0.52	(0.02)	5,029	0.27
10	CEREALS	0.55	(0.03)	2,884	0.26
11	MILLING PRODUCTS; MALT; STARCH; INULIN; WHT GLUTEN	0.53	(0.02)	2,688	0.34
12	OIL SEEDS ETC.; MISC GRAIN, SEED, FRUIT, PLANT ETC	0.52	(0.02)	4,249	0.24
13	LAC; GUMS, RESINS & OTHER VEGETABLE SAP & EXTRACT	0.31	(0.04)	2,590	0.13
14	VEGETABLE PLAITING MATERIALS & PRODUCTS NESOI	0.44	(0.04)	1,453	0.13
15	ANIMAL OR VEGETABLE FATS, OILS ETC. & WAXES	0.64	(0.02)	3,949	0.40
16	EDIBLE PREPARATIONS OF MEAT, FISH, CRUSTACEANS ETC	0.60	(0.02)	3,402	0.31
17	SUGARS AND SUGAR CONFECTIONARY	0.59	(0.02)	4,059	0.34
18	COCOA AND COCOA PREPARATIONS	0.68	(0.04)	3,213	0.35
19	PREP CEREAL, FLOUR, STARCH OR MILK; BAKERS WARES	0.69	(0.03)	4,084	0.38
20	PREP VEGETABLES, FRUIT, NUTS OR OTHER PLANT PARTS	0.71	(0.02)	4,567	0.39
21	MISCELLANEOUS EDIBLE PREPARATIONS	0.47	(0.03)	4,779	0.30
22	BEVERAGES, SPIRITS AND VINEGAR	0.60	(0.02)	4,906	0.35
23	FOOD INDUSTRY RESIDUES & WASTE; PREP ANIMAL FEED	0.50	(0.03)	3,145	0.25
24	TOBACCO AND MANUFACTURED TOBACCO SUBSTITUTES	0.63	(0.03)	3,124	0.25
25	SALT; SULFUR; EARTH & STONE; LIME & CEMENT PLASTER	0.65	(0.02)	4,633	0.38
26	ORES, SLAG AND ASH	0.58	(0.03)	1,926	0.28
27	MINERAL FUEL, OIL ETC.; BITUMIN SUBST; MINERAL WAX	0.64	(0.02)	3,811	0.37
28	INORG CHEM; PREC & RARE-EARTH MET & RADIOACT COMPD	0.68	(0.02)	5,052	0.43
29	ORGANIC CHEMICALS	0.53	(0.02)	5,393	0.34
30	PHARMACEUTICAL PRODUCTS	0.57	(0.02)	5,742	0.35
31	FERTILIZERS	0.66	(0.03)	2,694	0.31
32	TANNING & DYE EXT ETC; DYE, PAINT, PUTTY ETC; INKS	0.77	(0.02)	5,113	0.45
33	ESSENTIAL OILS ETC; PERFUMERY, COSMETIC ETC PREPS	0.71	(0.02)	5,312	0.39
34	SOAP ETC; WAXES, POLISH ETC; CANDLES; DENTAL PREPS	0.92	(0.03)	4,751	0.43
35	ALBUMINOIDAL SUBST; MODIFIED STARCH; GLUE; ENZYMES	0.70	(0.04)	3,850	0.30
36	EXPLOSIVES; PYROTECHNICS; MATCHES; PYRO ALLOYS ETC	0.50	(0.03)	2,054	0.22
37	PHOTOGRAPHIC OR CINEMATOGRAPHIC GOODS	0.67	(0.03)	3,461	0.37
38	MISCELLANEOUS CHEMICAL PRODUCTS	0.54	(0.02)	5,467	0.35
39	PLASTICS AND ARTICLES THEREOF	0.70	(0.02)	7,819	0.41
40	RUBBER AND ARTICLES THEREOF	0.67	(0.02)	6,714	0.40
41	RAW HIDES AND SKINS (NO FURSKINS) AND LEATHER	0.48	(0.03)	3,205	0.24
42	LEATHER ART; SADDLERY ETC; HANDBAGS ETC; GUT ART	0.48	(0.02)	5,117	0.28
43	FURSKINS AND ARTIFICIAL FUR; MANUFACTURES THEREOF	0.52	(0.04)	1,763	0.20
44	WOOD AND ARTICLES OF WOOD; WOOD CHARCOAL	0.70	(0.02)	6,478	0.39
45	CORK AND ARTICLES OF CORK	0.56	(0.05)	1,342	0.19
46	MFR OF STRAW, ESPARTO ETC.; BASKETWARE & WICKERWRK	0.21	(0.06)	1,998	0.12
47	WOOD PULP ETC; RECOVD (WASTE & SCRAP) PPR & PPRBD	0.54	(0.04)	1,638	0.27
48	PAPER & PAPERBOARD & ARTICLES (INC PAPR PULP ARTL)	0.78	(0.02)	6,448	0.47
49	PRINTED BOOKS, NEWSPAPERS ETC; MANUSCRIPTS ETC	0.56	(0.03)	6,150	0.33
50	SILK, INCLUDING YARNS AND WOVEN FABRIC THEREOF	0.43	(0.06)	1,469	0.16
51	WOOL & ANIMAL HAIR, INCLUDING YARN & WOVEN FABRIC	0.59	(0.03)	2,628	0.27
52	COTTON, INCLUDING YARN AND WOVEN FABRIC THEREOF	0.62	(0.02)	5,209	0.37
53	VEG TEXT FIB NESOI; VEG FIB & PAPER YNS & WOV FAB	0.40	(0.03)	2,237	0.16
54	MANMADE FILAMENTS, INCLUDING YARNS & WOVEN FABRICS	0.57	(0.02)	4,336	0.32
55	MANMADE STAPLE FIBERS, INCL YARNS & WOVEN FABRICS	0.59	(0.02)	4,521	0.33
56	WADDING, FELT ETC; SP YARN; TWINE, ROPES ETC.	0.45	(0.02)	4,024	0.32
57	CARPETS AND OTHER TEXTILE FLOOR COVERINGS	0.53	(0.03)	3,686	0.27
58	SPEC WOV FABRICS; TUFTED FAB; LACE; TAPESTRIES ETC	0.49	(0.02)	3,834	0.35
59	IMPREGNATED ETC TEXT FABRICS; TEX ART FOR INDUSTRY	0.48	(0.03)	3,669	0.33

Table 3: Love of Variety Estimates – cont'd

HS 2	Description	LoV Coeff.	s.e.	Nobs	R2
60	KNITTED OR CROCHETED FABRICS	0.50	(0.04)	2,885	0.27
61	APPAREL ARTICLES AND ACCESSORIES, KNIT OR CROCHET	0.54	(0.02)	6,407	0.37
62	APPAREL ARTICLES AND ACCESSORIES, NOT KNIT ETC.	0.63	(0.02)	6,906	0.40
63	TEXTILE ART NESOI; NEEDLECRAFT SETS; WORN TEXT ART	0.52	(0.02)	5,948	0.31
64	FOOTWEAR, GAITERS ETC. AND PARTS THEREOF	0.63	(0.02)	5,422	0.33
65	HEADGEAR AND PARTS THEREOF	0.23	(0.04)	3,689	0.19
66	UMBRELLAS, WALKING-STICKS, RIDING-CROPS ETC, PARTS	0.52	(0.04)	2,138	0.20
67	PREP FEATHERS, DOWN ETC; ARTIF FLOWERS; H HAIR ART	0.36	(0.04)	1,922	0.14
68	ART OF STONE, PLASTER, CEMENT, ASBESTOS, MICA ETC.	0.62	(0.02)	4,766	0.40
69	CERAMIC PRODUCTS	0.73	(0.02)	5,463	0.38
70	GLASS AND GLASSWARE	0.73	(0.02)	5,872	0.41
71	NAT ETC PEARLS, PREC ETC STONES, PR MET ETC; COIN	0.70	(0.02)	4,341	0.33
72	IRON AND STEEL	0.73	(0.02)	5,205	0.45
73	ARTICLES OF IRON OR STEEL	0.60	(0.02)	7,069	0.37
74	COPPER AND ARTICLES THEREOF	0.64	(0.02)	4,222	0.36
75	NICKEL AND ARTICLES THEREOF	0.71	(0.04)	1,687	0.27
76	ALUMINUM AND ARTICLES THEREOF	0.75	(0.02)	5,356	0.38
78	LEAD AND ARTICLES THEREOF	0.77	(0.05)	1,480	0.33
79	ZINC AND ARTICLES THEREOF	0.71	(0.04)	2,055	0.27
80	TIN AND ARTICLES THEREOF	0.67	(0.06)	1,486	0.23
81	BASE METALS NESOI; CERMETS; ARTICLES THEREOF	0.41	(0.03)	1,899	0.18
82	TOOLS, CUTLERY ETC. OF BASE METAL & PARTS THEREOF	0.60	(0.02)	5,864	0.37
83	MISCELLANEOUS ARTICLES OF BASE METAL	0.74	(0.02)	5,460	0.43
84	NUCLEAR REACTORS, BOILERS, MACHINERY ETC.; PARTS	0.39	(0.01)	9,977	0.32
85	ELECTRIC MACHINERY ETC; SOUND EQUIP; TV EQUIP; PTS	0.52	(0.01)	9,478	0.37
86	RAILWAY OR TRAMWAY STOCK ETC; TRAFFIC SIGNAL EQUIP	0.80	(0.04)	2,409	0.29
87	VEHICLES, EXCEPT RAILWAY OR TRAMWAY, AND PARTS ETC	0.55	(0.02)	7,272	0.36
88	AIRCRAFT, SPACECRAFT, AND PARTS THEREOF	0.50	(0.03)	2,723	0.16
89	SHIPS, BOATS AND FLOATING STRUCTURES	0.73	(0.03)	2,491	0.31
90	OPTIC, PHOTO ETC, MEDIC OR SURGICAL INSTRMENTS ETC	0.48	(0.02)	7,535	0.32
91	CLOCKS AND WATCHES AND PARTS THEREOF	0.36	(0.03)	3,596	0.24
92	MUSICAL INSTRUMENTS; PARTS AND ACCESSORIES THEREOF	0.55	(0.03)	3,067	0.21
93	ARMS AND AMMUNITION; PARTS AND ACCESSORIES THEREOF	0.58	(0.03)	1,860	0.22
94	FURNITURE; BEDDING ETC; LAMPS NESOI ETC; PREFAB BD	0.74	(0.02)	6,835	0.38
95	TOYS, GAMES & SPORT EQUIPMENT; PARTS & ACCESSORIES	0.45	(0.02)	5,489	0.29
96	MISCELLANEOUS MANUFACTURED ARTICLES	0.59	(0.02)	5,398	0.37

Figure 7: Log of number of HS 10 categories rel. to the ROW and log of number of HS 6 categories rel. to the ROW for an HS 2 category and an exporter to US

Log of number of HS 10 categories rel. to the ROW

Log of number of HS 6 categories rel. to the ROW

The line is the 45 degree line

Figure 8: U.S. Love of Variety Estimates across HS2
- weighted by value -

Variety defined at HS 6 commodity level

Figure 9: U.S. Elasticity of Substitution Estimates across HS2
- weighted by value -

Variety defined at HS 6 commodity level

Table 4: Consumer's choice of cars' varieties

Consumers	1st choice	2nd choice of the highest # of consumers	2nd choice of the *next* highest # of consumers
Group 1	Chevrolet Metro	Ford Escort	Geo Storm
Group 2	Chevrolet Cavalier	Ford Escort	Chrysler LeBaron
Group 3	Ford Escort	Ford Tempo	Ford Taurus
Group 4	Cadillac Seville	Cadillac Deville	Lincoln MK8
Group 5	Ford Taurus	Toyota Camry	Mercury Sable
Group 6	Toyota Corolla	Honda Civic	Toyota Camry
Group 7	Nissan Sentra	Toyota Corolla	Honda Civic
Group 8	Honda Accord	Toyota Camry	Ford Taurus
Group 9	Acura Legend	Toyota Lex ES300	Toyota Lex SC300
Group 10	Toyota Lex LS400	Cadillac Deville	Infiniti Q45

Data Source: CAMIP – propriety survey conducted on the behalf of General Motors for 1993 (Berry, Levinsohn and Pakes - 2004

Appendix 1. Price index decomposition[11]

The general CES utility function:

$$(1) \qquad U = n_j^{\frac{\beta-1}{\sigma-1}} \left(\sum_{l \in I_j} b_{jl}^{\frac{\beta}{\sigma}} x_{jl}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

The minimum cost of obtaining one unit of utility from varieties l of a product corresponding to the above utility function:

$$(2) \qquad P_j = n_j^{\frac{1-\beta}{1-\sigma}} \left(\sum_{l \in I_j} b_{jl}^{\beta} p_{jl}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$

where σ is the elasticity of substitution between varieties and $I_j = \{1,...,N_j\}$ is the set of imported varieties from country j with the quantity per variety $x_{jl} > 0 \quad \forall \, l \in I_j$, prices $p_{jl} > 0 \quad \forall l \in I_j$ and the unobservable demand shifter $b_{jl} > 0$.

This setup is equivalent to Feenstra(1994)'s when $\beta = 1$ corresponding to the upper bound of the "love of variety" parameter. I preserve Feenstra(1994)'s notation for the minimum cost of obtaining one unit of utility from varieties l of a product when $\beta = 1$ with lower case c. In the following, I extend the price index decomposition derived by Feenstra(1994) to allow for different degrees of preference for variety.

First, I define the variety-adjusted price index based on the assumption that the number of varieties is identical between country j and k ($I_j = I_k = I$) and the unobservable demand

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[11] The notation is adapted to this paper even though I follow closely Feenstra(1994).

shifter is the same for the common set of varieties ($b_{jl} = b_{kl} = b \quad \forall l \in I$). The price index as

defined by Diewert(1976)[12] is:

$$(3) \quad \widetilde{P}_{jk} = \frac{P_j(p_j, I, b)}{P_k(p_k, I, b)} = \frac{c_j(p_j, I, b)}{c_k(p_k, I, b)}$$

The second equality comes from plugging (2) into (3) and using the assumption that the

number of varieties is the same in both countries.

Sato(1976)[13] shows that the price index corresponding to the CES unit cost function can

be written as:

$$(4) \quad \widetilde{P}_{jk} = \prod_{l \in I} \left(\frac{p_{jl}}{p_{kl}} \right)^{\omega_{jl}(I)}$$

which is a geometric mean of variety prices with weights $\omega_{jl}(I)$. The weights are defined as

follows:

$$(5) \quad \omega_{jl}(I) \equiv \frac{\left(\dfrac{s_{jl}(I) - s_{kl}(I)}{\ln s_{jl}(I) - \ln s_{kl}(I)} \right)}{\displaystyle\sum_{l \in I} \left(\dfrac{s_{jl}(I) - s_{kl}(I)}{\ln s_{jl}(I) - \ln s_{kl}(I)} \right)}, \text{ where the cost shares } s_{jl}(I) \text{ are:}$$

$$(6) \quad s_{rl}(I) \equiv \frac{p_{rl} x_{rl}}{\displaystyle\sum_{l \in I} p_{rl} x_{rl}} \quad for \quad r = j, k.$$

Proposition 1: If $b_{jl} = b_{kl}$ for $l \in I \subseteq (I_j \cap I_k)$, $I \neq \emptyset$, then $\dfrac{P_j}{P_k} = \widetilde{P}_{jk} \left(\dfrac{\lambda_j}{\lambda_k} \right)^{\frac{\beta}{1-\sigma}}$

where (7) $\quad \lambda_r \equiv \dfrac{\displaystyle\sum_{l \in I} p_{rl} x_{rl}}{\displaystyle\sum_{l \in I_r} p_{rl} x_{rl}} \quad for \quad r = j, k$

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[12] I adapt the time series result of this paper to cross section f.
[13] I adapt the time series result to cross section.

Proof:

The expenditure shares of each variety *l of* country *r=j,k* can be derived as the elasticity of unit cost function with respect to the price of variety *l*:

$$(8) \qquad s_{lr}(I_r) = \frac{\partial P_r(p_r, n_r, I_r)}{\partial p_{rl}} \frac{p_{rl}}{P_r(p_r, n_r, I_r)} = c_r(p_r, n_r, I_r)^{\sigma-1} b_{rl}^{\beta} p_{rl}^{1-\sigma} \quad for \ r = j, k$$

Rearranging, I can obtain:

$$(9) \qquad c_r(p_r, n_r, I_r) = s_{rl}(I_r)^{\frac{1}{\sigma-1}} b_{rl}^{\frac{\beta}{1-\sigma}} p_{rl} \quad for \ r = j, k$$

The price index associated with the general CES unit cost function can be written using (9) as:

$$(10) \qquad \frac{P_j(p_j, b_j, I_j)}{P_k(p_k, b_k, I_k)} = \frac{n_j^{\frac{1-\beta}{1-\sigma}} c_j(p_j, b_j, I_j)}{n_k^{\frac{1-\beta}{1-\sigma}} c_k(p_k, b_k, I_k)} = \frac{n_j^{\frac{1-\beta}{1-\sigma}} s_{jl}(I_j)^{\frac{1}{\sigma-1}} b_{jl}^{\frac{\beta}{1-\sigma}} p_{jl}}{n_k^{\frac{1-\beta}{1-\sigma}} s_{kl}(I_k)^{\frac{1}{\sigma-1}} b_{kl}^{\frac{\beta}{1-\sigma}} p_{kl}} \ ^{for \ l \in I} =$$

$$^{for \ l \in I} = \frac{n_j^{\frac{1-\beta}{1-\sigma}} s_{jl}(I_j)^{\frac{1}{\sigma-1}} p_{jl}}{n_k^{\frac{1-\beta}{1-\sigma}} s_{kl}(I_k)^{\frac{1}{\sigma-1}} p_{kl}}$$

The expenditure shares of each variety can be written:

$$(11) \quad s_{rl}(I_r) = \underbrace{\frac{p_{rl} x_{rl}}{\sum_{l \in I} p_{rl} x_{rl}}}_{s_{rl}(I)} \underbrace{\frac{\sum_{l \in I} p_{rl} x_{rl}}{\sum_{l \in I_r} p_{rl} x_{rl}}}_{\lambda_r} \quad for \ r = j, k$$

I can define the number of varieties as:

$$(12) \quad \frac{n_j}{n_k} \equiv \frac{\sum_{l \in I_j} p_{jl} x_{jl} \Big/ \sum_{l \in I} p_{jl} x_{jl}}{\sum_{l \in I_k} p_{kl} x_{kl} \Big/ \sum_{l \in I} p_{kl} x_{kl}} = \frac{\lambda_k}{\lambda_j}$$

Rewriting the variety expenditure shares as in (11) and using (12), (10) becomes:

$$(13) \quad \frac{P_j}{P_k} = \frac{\lambda_j^{\frac{\beta}{1-\sigma}} s_{jl}(I)^{\frac{1}{\sigma-1}} p_{jl}}{\lambda_k^{\frac{\beta}{1-\sigma}} s_{kl}(I)^{\frac{1}{\sigma-1}} p_{kl}}$$

Taking the geometric mean across varieties in (13) and using the weights $\omega_{jl}(I)$, I get:

$$(14) \quad \frac{P_j}{P_k} = \left(\frac{\lambda_j}{\lambda_k}\right)^{\frac{\beta}{1-\sigma}} \widetilde{P_{jk}} \prod_{l \in I} \left(\frac{s_{jl}(I)}{s_{kl}(I)}\right)^{\frac{\omega_{jl}(I)}{\sigma-1}}$$

It is easy to prove that the product in (14) equals 1. q.e.d

So, the CES price index can be written as:

$$(15) \quad \frac{P_j}{P_k} = \left(\frac{\lambda_j}{\lambda_k}\right)^{\frac{\beta}{1-\sigma}} \widetilde{P_{jk}}$$

The price index defined by (15) is equivalent to the CES price index derived by Feenstra(1994) when $\beta = 1$.

Appendix 2. Variety gains – a simple calculation

The general CES utility function:

$$U(x_l) = n^{\frac{\beta-1}{\sigma-1}} \left(\sum_{l=1}^{n} x_l^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \quad \overset{x_l=x,\ \forall l=\overline{1,n}}{\Longrightarrow} \quad U(x) = n^{\frac{\beta}{\sigma-1}}(nx)$$

where x_l and n represent the quantity per variety and number of variety consumed.

In a symmetric world, I can perform a simple calculation of the impact of the *"love of variety"* strength on the calculated gains from greater variety independent of the total quantity consumed:

$$\frac{\dfrac{U_1(n_1,x)}{n_1 x} - \dfrac{U_0(n_0,x)}{n_0 x}}{\dfrac{U_0(n_0,x)}{n_0 x}} = \frac{n_1^{\frac{\beta}{\sigma-1}} - n_0^{\frac{\beta}{\sigma-1}}}{n_0^{\frac{\beta}{\sigma-1}}} = \left(\frac{n_1}{n_0} \right)^{\frac{\beta}{\sigma-1}} - 1$$

"Love of variety"	%U change for a 10% increase in n	Decrease in variety gains (LoV=1 as base)
1.0	4.88%	
0.9	4.38%	10.22%
0.8	3.89%	20.38%
0.7	3.39%	30.50%
0.6	2.90%	40.57%
0.5	2.41%	50.60%
0.4	1.92%	60.57%
0.3	1.44%	70.50%
0.2	0.96%	80.38%
0.1	0.48%	90.21%
0.0	0.00%	100.00%

Note: The calculations assume the elasticity of substitution to be equal to 3.
Even though magnitudes change as the elasticity of substitution changes,
the message of the calculations remains robust.

Column 3 of the above table shows the impact of the "love of variety" on variety gains. For a

lower love of variety, the variety gains are smaller relative to the case when "love of variety"

equals one.