Product Variety and the Gains from International Trade

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Introduction:

Monopolistic competition model has several sources of the gains from trade:

(1) increased import variety for consumers

Later literature (Melitz, 2003) added:

(2) self-selection of more efficient firms, who are exporters

Early (Krugman, 1979) and later literature (Melitz and Ottaviano, 2008) added:

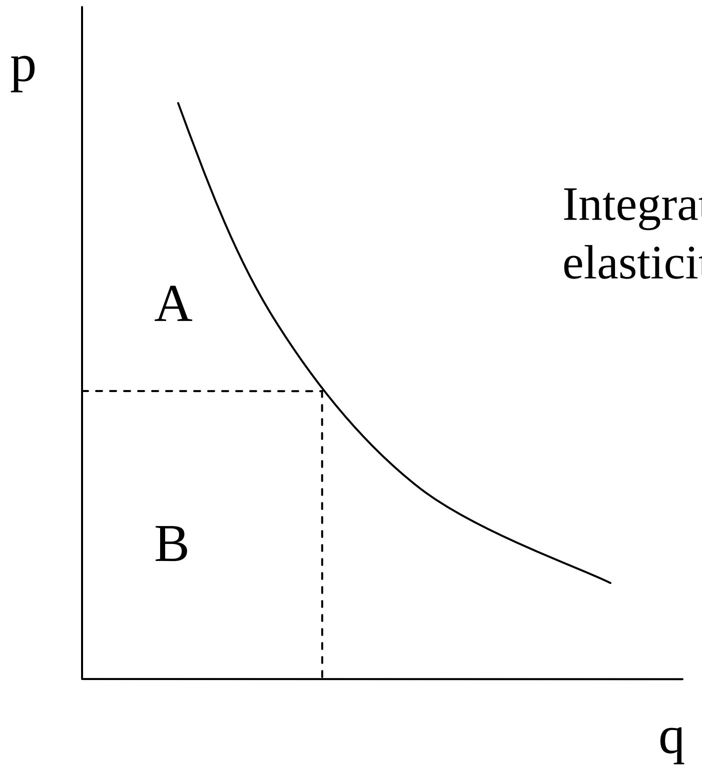
(3) reduced markups, leading to lower prices

Discuss evidence in (i) from Feenstra (*AER*, 1994) and Broda and Weinstein (*QJE*, 2006), and new findings on (ii) and (iii).

Source: Robert Feenstra, *Product Variety and the Gains from International Trade*. MIT Press, 2010 (and references at end of talk).

1. Consumer Gains due to Product Variety:

Treat the price of a new good as its reservation price, where demand is zero. For CES case with σ>1, reservation price is infinite. But we still get a bounded region of consumer gain:



Integrating demand curve with constant-elasticity σ above the price shows that:

$$\frac{A}{B} = \frac{1}{(\sigma - 1)}$$

Feenstra, *AER*, 1994: Generalize this to many new goods -

Work with the non-symmetric CES function,

$$U_t = U(q_t, I_t) = \left[\sum_{i \in I_t} a_{it} q_{it}^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}, \ \sigma > 1,$$

where $a_{it} > 0$ are parameters and I_t denotes the set of goods available in period t, at the prices p_{it}. The CES unit-expenditure function dual to this is,

$$e(p_t, I_t) = \left[\sum_{i \in I_t} b_{it} p_{it}^{1-\sigma}\right]^{1/(1-\sigma)}, \ \sigma > 1, \ b_{it} \equiv a_{it}^{\sigma}.$$

First consider the case where $I_{t-1} = I_t = I$, and $b_{it-1} = b_{it}$. Assume that q_{it} are optimal for the prices and utility, that is, $q_{it} = U_t(\partial e / \partial p_{it})$. Then:

Theorem 1 (Sato, 1976; Vartia, 1976)

If the set of goods available is fixed at $I_{t-1} = I_t = I$, and the parameters $b_{it-1} = b_{it}$ are constant, then the ratio of unit-expenditure can be measured by the index:

$$\frac{e(p_t, I)}{e(p_{t-1}, I)} = P_{SV}(p_{t-1}, p_t, q_{t-1}, q_t, I) \equiv \prod_{i \in I} \left(\frac{p_{it}}{p_{it-1}} \right)^{w_i(I)},$$

where $w_i(I)$ are constructed from the shares $s_{it}(I) \equiv p_{it} q_{it} / \sum_{i \in I} p_{it} q_{it}$ as,

$$w_i(I) \equiv \left(\frac{s_{it}(I) - s_{it-1}(I)}{\ln s_{it}(I) - \ln s_{it-1}(I)} \right) \Big/ \sum_{i \in I} \left(\frac{s_{it}(I) - s_{it-1}(I)}{\ln s_{it}(I) - \ln s_{it-1}(I)} \right) .$$

The “Sato-Vartia” weights $w_i(I)$ are logarithmic means of s_{it} and s_{it-1}, normalized to sum to unity.

Now consider the case where the set of goods is changing over time, but $I_{t-1} \cap I_t \neq \varnothing$. We again let e(p,I) denote the unit-expenditure function defined over the goods within the set I. Then the ratio $e(p_t,I)/e(p_{t-1},I)$ is still measured by the Sato-Vartia index. Our interest is in the ratio $e(p_t,I_t)/e(p_{t-1},I_{t-1})$, which can be measured as follows:

Theorem 2 (Feenstra, 1994)

Assume that $b_{it-1} = b_{it}$ for $i \in I \subseteq I_{t-1} \cap I_t \neq \varnothing$. Then for $\sigma > 1$:

$$\frac{e(p_t, I_t)}{e(p_{t-1}, I_{t-1})} = P_{SV}(p_{t-1}, p_t, q_{t-1}, q_t, I)\left(\frac{\lambda_t(I)}{\lambda_{t-1}(I)}\right)^{1/(\sigma-1)},$$

where values $\lambda_t(I)$ and $\lambda_{t-1}(I)$ are constructed as:

$$\lambda_\tau(I) = \left(\frac{\sum_{i\in I} p_{i\tau} q_{i\tau}}{\sum_{i\in I_\tau} p_{i\tau} q_{i\tau}} \right) = 1 - \left(\frac{\sum_{i\in I_\tau, i\notin I} p_{i\tau} q_{i\tau}}{\sum_{i\in I_\tau} p_{i\tau} q_{i\tau}} \right), \quad \tau = \text{t-1,t}.$$

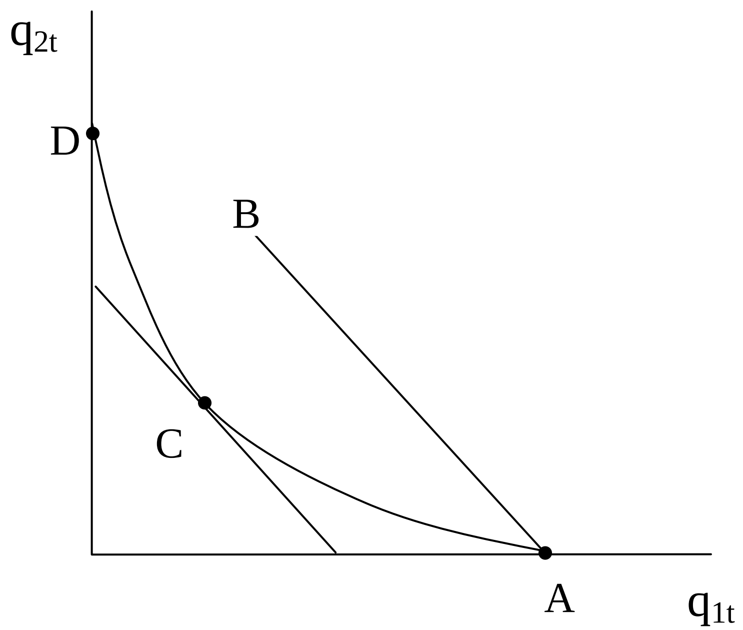
Each of the terms $\lambda_\tau(I) \leq 1$ can be interpreted as the *period τ expenditure on the goods in the set I, relative to the period τ total expenditure*. Alternatively, this can be interpreted as *one minus the period τ expenditure on "new" goods (not in the set I), relative to the period τ total expenditure.*

$\lambda_t(I)^{1/(\sigma-1)}$ is the reduction in expenditure due to new product varieties.

$\lambda_{t-1}(I)^{1/(\sigma-1)}$ is the increase in expenditure due to disappearing varieties.

See this in a graph:

Move from having just good one available (A), to both goods (C):



With only q_1 is available at A, the cost of achieving U is the budget line AB

With q_1 and q_2 available, the cost of achieving U is the budget line through C

Inward shift in the budget line measures *consumer gain from product variety*.

Applications:

a) New method to estimate the "Armington" elasticity of substitution between varieties of a good available from different source countries (Feenstra, AER, 1994):

- Conventional estimates of this elasticity suffer from downward bias due to simultaneous equation bias and measurement error in unit-values
- New method can be developed that exploits the panel nature of the dataset (multiple countries over multiple years), and relies on heteroskedasticity in the errors across countries
- This is "identification through heteroskedasticity" or GMM estimator
- Applied this to six products (men's leather athletic shoes; men's and boy's cotton knit shirts; stainless/carbon steel bars; color TV; portable typewriters) and obtained elasticities between 3 and 8; for gold and silver bullion, get 27 or 43.

b) U.S. Gains from Import Variety, Broda and Weinstein (QJE, 2006)

Measure the gains to the United States from increased import variety, 1972-2001

U.S. disaggregate imports: TSUSA (8-digit), 1972-1988

HS (10-digit), 1990-2001

A ***good*** is a TSUSA (8-digit) or HS (10-digit), or more aggregate if needed.

A ***variety*** is the import to the United States from a source country, like the "Armington assumption"

- I = set of varieties selling to U.S. in year t and the base year (1972 or 1990), so that lambda's are measured as the *expenditure on imported varieties from all other countries* relative to the base year.
- Estimated 10,000+ elasticities σ, with median of 3.7 across HS goods

Conclusions:

- There has been large growth in the variety of imported products to the U.S.
- A simple "count" of products should not be used to assess this growth
- The "lambda ratio" is easily constructed from disaggregate trade data, and allows for a measure of variety growth that is consistent with CES
- The cumulative growth in varieties over 1972-2001 leads to a fall in the true import price index of 28% by 2001
- **That fall in import prices corresponds to *gains to the U.S.* from increased import variety which are 2.6% of GDP in 2001**

Look at other applications:

- **Predicted and actual effects of NAFTA on Mexican exports to the U.S. (Feenstra and Rose, 1993; Feenstra and Kee, *World Economy*, 2007)**

Feenstra and Rose (1993):

- Argued that gains to California from NAFTA will depend on the extent to which increased agricultural imports/exports change water use
- Estimated the increase in *imports* of vegetable crops, and their elasticities of substitution σ, using GMM methodology
- Social gains from the increase in vegetable imports ≈ \$11 million, but social gains due to reduced water use ≈ \$20 million
- did not consider increased *exports* of water-intensive crops (rice, dairy)

Feenstra and Kee (*World Economy*, 2007):

- Estimated the "lambda ratio" for goods shipped from Mexico to the United States, including agricultural goods, during the opening of NAFTA. This is also called the "extensive margin of trade":

Table 1: Mexico's Trade with the U.S., 1990-2001

(a) Mexico's Export Variety to the U.S.

	Average	Agriculture	Textiles & Garments	Wood &Paper	Petroleum & Plastics	Mining &Metals	Machinery &Transport	Electronics
1990	51.3	41.5	71.2	47.3	55.4	46.6	65.6	39.5
2001	69.6	50.9	82.6	63.2	72.7	56.4	75.8	65.6
Growth	2.8	1.9	1.4	2.6	2.5	1.7	1.3	4.6

(b) U.S. Tariffs on Imports from Mexico

	Average	Agriculture	Textiles & Garments	Wood &Paper	Petroleum & Plastics	Mining &Metals	Machinery &Transport	Electronics
1990	3.2	4.4	13.0	2.2	0.6	2.1	2.5	4.1
2001	0.2	0.8	0.4	0.0	0.1	0.7	0.1	0.1

2. Producer Benefits from Export/Output Variety

A. First rationale: When $\sigma < 0$ we will denote its positive value by $\omega \equiv -\sigma$, and using labor resources L_t to replace utility U_t:

$$L_t = \left(\sum_{i \in I_t} a_{it} q_{it}^{(\omega+1)/\omega} \right)^{\omega/(\omega+1)}, \quad a_{it} > 0, \ \omega > 0.$$

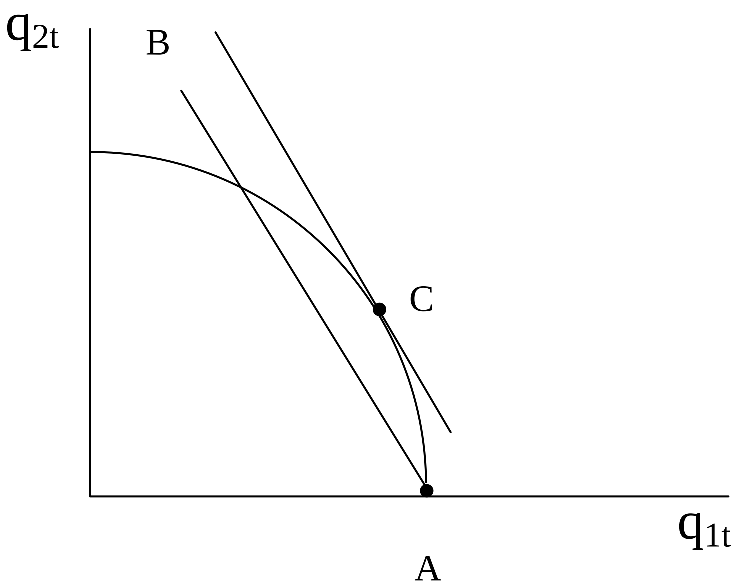
The maximum revenue obtained using one unit of labor resources is then:

$$r(p_t, I_t) = \left[\sum_{i \in I_t} b_{it} p_{it}^{\omega+1} \right]^{1/(\omega+1)}, \qquad b_{it} \equiv a_{it}^{-\omega}, \ \omega > 0.$$

With this reinterpretation, **Theorem 2** continues to hold as:

$$\frac{r(p_t, I_t)}{r(p_{t-1}, I_{t-1})} = P_{SV}(p_{t-1}, p_t, q_{t-1}, q_t, I) \left(\frac{\lambda_t(I)}{\lambda_{t-1}(I)} \right)^{-1/(\omega+1)},$$

where the exponent appearing on $(\lambda_{t/}\lambda_{t-1})$ is now negative. In other words, the appearance of "new outputs," so that $\lambda_t < 1$, will *raise revenue* on the producer side of the economy.

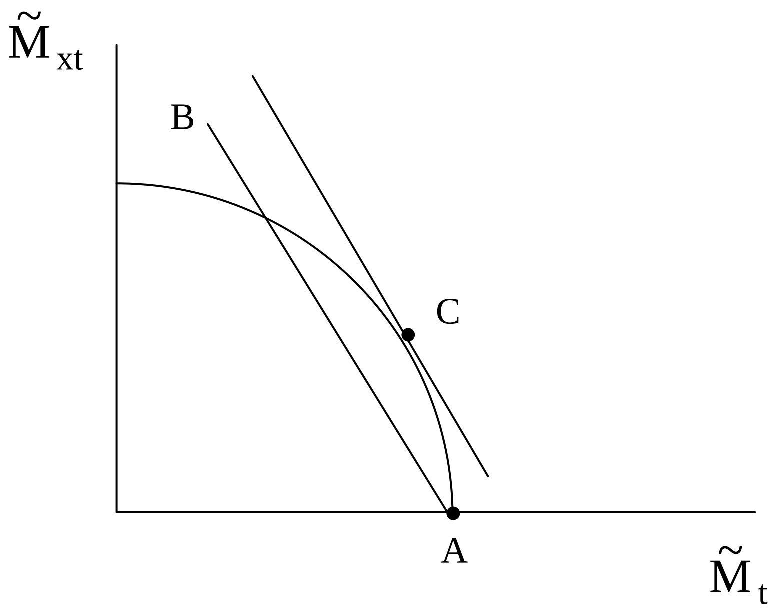


If only q_{1t} is available, the economy produces at A, with output revenue AB. Then if variety 2 becomes available, then economy is at C, with an *increase* in revenue. This illustrates the benefits of *export/output variety*.

Problem: if factor proportions between the two varieties are the *same*, then the transformation curve is linear, and there is *no gain to export/output variety*

B. Second Rationale

Can show that in the Melitz (2003) model, there is a concave tradeoff between export and domestic varieties, even with the same factor intensities!



Gains to export variety depend on the *elasticity of transformation* ω.

Application: Gains from Export Variety, Feenstra and Kee (JIE, 2008)

- For sample of 48 countries exporting to the U.S. over 1980–2000, find that average export variety to the United States increases by 3.3% per year, so it nearly doubles over these two decades.
- That total increase in export variety is associated with a cumulative 3.3% productivity improvement for exporting countries, i.e. after two decades, GDP is 3.3% higher than otherwise due to growth in export variety
- That estimate is *greater* than the welfare gains for the U.S. found by Broda and Weinstein (2006), which was that after 30 years, real GDP was 2.6% higher than otherwise due to growth in import variety.
- Export variety is correlated with *times series* changes in country productivity, but does not explain that much of *cross-section* differences

- These estimates depend on the *elasticity of transformation* ω, which in turn depends on the elasticity of substitution σ and most crucially on θ, which is the parameter of the Pareto distribution of firms productivities.
- New results from Arkolakis, Costinot and Rodriguez-Clare (2008, 2009) argue that the Pareto parameter θ and the share of trade are all we need to know for the gains from trade:

Theorem 2 (Arkolakis, *et al*, 2008, 2009; Feenstra, *CJE*, 2010)

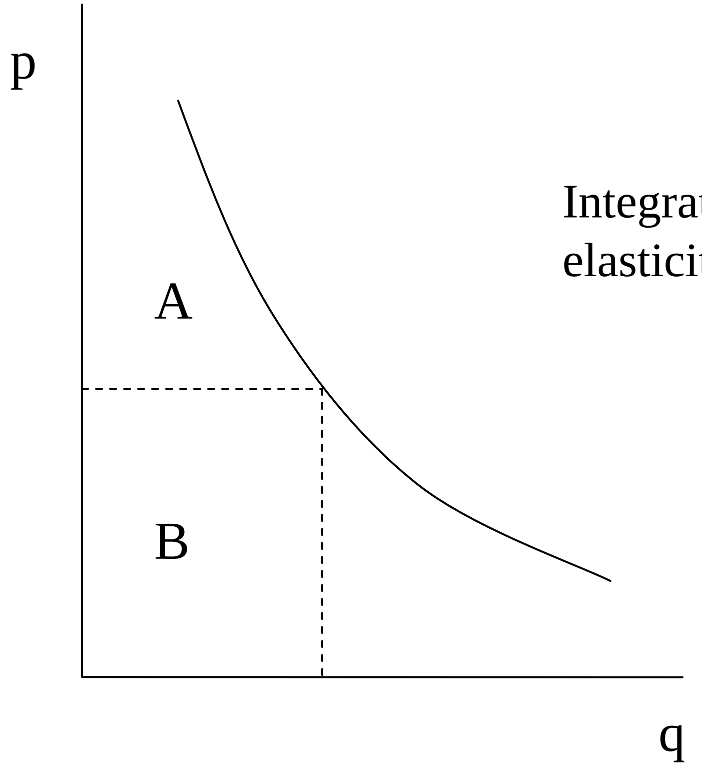
The gains from trade in the Melitz (2003) model are:

$$\frac{w_t / P_t^H}{w_{t-1} / P_{t-1}^H} = \lambda_t^{-\frac{1}{\theta}} \quad \text{where} \quad \lambda_t = \left(\frac{R_{dt}}{R_{dt} + R_{xt}} \right).$$

So the gains from trade only depend on what a country buys from itself!

3. Markups with Translog Preferences

Perhaps the CES case *overstates* the consumer gains from variety, because the reservation price is infinite.



Integrating demand curve with constant-elasticity σ above the price shows that:

$$\frac{A}{B} = \frac{1}{(\sigma - 1)}$$

Can we develop the analogous theory for other preferences, like translog?

Yes! Furthermore, while we will find that the gains from variety are indeed lower with translog, there is a new source of gains from trade that does not arise in the CES case: rising imports will have a *pro-competitive impact* on reducing U.S. prices and those from all other selling countries, due to reduced markups. (In contrast, markups are fixed in the CES case).

We find that the pro-competitive gains *exceed* the import variety gains.

Technical issues with translog:

1. Need to solve for reservation prices for goods not available.
2. To get the right markups, need to allow multiple exporters in each country. Sufficient to have the Herfindahl indexes of exports from each country, which we purchased from piers.com and from Statistics Canada.

Translog unit-expenditure function over the universe of goods $\tilde{N}$:

$$\ln e = \alpha_0 + \sum_{i=1}^{\tilde{N}} \alpha_i \ln p_i + \tfrac{1}{2} \sum_{i=1}^{\tilde{N}} \sum_{j=1}^{\tilde{N}} \gamma_{ij} \ln p_i \ln p_j, \text{ with } \gamma_{ij} = \gamma_{ij} \, .$$

To ensure that the expenditure function is homogenous of degree one, we need:

$$\sum_{i=1}^{\tilde{N}} \alpha_i = 1, \quad \text{and} \quad \sum_{i=1}^{\tilde{N}} \gamma_{ij} = 0.$$

We will further assume that all goods are "symmetrically" in the γ_{ij} coefficients:

$$\gamma_{ii} = -\gamma\left(\frac{\tilde{N}-1}{\tilde{N}}\right), \text{ and } \gamma_{ij} = \frac{\gamma}{\tilde{N}} \text{ for } i \neq j, \text{ with } i, j = 1, \ldots, \tilde{N}.$$

The share equations are: $\qquad s_i = \alpha_i + \sum_{j=1}^{\tilde{N}} \gamma_{ij} \ln p_j \, .$

Suppose $s_i > 0$ for i=1,…,N, while $s_j = 0$ for j=N+1,…, $\tilde{N}$. The we use $s_j = 0$ for unavailable goods to solve for the reservation prices $\tilde{p}_j$, j=N+1,…, $\tilde{N}$. These reservation prices $\tilde{p}_j$ are substituted back into the expenditure function to obtain:

Theorem 3 (Bergin and Feenstra, 2008)

$$\ln e = a_0 + \sum_{i=1}^{N} a_i \ln p_i + \tfrac{1}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} b_{ij} \ln p_i \ln p_j,$$

where: $b_{ii} = -\gamma(N-1)/N, \text{ and } b_{ij} = \gamma/N \text{ for } i \neq j$ with i, j = 1,…,N,

$a_i = \alpha_i + \tfrac{1}{N}\left(1 - \sum_{i=1}^{N} \alpha_i\right)$, for i = 1,…,N,

$$a_0 = \alpha_0 + \left(\frac{1}{2\gamma}\right)\left\{\sum_{i=N+1}^{\tilde{N}} \alpha_i^2 + \left(\frac{1}{N}\right)\left(\sum_{i=N+1}^{\tilde{N}} \alpha_i\right)^2\right\}.$$

Now distinguish t-1 and t, with i=N+1,…, $\tilde{N}$ are not available in either period.

The goods {1,…,N} are divided into two (overlapping) sets each period:

- the set $i \in I_\tau$ is available in period τ = t-1,t, with union $I_{t-1} \cup I_t = \{1,..., N\}$;
- We shall let $\bar{I} \subseteq I_{t-1} \cap I_t \neq \varnothing$ denote any non-empty subset of intersection, with $\bar{N} > 0$ goods within the set $\bar{I}$.

In general, the **Törnqvist price index** is exact for the translog function:

$$\ln\left(\frac{e_t}{e_{t-1}}\right) = \sum_{i=1}^{N} \tfrac{1}{2}(s_{it} + s_{it-1})(\ln p_{it} - \ln p_{it-1}).$$

Solving for the reservation prices for new and disappearing goods, we obtain the following expression for the exact price index:

Theorem 4 (Feenstra and Weinstein, 2009)

$$\ln\left(\frac{e_t}{e_{t-1}}\right) = \sum_{i\in\bar{I}} \tfrac{1}{2}(\bar{s}_{it} + \bar{s}_{it-1})(\ln p_{it} - \ln p_{it-1}) + V,$$

where, $$V \equiv -\left(\frac{1}{2\gamma}\right)\left\{\sum_{i\notin\bar{I}}\left(s_{it}^2 - s_{it-1}^2\right) + \left(\frac{1}{\bar{\bar{N}}}\right)\left[\left(\sum_{i\notin\bar{I}} s_{it}\right)^2 - \left(\sum_{i\notin\bar{I}} s_{it-1}\right)^2\right]\right\},$$

and the shares $\bar{s}_{it-1}$ and $\bar{s}_{it}$ are defined as:

$$\bar{s}_{i\tau} \equiv s_{i\tau} + \tfrac{1}{\bar{\bar{N}}}\left(1 - \sum_{i\in\bar{I}} s_{i\tau}\right), \text{ for } i \in \bar{I}, \text{ and } \tau = \text{t-1, t}.$$

- V is the ***variety*** effect. We need to further breakdown prices into marginal costs and markups, to identify a ***pro-competitive*** effect.

Optimal Prices:

The optimal price can be written as the familiar markup over marginal costs:

$$p_{it} = C_i'[x_i(p_t, E_t)]\left[\frac{\eta_i(p_t, E_t)}{\eta_i(p_t, E_t) - 1}\right].$$

The elasticity of demand for the "symmetric" translog is:

$$\eta_{it} = 1 + \frac{\gamma(N_t - 1)}{s_{it} N_t} \ .$$

It follows that the optimal prices are:

$$\ln p_{it} = \ln C'_{it} + \ln\left[1 + \frac{s_{it} N_t}{\gamma(N_t - 1)}\right],$$

Substitute into the Törnqvist price index to obtain the *pro-competitive* effect.

Problem:

We do not observe firm-level shares. So aggregate prices from the firm to the country level using Herfindahl indexes:

$$\ln p_{it} \approx \ln \ln C'_{it} + \ln\left[1 + \frac{H_{it} s_{it} N_t}{\gamma(N_t - 1)}\right],$$

using the Herfindahl index for firm exports by country i, $H_{it} \equiv \sum_{j \in J_{it}} (s^i_{jt})^2$.

- We see that the impact of import competition on prices will depend on the product $H_{it} s_{it}$ for importing countries i, and *also* for the United States
- $H_{it} s_{it}$ is interpreted as the “per firm” market shares, where lower market shares lead to lower markups.

Conclusions:

- Fall in market share for many U.S. industries, and a *smaller rise* in the U.S. Herfindahls $\Rightarrow$ U.S. firm market shares are falling, along with markups.
- Markups for exporters are lower than U.S. markups, and with rising shares $\Rightarrow$ a fall in *average* markup in the U.S. market due to import competition
- There has also been a growth in market share of "new" suppliers, with corresponding *partial* variety gains
- **Estimates of the *sum* of the partial variety gains and pro-competitive impact give a number that is similar to the gains from Broda and Weinstein (2006), i.e. around 2.6% of GDP in 2001, with 2/3 from pro-competitive effect and 1/3 from variety effect.**

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