# Nottingham Lectures, 2008

# New Product Varieties, the Terms of Trade, and the Measurement of Real GDP

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## Introduction (non-technical) to issues covered in lectures:

Robert Feenstra, 2006, "New Evidence on the Gains from Trade," *Review of World Economics/Weltwirtschaftliches Archiv*, December.

30 year since Dixit and Stiglitz published monopolistic competition model

25 year since it has been applied to international trade (Krugman, Helpman)

Our focus is on the empirical implementation of the monopolistic competition model, especially the measurement and gains from product variety

## Lecture 1: *Product Variety and the Gains from Trade*

Feenstra, Robert C., 1994, "New Product Varieties and the Measurement of International Prices," *American Economic Review*, 84(1), March, 157-177.

Broda, Christian and David E. Weinstein, 2006, "Globalization and the Gain from Trade," *Quarterly Journal of Economics,* 121, May, 541-585.

Focus is on *import variety*.

## Lecture 2: *Export Variety and Productivity*

Melitz, Marc J., 2003, "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica,* 71(6),1695-1725.

Feenstra, Robert C. and Hiau Looi Kee, 2006 "Export Variety and Country Productivity," NBER Working Paper no. 10830, 2004. (revised)

Show the extension to *export variety* using the Melitz model of monopolistic competition with heterogeneous firms.

## Lecture 3: Terms of Trade and the Measurement of Real GDP

Hummels, David L. and Klenow, Peter J., 2005, "The Variety and Quality of a Nation's Trade," *American Economic Review,* 95(3), June 704-723.

Feenstra, Robert C., Alan Heston, Marcel P. Timmer, and Haiyan Deng, "Estimating Real Production and Expenditures Across Countries: A Proposal for Improving the Penn World Tables," 2006, NBER Working Paper no. 10866, 2004. (revised)

Extend the measurement of import variety and export variety to all countries, and show the prices of an varieties imports and exports can influence the measurement of real GDP in the Penn World Table.

## Omitted topics:

*Product quality* – Hummels and Klenow, and Peter Schott, but little theory

*Non-CES preferences* – for example, linear-quadratic used in Melitz and Ottaviano, and translog preferences used in Bergin and Feenstra

## Measuring Product Variety (Feenstra, *AER*, 1994)

We will 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-cost function dual to this is,

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

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

## Theorem (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-cost can be measured by the index:

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

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

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

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 c(p,I) denote the unit-cost function defined over the goods within the set I. Then the ratio $c(p_t,I)/c(p_{t-1},I)$ is still measured by the Sato-Vartia index. Our interest is in the ratio $c(p_t,I_t)/c(p_{t-1},I_{t-1})$, which can be measured as follows:

**Theorem (Feenstra, 1994)**

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

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

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

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

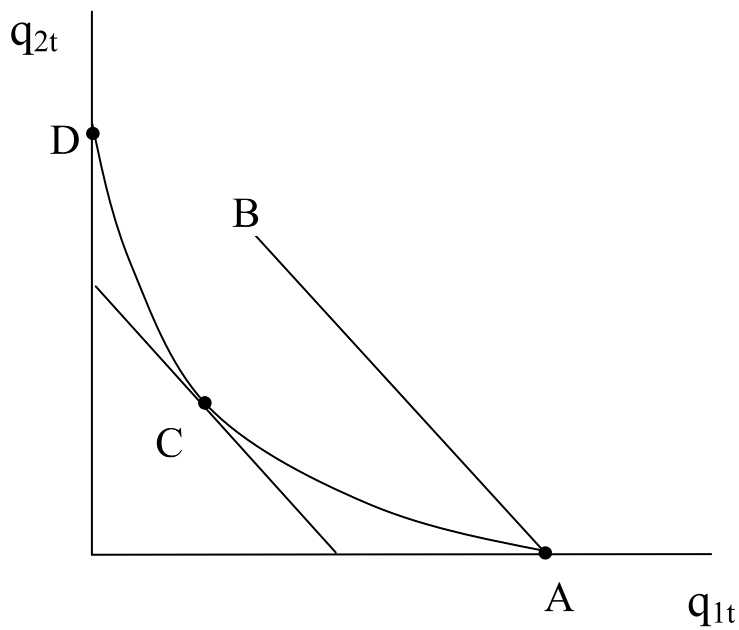
Each of the terms $\lambda_\tau(I) \le 1$ can be interpreted as the *period $\tau$ expenditure on the goods in the set I, relative to the period $\tau$ total expenditure.* Alternatively, this can be interpreted as *one minus the period $\tau$ expenditure on "new" goods (not in the set I), relative to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

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

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

*See this in a graph:*

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



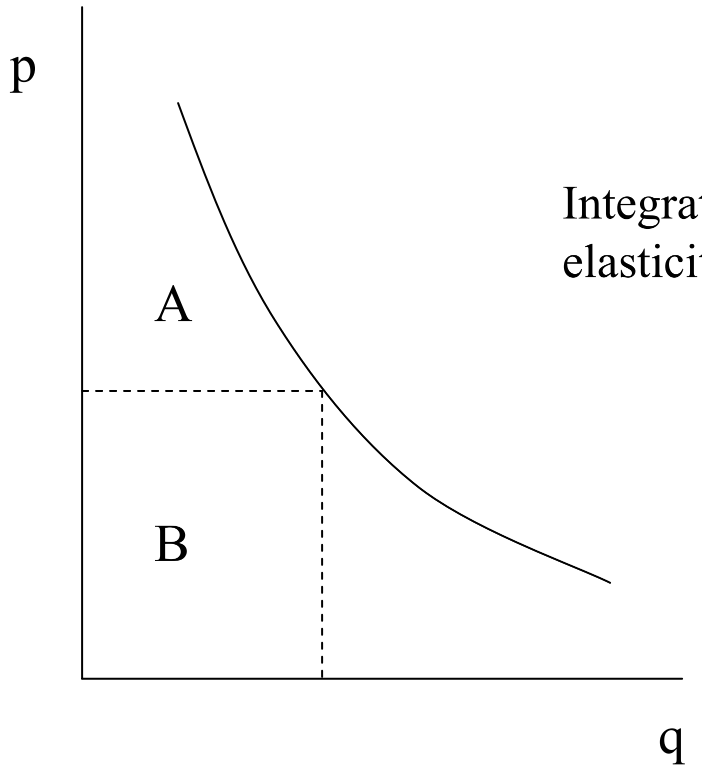

With only $q_1$ is available at A, the cost of achieving U is the budget line AB

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*.

## *Further intuition:*

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




Integrating demand curve with constant-elasticity $\sigma$ above the price shows that:

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

## Applications:

### *1. Productivity*

Measure "dual" factor productivity as the log difference between the index of input prices and the ratio of unit-costs:

$$TFP \equiv \ln P_{SV}(p_{t-1}, p_t, q_{t-1}, q_t, I) - \ln[c(p_t, I_t)/c(p_{t-1}, I_{t-1})].$$

Then using the above theorems, we immediately have:

$$TFP = \frac{1}{(\sigma - 1)} \ln\left(\frac{\lambda_{t-1}(I)}{\lambda_t(I)}\right).$$

Thus, the growth in new inputs, as reflected in a falling value of $\lambda_t(I)$ will be directly reflected in total factor productivity .

## *References*

**Feenstra et al (*Journal of Development Economics,* 1999)** provide an application to industry productivity growth in South Korea and Taiwan.

**Funke and Ruhwedel (2001a,b, 2002)** apply the same measure of product variety to analyze economic growth across the OECD and East Asian countries.

**Broda, Greenfield and Weinstein** ("From Groundnuts to Globalization: A Structural Estimates of Trade and Growth," 2006), assess the important of imported intermediate inputs to productivity growth in many countries.

## *2. 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," a product imported from each country is ***different*** from the product imported from another country.

**Problem:** even within each 8-digit or 10-digit category, countries might supply multiple products $N_{it}$ to the U.S., so the cost function is:

$$c(p_t, I_t) = \left( \sum_{i \in I_t} N_{it} p_{it}^{1-\sigma} \right)^{1/(1-\sigma)}.$$

where $N_{it}$ is the *number of varieties provided by each country* (just like $b_{it}$).

To apply earlier theorem, we need a set of countries for which $N_{it}$ is constant.

We will assume that the countries selling to the U.S. in the *base year* (1972 or 1990) do not have any increase in $N_{it}$, but the other "new" countries can have an increase in $N_{it}$.

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 *increase in imported varieties from all other countries* relative to the base year:

$$\left(\frac{\lambda_t(I)}{\lambda_0(I)}\right) = \left(\frac{\sum_{i\in I} p_{it}q_{it}}{\sum_{i\in I_t} p_{it}q_{it}}\right) \Bigg/ \left(\frac{\sum_{i\in I} p_{i0}q_{i0}}{\sum_{i\in I_0} p_{i0}q_{i0}}\right)$$

This measure of the growth in import variety is much larger than what you would get if the common set $I = I_{t-1} \cap I_t$ was updated each year.

## Table 1: Variety in US Imports (1972 - 2001)

### US Imports 1972-1988

| | Year | Number of Goods | Median Number of Exporting Countries | Average Number of Exporting Countries | Total Number of Varieties (country-good pairs) | Average Value per Variety (in 1990 million dollars) | Share of Total US Imports in year |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| All 1972 goods | 1972 | 7731 | 6 | 9.7 | 74667 | 2.92 | 1.00 |
| All 1988 goods | 1988 | 12822 | 9 | 13.6 | 173937 | 2.67 | 1.00 |
| Common 72-88 | 1972 | 4171 | 6 | 8.7 | 36191 | 2.31 | 0.48 |
| Common 72-88 | 1988 | 4171 | 10 | 13.5 | 56183 | 2.24 | 0.32 |
| 1972 not in 1988 | 1972 | 3560 | 7 | 10.8 | 38476 | 3.49 | 0.52 |
| 1988 not in 1972 | 1988 | 8651 | 8 | 13.6 | 117754 | 2.88 | 0.68 |

### US Imports 1990-2001

| | Year | Number of Goods | Median Number of Exporting Countries | Average Number of Exporting Countries | Total Number of Varieties (country-good pairs) | Average Value per Variety (in 1990 million dollars) | Share of Total US Imports in year |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| All 1990 goods | 1990 | 14572 | 10 | 12.5 | 182375 | 2.72 | 1.00 |
| All 2001 goods | 2001 | 16390 | 12 | 15.8 | 259215 | 4.30 | 1.00 |
| Common 90-01 | 1990 | 10636 | 10 | 12.4 | 132417 | 2.48 | 0.73 |
| Common 90-01 | 2001 | 10636 | 13 | 16.3 | 173776 | 3.75 | 0.67 |
| 1990 not in 2001 | 1990 | 3936 | 10 | 12.7 | 49958 | 3.34 | 0.27 |
| 2001 not in 1990 | 2001 | 5754 | 11 | 14.8 | 85439 | 5.41 | 0.33 |

Notes: For the period 1972-1988 goods are defined at the TSUSA level (8-digit). For the latter period, 10-digit HTS data is used. Source: NBER CD-ROM and http://data.econ.ucdavis.edu/international/usixd/wp5514d.html

## Table 7: Descriptive Statistic of Lambda Ratios

| Period | Statistic | SITC-3 |
|---|---|---|
| 1972-1988 | Percentile 5 | 0.12 |
| | Percentile 50 | 0.80 |
| | Percentile 95 | 2.20 |
| | Nobs | 220 |
| 1990-2001 | Percentile 5 | 0.52 |
| | Percentile 50 | 0.94 |
| | Percentile 95 | 3.29 |
| | Nobs | 251 |

Notes: See text for definitions.

- Using Count data we would infer that there is a growth in varieties that is 10 times larger that using Lambda ratios (25% vs 250%).

# Example: Splitting of product categories

- An HTS good is split into 2 different HTS within same SITC-5 category

| SITC 5 Level (5 digit) | HTS Level (10 digit) | Country Level (Variety) | Years 1990 | 2001 |
|---|---|---|---|---|
| Fresh, Dried and Preserved Apples | Fresh Apples | A | 10 | 10 |
| " | Dried and Preserved | B | 10 | 0 |
| " | Dried and Preserved | C | 5 | 0 |
| " | Dried | B | 0 | 5 |
| " | Preserved | B | 0 | 5 |
| " | Preserved | C | 0 | 5 |

- If simple number of goods used, then we would wrongly treat this change as variety growth.
- By contrast, Lambda ratio for F,D and P apples is unchanged.
- Robust to many other types of ‘splitting’ and ‘merging’ that can occur.

## *Measuring the Elasticity of Substitution:*

Share of expenditure on each variety is:

$$s_{it} = N_{it}\left[\frac{p_{it}}{c(p_t, I_t)}\right]^{1-\sigma}$$

In log differences:

$$\Delta \ln s_{it} = (\sigma - 1)\Delta \ln c(p_t, I_t) - (\sigma - 1)\Delta \ln p_{it} + \Delta \ln N_{it}$$

$$\Delta \ln s_{it} = \phi_t - (\sigma - 1)\Delta \ln p_{it} + \varepsilon_{it}$$

where: $\phi_t = (\sigma - 1)\Delta \ln c(p_t, I_t)$

$$\varepsilon_{it} = \Delta \ln N_{it}$$

**Problem:** Estimating this demand curve gives downward biased estimates of elasticity $\sigma$, due to simultaneous equation bias.

**Solution:** Add a supply curve

$$\Delta \ln p_{it} = \omega \Delta \ln q_{it} + \xi_{it}$$

**Problem:** How to estimate this system without any instruments?

**Solution:** "Identification through heteroskedasticity" (Rigobon, 2003; Feenstra, 1994). Take the following steps:

**1. Eliminate the quantity from the supply curve:**

$$\Delta \ln p_{it} = \psi_t + \frac{\rho \varepsilon_{it}}{(\sigma - 1)} + \delta_{it}$$

where: $\psi_t = \dfrac{\omega(\phi_t + \Delta \ln E_t)}{(1 + \phi\sigma)}$, $\quad \delta_{it} = \dfrac{\xi_{it}}{(1 + \omega\sigma)}$

$$\rho = \frac{\omega(\sigma - 1)}{(1 + \omega\sigma)}, \quad 0 < \rho < 1$$

## 2. Eliminate time-effects by taking difference w.r.t country k:

$$\tilde{\varepsilon}_{it} = \varepsilon_{it} - \varepsilon_{kt} = (\Delta \ln s_{it} - \Delta \ln s_{ik}) + (\sigma - 1)(\Delta \ln p_{it} - \Delta \ln p_{ik})$$

$$\tilde{\delta}_{it} = \delta_{it} - \delta_{kt} = (\Delta \ln p_{it} - \Delta \ln p_{ik}) + \rho \tilde{\varepsilon}_{it} / (\sigma - 1)$$

$$= (1 - \rho)(\Delta \ln p_{it} - \Delta \ln p_{ik}) + [\rho / (\sigma - 1)](\Delta \ln s_{it} - \Delta \ln s_{ik})$$

**Multiply these together and divide by (1-ρ)(σ-1), to get:**

$$Y_{it} = \theta_1 X_{1it} + \theta_2 X_{2it} + u_{it}$$

where, $Y_{it} = (\Delta \ln p_{it} - \Delta \ln p_{ik})^2$, $X_{1it} = (\Delta \ln s_{it} - \Delta \ln s_{ik})^2$

$$X_{2it} = (\Delta \ln p_{it} - \Delta \ln p_{ik})(\Delta \ln s_{it} - \Delta \ln s_{ik})$$

$$\theta_1 = \frac{\rho}{(\sigma - 1)^2 (1 - \rho)}, \quad \theta_2 = \frac{(2\rho - 1)}{(\sigma - 1)(1 - \rho)}, \quad u_{it} = \frac{\tilde{\varepsilon}_{it} \tilde{\delta}_{it}}{(\sigma - 1)(1 - \rho)}$$

**3. Assume:** $\varepsilon_{it}$ and $\delta_{it}$ are independent

***Average regression over time and run:***

$$\overline{Y}_i = \theta_1 \overline{X}_{1i} + \theta_2 \overline{X}_{2i} + \overline{u}_i$$

Notice that the error term in this equation tends to zero as $t \to \infty$!

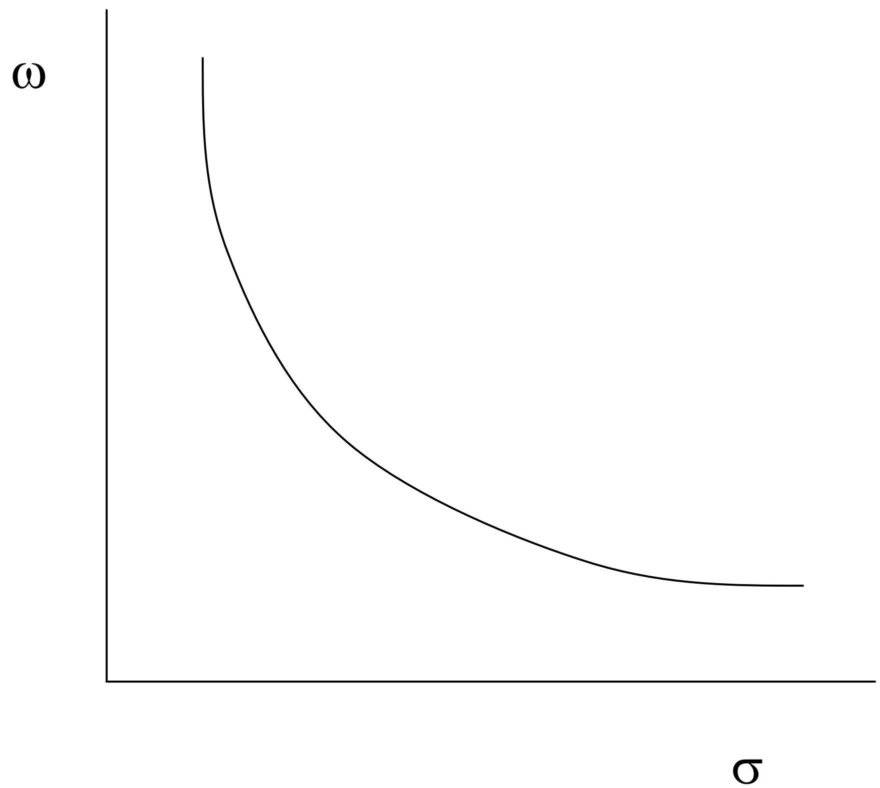
OLS or WLS will give consistent estimates of $\theta_1$ and $\theta_2$ provided that the two RHS variables are not co-linear as $t \to \infty$. This will be the case provided that there exist countries i and j such that:

$$\frac{\sigma^2_{\varepsilon i} + \sigma^2_{\varepsilon k}}{\sigma^2_{\varepsilon j} + \sigma^2_{\varepsilon k}} \neq \frac{\sigma^2_{\delta i} + \sigma^2_{\delta k}}{\sigma^2_{\delta j} + \sigma^2_{\delta k}}$$

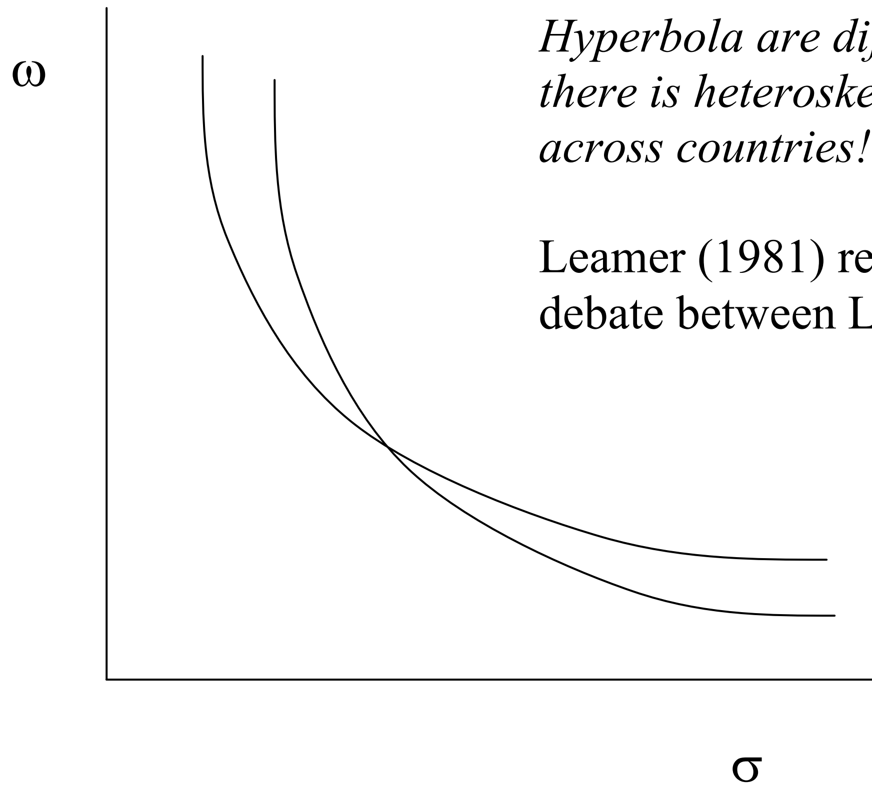
So the system is identified provided that there is heteroskedasticity in the errors!

## Intuition from Leamer (1981) article:

Writing down a demand and supply system, and solving for the maximum-likelihood estimates without instruments, gives non-unique solution:



But with panel of countries, we can obtain a solution if hyperbola are different:




*Hyperbola are different provided that there is heteroskedasticity in the errors across countries!*

Leamer (1981) relates this to a historical debate between Leontief and Frisch

## Table 4: Sigmas for different Aggregation Levels and Time Periods

| Period | Statistic | TSUSA/HTS | SITC-5 | SITC-3 |
|---|---|---|---|---|
| 1972-1988 | Percentile 90 | 16.0 | 10.9 | 7.0 |
| | Percentile 50 (Median) | 3.6 | 3.1 | 3.0 |
| | Percentile 10 | 1.6 | 1.7 | 1.9 |
| | Average | 11.7 | 6.4 | 5.9 |
| | Nobs of categories | 12219 | 1480 | 243 |
| | Median varieties per category (1) | 12 | 45 | 288 |
| 1990-2001 | Percentile 90 | 14.1 | 9.7 | 6.1 |
| | Percentile 50 (Median) | 2.9 | 2.7 | 2.7 |
| | Percentile 10 | 1.5 | 1.6 | 1.8 |
| | Average | 8.2 | 5.6 | 3.9 |
| | Nobs of categories | 14549 | 2731 | 255 |
| | Median varieties per category (1) | 14 | 42 | 552 |

Notes: (1) As in Table 3, a variety is defined as a TSUSA/HTS-country pair. For the TSUSA/HTS column: number of observations is equivalent to the median number of countries. For SITC-5 (SITC-3) column it is the median number of TSUSA/HTS-good/country pairs in a given SITC-5 (SITC-3) level.

## Table 5: Sigmas for the 20 SITC-5 Sectors with the Largest Import Share by Period

### Period 1972-1988

| SITC-5 | Sigma | Average Share (in %) | Descriptions |
|---|---|---|---|
| 33300 | 9.66 | 10.10 | CRUDE PETROLEUM, SHALE OIL INC RECONST, TEST 25DEG API AOV |
| 93100 | 8.51 | 5.11 | SPECIAL TRANSACTIONS & COMMOD NOT CLASSIF BY KIND |
| 1112 | 7.99 | 1.52 | BEEF, FRSH, OR FRZN, VEAL PREP OR PRSVD |
| 76210 | 6.29 | 5.14 | RADIO TAPE PLAYER AND RECEIVERS FOR MOT VEH, NO BATTERY OPERATION |
| 78210 | 5.83 | 2.35 | TRUCKS, TRACTORS W/WO TRAILER GASOLINE OR DIESEL |
| 7111 | 5.31 | 2.33 | COFFEE, CRUDE |
| 24822 | 4.82 | 2.15 | LUMBER (SPRUCE, PINE, PARANA, DOUG-FIR, HEMLOCK, CEDAR, ETC) WRKD OR DRSD, WOOD SIDING |
| 89423 | 4.51 | 1.06 | PARTS & ACCESSORIES OF TOYS (INFLAT, RUBBER, PLASTIC, W/SPRING MECHANISM) |
| 33440 | 4.08 | 2.93 | FUEL OILS, HEAVY, CONDENSATE AND NO.4-TYPE |
| 78490 | 3.00 | 2.51 | PARTS AND ACCESSORIES OF MOTOR VEHICLES, ETC |
| 75200 | 2.99 | 2.17 | COMPUTERS, DATA PROCESSING MACHINES, PRINTERS AND PARTS |
| 68310 | 2.84 | 1.28 | UNWROUGHT NICKEL |
| 82100 | 2.74 | 1.64 | FURNITURE & PTS; BEDS, SOFAS, CABINETS, ETC.; SEATS USED FOR MOTORVEHICLES |
| 78510 | 2.58 | 1.21 | MOTORCYCLES AND CYCLES, MOTORIZED & NOT MOTORIZED |
| 64110 | 2.53 | 2.64 | NEWSPRINT PAPER |
| 66729 | 2.40 | 1.22 | DIAMONDS (NO INDUST), WORKED, NOT SET, FOR JEWELRY |
| 3600 | 2.23 | 1.24 | CRUSTACEAN ETC FRSH, CH, FZ, DRD, SALTED, ETC. |
| 78100 | 2.29 | 19.80 | MOTOR CARS & OTH PASSENGER VEHICLES |
| 6120 | 2.21 | 1.13 | CANE/BEET SUGAR, SYRUP, MOLASSES |
| 85102 | 2.02 | 2.41 | LEATHER FOOTWEAR AND SNEAKERS |

### Period 1990-2001

| SITC-5 | Sigma | Average Share (in %) | Descriptions |
|---|---|---|---|
| 33411 | 9.85 | 1.17 | GASOLINE INCLUDING AVIATION (EXCEPT JET) FUEL |
| 78210 | 9.83 | 3.16 | MOTOR VEHICLES FOR THE TRANSPORT OF GOODS |
| 33300 | 7.24 | 15.38 | CRUDE OIL FROM PETROLEUM OR BITUMINOUS MINERALS |
| 84300 | 6.37 | 1.58 | MEN'S OR BOYS' COATS, JACKETS ETC, TEXT, KNITTED |
| 75270 | 5.89 | 2.52 | STORAGE UNITS FOR DATA PROCESSING SYSTEMS |
| 79290 | 5.14 | 1.20 | PTS, N.E.S. AIRCRAFT & ASSOC EQUIP; SPACECRAFT ETC |
| 78100 | 4.51 | 18.59 | MOTOR CARS & OTH MOTOR VEHICLES |
| 75260 | 4.29 | 2.36 | INPUT OR OUTPUT UNITS FOR DATA PROCESSING SYSTEMS |
| 24821 | 4.12 | 1.07 | CHEESE AND CURD (24) |
| 34140 | 3.89 | 1.75 | TUNA, SKIPJACK/STRIPE-BELLIED BONITO FR EX LVR/ROE |
| 75230 | 3.79 | 1.49 | DIGITAL PROCESSNG UNITS |
| 76430 | 3.52 | 1.52 | TRANSMISSION APPARATUS FOR RADIOTELEPHONY, ETC |
| 85120 | 3.41 | 2.04 | SPORTS FOOTWEAR |
| 76381 | 3.13 | 1.25 | VIDEO RECORDING OR REPRODUCING APPARATUS ETC |
| 93100 | 3.06 | 5.54 | SPECIAL TRANSACTIONS AND COMMODITIES NOT CLASSIFIED ACCORDING TO KIND |
| 78400 | 2.68 | 3.40 | PARTS AND ACCESSORIES OF MOTOR VEHICLES, ETC |
| 64110 | 2.40 | 1.17 | NEWSPRINT IN ROLLS OR SHEETS |
| 76110 | 2.34 | 1.13 | TELEVISION RECEIVERS, COLOR, INCLUDING MONITORS, PROJECTORS AND RECEIVERS |
| 77640 | 1.84 | 4.16 | ELECTRONIC INTEGRATED CIRCUITS & MICROASSEMBLIES |
| 77210 | 1.71 | 1.03 | ELECRICL APPARAT FOR SWITCHG OR PROTECTG ELEC CIRC (772) |

Notes: SITC-5 Revision 2 (Revision 3) codes are used for the period 1972-1988 (1990-2001). Shares are simple averages of start and end years. Also see notes from Table 5.

## Table 6: Estimated Sigmas and Rauch Classification

| | Rauch's Classification of Goods: | | |
|---|---|---|---|
| | Commodity | Reference Priced | Differentiated |
| | 1972-1988 (TSUSA) | | |
| Median | 4.32 | 3.58 | 3.54 |
| Average | 13.57 | 10.22 | 11.72 |
| | 1990-2001 (HTS) | | |
| Median | 3.10 | 2.92 | 2.92 |
| Average | 12.91 | 8.74 | 8.13 |

Notes: Rauch's (1999) classification is at the 4-digit SITC level. This table presents the median and average elasticities of substitution for the TSUSA/HTS goods within those SITC-4 classified by Rauch.

## Table 7: Descriptive Statistic of Lambda Ratios

| Period | Statistic | SITC-3 |
|---|---|---|
| 1972-1988 | Percentile 5 | 0.12 |
| | Percentile 50 | 0.80 |
| | Percentile 95 | 2.20 |
| | Nobs | 220 |
| 1990-2001 | Percentile 5 | 0.52 |
| | Percentile 50 | 0.94 |
| | Percentile 95 | 3.29 |
| | Nobs | 251 |

Notes: See text for definitions.

- Using Count data we would infer that there is a growth in varieties that is 10 times larger that using Lambda ratios (25% vs 250%).

## Table 8: The Impact of Variety in US Import Prices

| | Ratio between Aggregate Exact Price Index that adjusts For variety and the Conventional Price Index | |
|---|---|---|
| | End-point Ratio | Average Per-annum Ratio |
| 1972-1988 | 0.775 | 0.984 |
| 1990-2001 | 0.950 | 0.995 |
| 1972-2001 | 0.719 (1) | 0.988 |

Notes: This table shows the estimated values of equation (12) by period. (1) For the period between 1988 and 1990 the average per-annum rate was applied.

- Over the last 30 years the Variety Bias accounts for over 28 percent.

## Conclusions:

1. There has been huge growth in the variety of imported products to the U.S.

   (as should also hold for other countries)

2. A simple "count" pf products should not be used to asses this growth

3. The "lambda ratio" is easily constructed from disaggregate trade data, and allows for a measure of variety growth that is consistent with CES

4. The cumulative growth in varieties over 1972-2001 leads to a fall in the true import price index of 28% by 2001

5. **That fall in import prices corresponds to *gains to the U.S.* from increased import variety which are 2.6% of GDP in 2001**

## Measuring Export Variety Across Countries

Using the U.S. import data over time, we can measure the *times series variation* in U.S. import variety, and also the *cross-sectional variation* in exports of countries to the U.S.

## Explain the rationale for this measure of export variety:

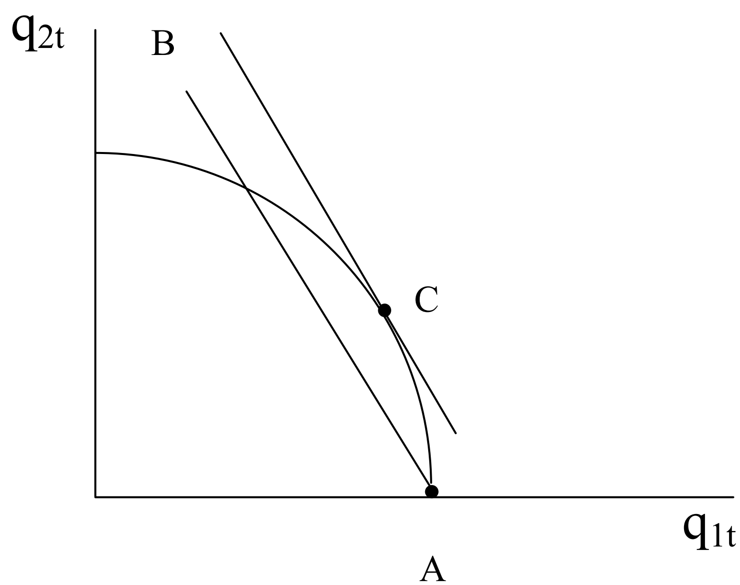
### *1. First rationale*

Exporting countries h=1,…,H producing and exporting goods $I_t^h \subset \{1,2,3,....\}$.

Aggregate output $Q_t^h$, is a CES function of the outputs of each good:

$$Q_t^h = f(q_t^h, I_t^h) = \left( \sum_{i \in I_t^h} a_i (q_{it}^h)^{(\omega+1)/\omega} \right)^{\omega/(\omega+1)}, \quad a_i > 0,$$

where the *elasticity of transformation* between goods is $\omega > 0$.



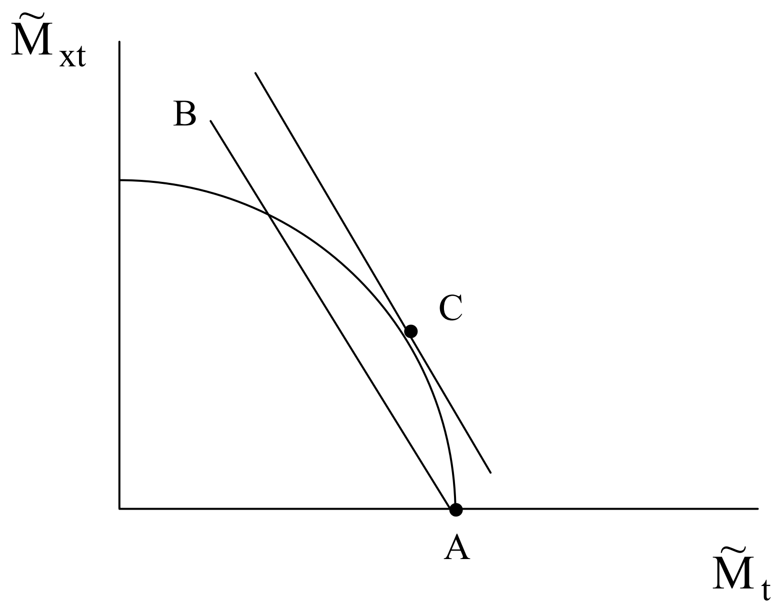

If only $q_{1t}$ is available, the economy produces at A, with output revenue AB.

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*

***2. Second Rationale***

Will 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 (elasticity ω) depends on σ from the demand side!

## Measurement of export variety:

Earlier theorem still applies. The unit-revenue function is:

$$c(p_t^h, I_t^h) = \left( \sum_{i \in I_t^h} b_i (p_{it}^h)^{1+\omega} \right)^{1/(1+\omega)}, b_i \equiv a_i^{-\omega} > 0, \quad \omega > 0.$$

The ratio of the CES revenue functions over two countries h and j, with common goods $I_t \equiv \left(I_t^h \cap I_t^j\right) \neq \varnothing$, equals:

$$\frac{c(p_t^h, I_t^h)}{c(p_t^j, I_t^j)} = \prod_{i \in I_t} \left( \frac{p_{it}^h}{p_{it}^j} \right)^{w_{it}(I_t)} \left( \frac{\lambda_t^h(I_t)}{\lambda_t^j(I_t)} \right)^{-1/(1+\omega)}, \quad h, j = 1, \ldots, H,$$

where the Sato-Vartia weights $w_{it}(I_t)$ are constructed from the revenue shares in the two countries, and the terms $\lambda_t^h(I_t)$ and $\lambda_t^j(I_t)$ are:

$$\lambda_t^h(I_t) = \frac{\sum_{i\in I_t} p_{it}^h q_{it}^h}{\sum_{i\in I_t^h} p_{it}^h q_{it}^h} = 1 - \frac{\sum_{i\in I_t^h, i\notin I_t} p_{it}^h q_{it}^h}{\sum_{i\in I_t^h} p_{it}^h q_{it}^h}, \text{ and likewise for j.}$$

Each of the terms $\lambda_t^h(I_t) \leq 1$ can be interpreted as the *exports of country h goods that are also sold by country j, relative to total exports of country h goods*.

So $\lambda_t^h / \lambda_t^j$ is an *inverse measure* of country h export variety relative to country j.

Notice that having more export varieties in country h (lower $\lambda_t^h / \lambda_t^j$) leads to a *higher* price index for country h, since revenues increase. So new goods lead to a *fall in prices* (from reservation level on demand) for consumers, but a *rise in prices* (from reservation level on supply) for producers.

**Question:** What is the *comparison country?***:**

1. **Feenstra *et al* (*Journal of Development Economics*, 1999):**

Compare Taiwan and Korea in their exports to the United States, and find that Taiwan consistently has *greater export variety* in nearly all industries.

2. **Feenstra and Kee (*AER*, May, 2004)**

Use the *worldwide exports* from all countries to the U.S. as the comparison. Denote this comparison by F, so that the set $I_t^F = \bigcup_{h=1}^{H} I_t^h$ is the complete set of varieties imported by the U.S. in year t, and $p_{it}^F q_{it}^F$ is the total value of imports for good i. Then comparing country h to country F in year t, it is immediate that the common set of goods exported is $I_t^h \cap I_t^F = I_t^h$, or simply the set of goods exported by country h. Therefore, we have that $\lambda_t^h(I_t^h) = 1$, and:

$$\frac{\lambda_t^F(I_t^h)}{\lambda_t^h(I_t^h)} = \frac{\sum_{i \in I_t^h} p_{it}^F q_{it}^F}{\sum_{i \in I_t^F} p_{it}^F q_{it}^F}.$$

The *share of total U.S. imports from products that are exported by country h.*

3. **Hummels and Klenow (*AER*, 2005)**

Take the export variety from country h to every partner j, and then average over these using Sato-Vartia weights. "Rest of the world" in 1995 is comparison.

*Note:* This approach treats exports to different countries are different varieties!

4. **Feenstra and Kee (2006)**

Take the *union of all products sold to the United States over all years*, 1980-2001, and also average export and import sales of each product across years.

## Results from Feenstra and Kee (AER, 2004):

**Figure 2:** scatter plot of the export variety in 1991 for the sales of 34 countries to the United States, against their country productivities.

**Canada** produces nearly twice as much variety as the sample mean, and has productivity 7 percent higher than the sample mean.

**Japan** has the highest productivity which is 12 percent higher than the sample mean, and has 80 percent more export products than the sample mean.

Other countries that have higher than average productivity and export variety include **South Korea, Singapore, and some other OECD countries such as France and Australia**. These countries appear on the first quadrant.

Countries that perform poorly in terms of the country productivity and export variety are in the third quadrant. They include **Kenya, Greece, the Philippines, Turkey and Uruguay**.

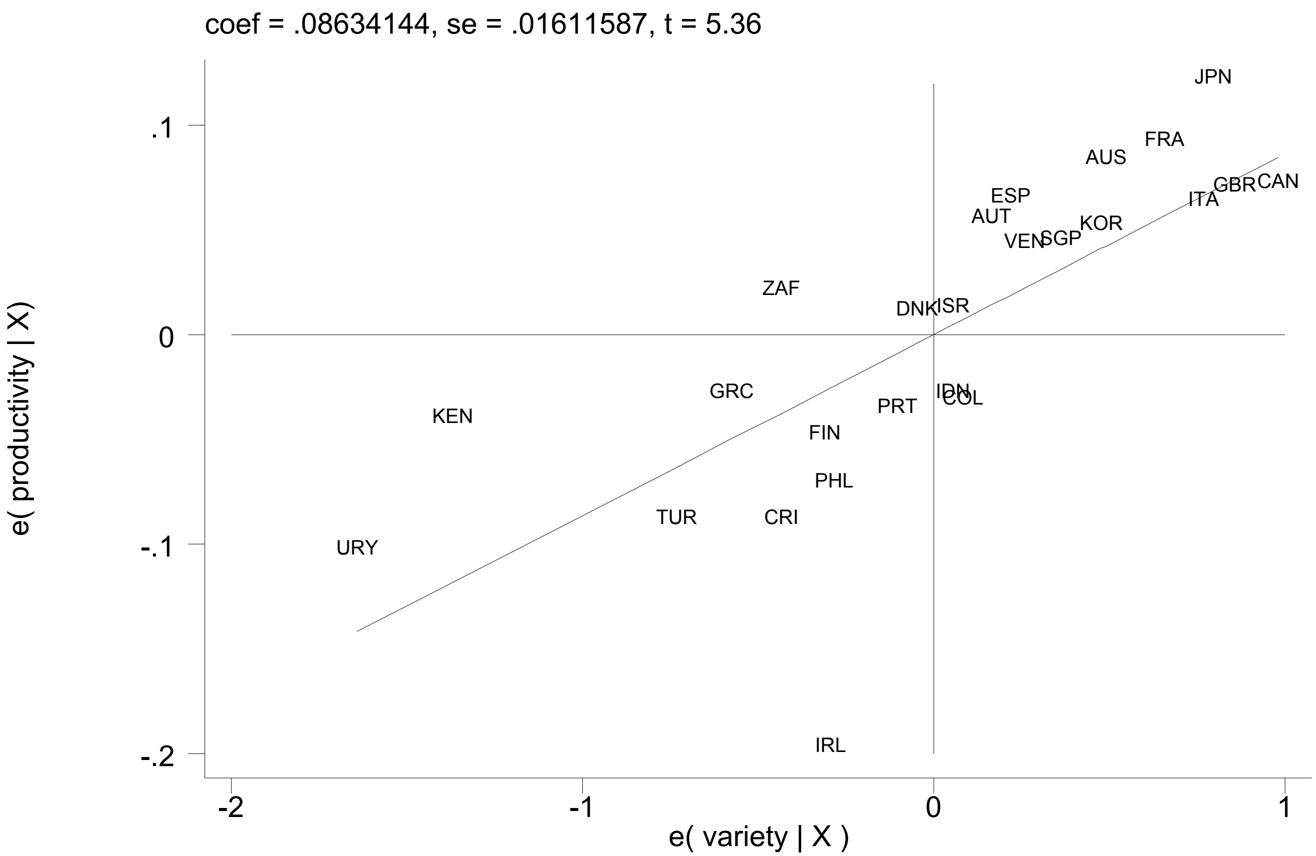



**Figure 2: Productivity Differences without Country Fixed Effects versus Product Variety Differences, 1991**

Also explore export variety and productivity *within a country over time*.

**Figure 3, Canada:** Over the years we see a gradual decline of export variety in Canada, especially since the early 1990s, and sa decline in productivity.

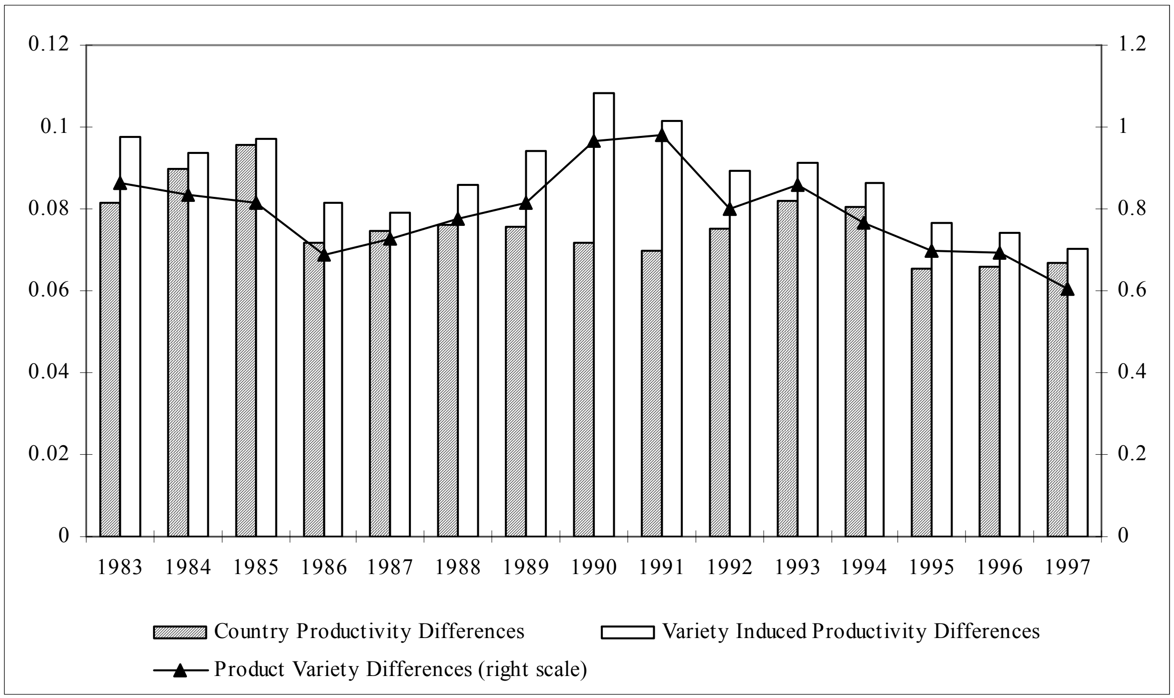



**Figure 3: Canada compared to Sample Mean**

F**igure 4 compares Japan to South Korea.** The Japanese advantage over Korea in export variety deteriorates over time as does it productivity advantage.

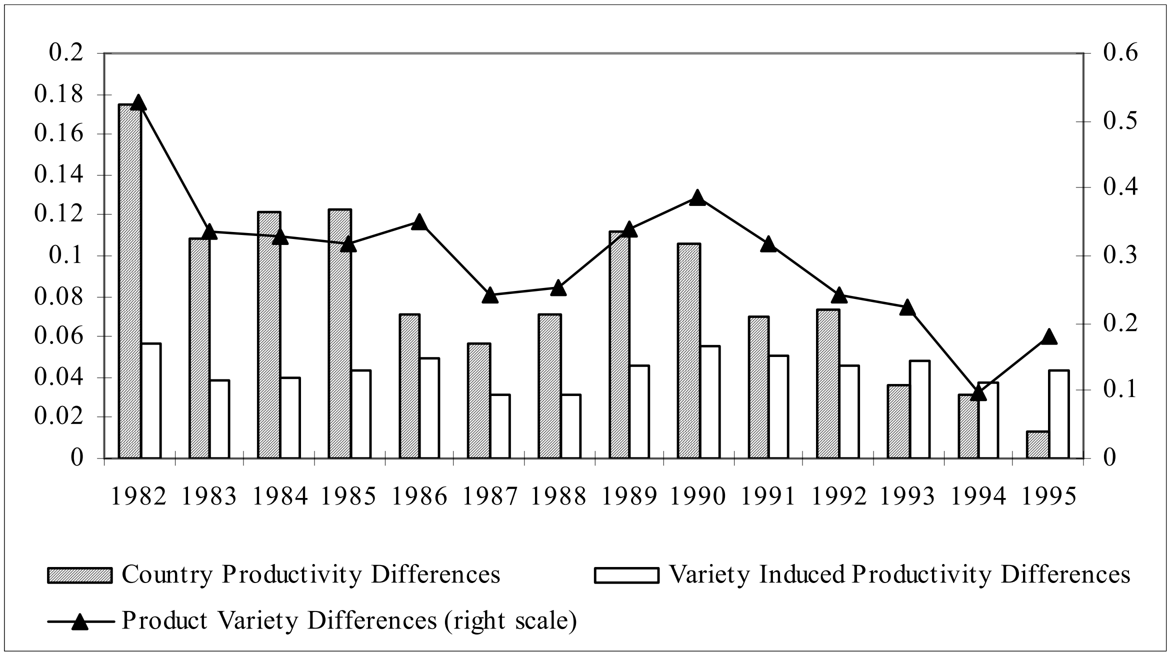



**Figure 4: Japan Compared to South Korea**