Lecture 2- Export Variety and Country Productivity

From Lecture 1:

Import variety is an important source of gains from trade, for the United States (and other countries).

Also appears that *export variet*y is correlated with country productivity.

Question: What is the link between *export variety* and country productivity?

Recent monopolistic competition model due to Melitz (2003) allows for firms that are heterogeneous in the productivities. Only the most efficient firms export. An increase in export opportunities will draw more firms into exporting. Even though the new entrants are less efficient than other exporter, they are more efficient than the marginal domestic firm, so average productivity rises. Therefore, export variety is positively related to productivity.

Feenstra and Kee (2006):

Empirical results

- Export variety to the US has expanded by 4.6% per year over 1980-2000, or two and one-half times over two decades, but only a small part of this is explained by falling U.S. tariffs.

- The total increase in export variety is associated with a 4.5% productivity improvement in exporters over the two decades.

- We are thus able to explain a substantial part of the time-series variation in country productivity, but very little of the large cross-country variation.

Theoretical results:

- Derive a GDP function for the economy, whose FOC are the monopolistic competition equilibrium conditions.

- Simplify this function using the Pareto distribution for productivities (similar to Chaney, 2005). Can estimate *without* firm-level data.

Theory: Model of Melitz (2003)

Cumulative distribution of firm productivities is $G_i(\varphi_i)$, which gives rise to the condition density $\mu_i(\varphi_i)$ for successful entrants. Marginal cost is m_i / φ_i.

Revenue earned by a home firm from selling in the domestic sector:

$$r_i(\varphi_i) = p_i(\varphi_i) q_i(\varphi_i) = \left[\frac{p_i(\varphi_i)}{P_i^H}\right]^{1-\sigma_i} E_i^H, \qquad \sigma_i > 1,$$

Or,

$$r_i(\varphi_i) = A_{id}\, q_i(\varphi_i)^{\frac{\sigma_i - 1}{\sigma_i}}, \text{ where } A_{id} \equiv P_i^H \left(\frac{E_i^H}{P_i^H}\right)^{\frac{1}{\sigma_i}}.$$

All firms have fixed cost of f_i and exporter face an additional fixed cost of f_{ix}.

Firms with productivities $\varphi_i \geq \varphi_i^*$ find it profitable to produce for the domestic market, those with productivities $\varphi_i \geq \varphi_{ix}^* \geq \varphi_i^*$ find it profitable to also export.

Revenue earned by the exporter is:

$$r_{ix}(\varphi_i) = p_{ix}(\varphi_i) q_{ix}(\varphi_i) = \left[\frac{p_{ix}(\varphi_i)\tau_i}{P_i^F}\right]^{1-\sigma_i} E_i^F,$$

Or,

$$r_{ix}(\varphi_i) = A_{ix} q_{ix}(\varphi_i)^{\frac{\sigma_i - 1}{\sigma_i}}, \text{ where } A_{ix} \equiv \left(\frac{P_i^F}{\tau_i}\right)\left(\frac{\tau_i E_i^F}{P_i^F}\right)^{\frac{1}{\sigma_i}}.$$

GDP equals:

$$\sum_{i=1}^{M} M_i A_{id} \int_{\varphi_i^*}^{\infty} q_i(\varphi_i)^{\frac{\sigma_i - 1}{\sigma_i}} \mu_i(\varphi_i) d\varphi_i + M_i A_{ix} \int_{\varphi_{ix}^*}^{\infty} q_{ix}(\varphi_i)^{\frac{\sigma_i - 1}{\sigma_i}} \mu_i(\varphi_i) d\varphi_i.$$

Mass of firms is M_i, which equals *domestic variety*. *Export variety* is:

$\int_{\varphi_{ix}^*}^{\infty} M_i \mu_i(\varphi_i) d\varphi_i = \chi_i M_i \leq M_i$. χ_i = *Export variety relative to domestic.*

Proposition 1

Choose $q_i(\varphi_i)$, $q_{ix}(\varphi_i)$, $\varphi_i^*, \varphi_{ix}^*$, and M_i for i = 1,…,N, to maximize GDP subject to the resource constraints. Holding fixed the shift parameters $A_d = (A_{1d},\ldots,A_{Nd})$ and $A_x = (A_{1x},\ldots,A_{Nx})$, the FOC for an interior maximum are identical to the equilibrium conditions for the monopolistically competitive economy. Then GDP can be written as a function $R(A_d, A_x, V)$, and satisfies:

(a) $R(A_d, A_x, V)$ is homogeneous of degree one in (A_d, A_x), and if R is differentiable then,

$$\frac{\partial \ln R}{\partial \ln A_{id}} = \frac{R_{id}}{R}, \text{ and } \frac{\partial \ln R}{\partial \ln A_{ix}} = \frac{R_{ix}}{R};$$

(b) $R(A_d, A_x, V)$ is homogeneous of degree one in V, and $\partial R / \partial V = w$ which is the vector of factor prices.

We assume the **Pareto distribution for productivities**, defined by:

$$G_i(\varphi_i) = 1 - \varphi_i^{-\theta_i}, \text{ with } \theta_i > \sigma_i - 1.$$

Using this distribution, we calculate export relative to domestic variety as:

$$\chi_i = \left(\frac{1 - G(\varphi_{ix}^*)}{1 - G(\varphi_i^*)} \right) = \left(\frac{\varphi_i^*}{\varphi_{ix}^*} \right)^{\theta_i}.$$

Then compute $r_i(\varphi_i^*)$ and $r_{ix}(\varphi_{ix}^*)$, and set these equal to fixed costs:

$$\frac{r_{ix}(\varphi_{ix}^*)}{r_i(\varphi_i^*)} = \left(\frac{\varphi_{ix}^* P_i^F / \tau_i}{\varphi_i^* P_i^H} \right)^{\sigma_i - 1} \frac{E_i^F}{E_i^H} = \frac{f_{ix}}{f_i} \Rightarrow \left(\frac{A_{ix}}{A_{id}} \right) = \chi_i^{\frac{\sigma_i - 1}{\sigma_i \theta_i}} \left(\frac{f_{ix}}{f_i} \right)^{1/\sigma_i}.$$

So relative export variety can be used as a proxy for (A_{ix}/A_{id}).

Proposition 2

Assume that the distribution of firm productivity in Pareto. Then the domestic and export parameters (A_{id}, A_{ix}) can be aggregated into a **CES function**:

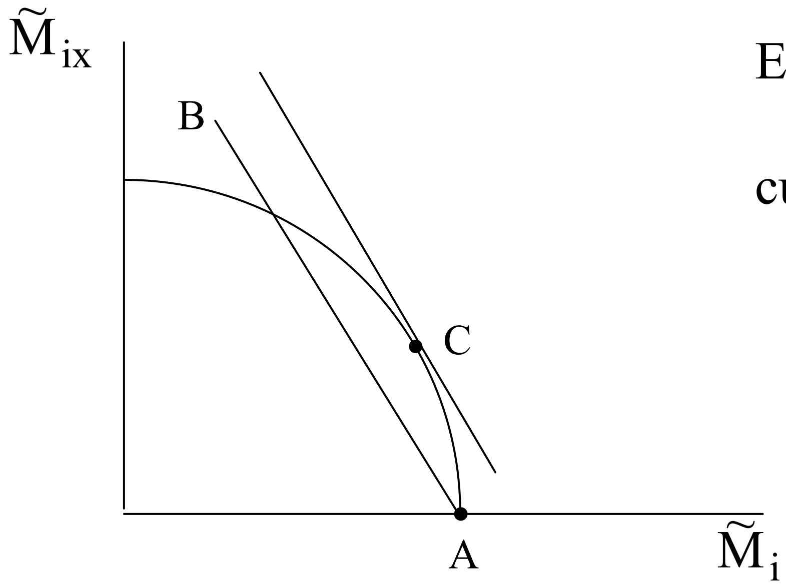
$$\psi_i(A_{id}, A_{ix}) \equiv \left[A_{id}^{\frac{\sigma_i\theta_i}{(\sigma_i-1)}} + A_{ix}^{\frac{\sigma_i\theta_i}{(\sigma_i-1)}} (f_{ix}/f_i)^{1-\frac{\theta_i}{(\sigma_i-1)}} \right]^{\frac{(\sigma_i-1)}{\sigma_i\theta_i}}.$$

It follows that GDP can be written as $R(\psi_1,\ldots,\psi_N,V)$, and if R is differentiable:

$$\frac{\partial \ln R}{\partial \ln P_i} = \frac{(R_{id} + R_{ix})}{R},$$

which is the share of sector i in GDP.

Dual to the CES price index is a CES transformation curve:



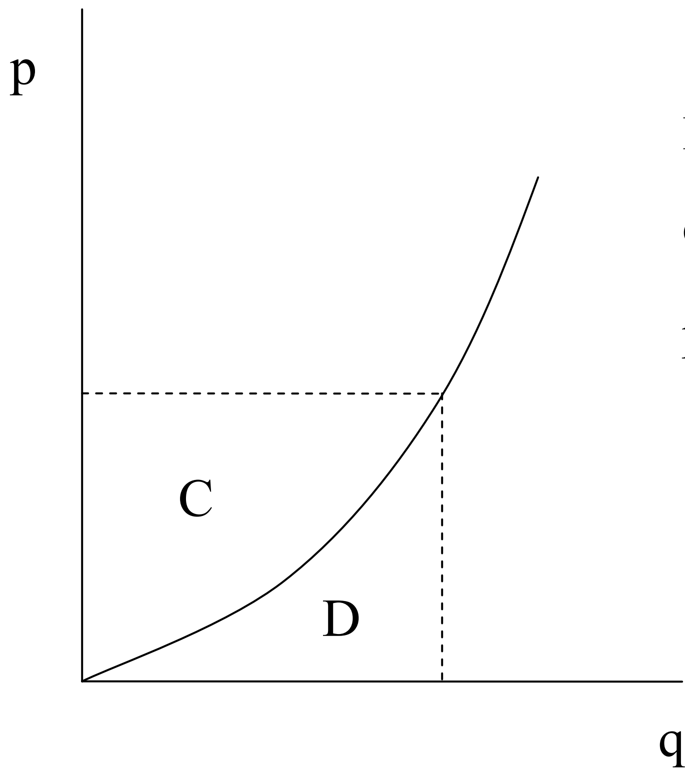
Elasticity of the transformation curve is: $\omega_i = \dfrac{\sigma_i \theta_i}{(\sigma_i - 1)} - 1 > 0$

where:

$$\widetilde{M}_i = M_i \tilde{q}_i^{\frac{\sigma_i - 1}{\sigma_i}} \quad \text{and,} \quad \widetilde{M}_{ix} = M_{ix} \tilde{q}_{ix}^{\frac{\sigma_i - 1}{\sigma_i}}, \quad \text{adjusting for average outputs.}$$

Further intuition:

The gain to producers from having new goods available is the producer surplus. For a CES supply curve, we can calculate that as:



Integrating supply curve with constant-elasticity $\omega_i = \frac{\sigma_i \theta_i}{(\sigma_i - 1)} - 1$ to obtain producer surplus shows that:

$$\frac{C}{C+D} = \frac{(\sigma_i - 1)}{\sigma_i \theta_i} < 1$$

The terms $\psi_i(A_{id}, A_{ix})$ enter the GDP function like sectoral "prices." This CES function is related to the results in Chaney (2005), who derives a gravity equation. For the case of a *single export market*, we have:

$$\frac{R_{ix}}{R_{id}} = \chi_i \left(\frac{f_{ix}}{f_i}\right) = \left(\frac{P_i^F / \tau_i}{P_i^H}\right)^{\theta_i} \left(\frac{E_i^F}{E_i^H}\right)^{\frac{\theta_i}{(\sigma_i - 1)}} \left(\frac{f_{ix}}{f_i}\right)^{1 - \frac{\theta_i}{(\sigma_i - 1)}}.$$

Empirical Specification:

1. *Translog GDP Function*
2. *Measurement of Sectoral CES functions and Export Variety*
3. *Other Data and Estimating Equations*

Translog GDP Function

Let $\psi_{it} = \psi_i(A^h_{idt}, A^h_{ixt})$ denote the CES functions. Let $\psi^h_t = (\psi^h_{1t}, \ldots, \psi^h_{N+1,t})$ also include a price for non-traded sector N+1. The translog GDP function is:

$$\ln R^h_t\left(\psi^h_t, V^h_t\right) = \alpha^h_0 + \beta_{0t} + \sum_{i=1}^{N+1} \alpha_i \ln \psi^h_{it} + \sum_{k=1}^{K} \beta_k \ln v^h_{kt} + \frac{1}{2} \sum_{i=1}^{N+1} \sum_{j=1}^{N+1} \gamma_{ij} \ln \psi^h_{it} \ln \psi^h_{jt}$$

$$+ \frac{1}{2} \sum_{k=1}^{K} \sum_{\ell=1}^{K} \delta_{k\ell} \ln v^h_{kt} \ln v^h_{\ell t} + \sum_{i=1}^{N+1} \sum_{k=1}^{K} \phi_{ik} \ln \psi^h_{it} \ln v^h_{kt}.$$

The share of sector i and the share of factor k in GDP equals:

$$s^h_{it} = \alpha_i + \sum_{j=1}^{N+1} \gamma_{ij} \ln \psi^h_{jt} + \sum_{k=1}^{K} \phi_{ik} \ln v^h_{kt}, \quad i = 1, \ldots, N+1.$$

$$s^h_{kt} = \beta_k + \sum_{\ell=1}^{K} \delta_{k\ell} \ln v^h_{\ell t} + \sum_{i=1}^{N+1} \phi_{ik} \ln \psi^h_{it}, \quad k = 1, \ldots, K.$$

CES Aggregates

Will measure the CES aggregates $\psi_{it} = \psi_i(A^h_{idt}, A^h_{ixt})$ in ratio form as $\psi^h_{it} / \psi^F_{it}$.

Assuming that the fixed costs (f_{ix}/f_i) are the same across countries, the CES ratio in sector i equals:

$$\frac{\psi_i(A^h_{idt}, A^h_{ixt})}{\psi_i(A^F_{idt}, A^F_{ixt})} = \left(\frac{A^h_{idt}}{A^F_{idt}}\right)^{1-W^h_{it}} \left(\frac{A^h_{ixt}}{A^F_{ixt}}\right)^{W^h_{it}} = \left(\frac{A^h_{idt}}{A^F_{idt}}\right)\left(\frac{A^h_{ixt} / A^F_{idt}}{A^h_{ixt} / A^F_{idt}}\right)^{W^c_{it}}$$

$$= \frac{A^h_{idt}}{A^F_{idt}}\left(\frac{\chi^h_{it}}{\chi^F_{it}}\right)^{\frac{(\sigma_i-1)}{\sigma_i\theta_i}W^c_{it}}$$ by substituting for A^h_{idt} / A^h_{ixt}

Need two assumptions:

1) Domestic shift parameters A_{idt}^{h} reflect *country-level* prices P_t^h plus error:

$$\ln\left(\frac{A_{idt}^{h}}{A_{idt}^{F}}\right) = \ln\left(\frac{P_t^h}{P_t^F}\right) + u_{1it}^{h}.$$

2) Relative *export/domestic* variety will be measured by relative *export* variety:

$$\ln\left(\frac{\chi_{it}^{h}}{\chi_{it}^{F}}\right) = \ln\left(\frac{M_{ixt}^{h}}{M_{ixt}^{F}}\right) - u_{2it}^{h}, \text{ with } u_{2it}^{h} \equiv \ln(M_{it}^{h} / M_{it}^{F})$$

Then CES aggregates become:

$$\ln\left[\frac{\psi_i(A_{idt}^{h}, A_{ixt}^{h})}{\psi_i(A_{idt}^{F}, A_{ixt}^{F})}\right] = \ln\left(\frac{P_t^h}{P_t^F}\right) + \frac{(\sigma_i - 1)}{\sigma_i \theta_i} W_{it}^{h}\left(\frac{M_{ixt}^{h}}{M_{it}^{F}}\right) + (u_{1it}^{h} - u_{2it}^{h})$$

Substituting the CES aggregates into the **differenced share equation**:

$$s_{it}^{h} = s_{it}^{F} + \sum_{j=1}^{N} \rho_j \gamma_{ij} W_{jt}^{h} \ln\left(\frac{M_{jxt}^{h}}{M_{jxt}^{F}}\right) + \gamma_{iN+1} \ln\left(\frac{\psi_{N+1t}^{h} / P_t^{h}}{\psi_{N+1t}^{F} / P_t^{F}}\right) + \sum_{k=1}^{K} \phi_{ik} \ln\left(\frac{v_{kt}^{h}}{v_{kt}^{F}}\right) + \varepsilon_{it}^{h},$$

where $\rho_j = (\sigma_j - 1)/\theta_j\sigma_j$. Combine the share equations with **TFP equation:**

$$\mathrm{TFP}_t^{h} \equiv \ln\left(\frac{\mathrm{RGDP}_t^{h}}{\mathrm{RGDP}_t^{F}}\right) - \sum_{k=1}^{K} \tfrac{1}{2}(s_{kt}^{h} + s_{kt}^{F}) \ln\left(\frac{v_{kt}^{h}}{v_{kt}^{F}}\right) - \tfrac{1}{2}(s_{N+1t}^{h} + s_{N+1t}^{F}) \ln\left(\frac{\psi_{N+1t}^{h} / P_t^{h}}{\psi_{N+1t}^{F} / P_t^{F}}\right)$$

$$= \alpha_0^{h} + \beta_{0t} + \sum_{i=1}^{N} \tfrac{1}{2}(s_{it}^{h} + s_{it}^{F}) \rho_i W_{it}^{h} \ln\left(\frac{M_{ixt}^{h}}{M_{ixt}^{F}}\right) + \varepsilon_t^{h},$$

Gives a **system of N+1 equations**. Will estimate this with 7 traded sectors + TFP equation, for 44 countries over 1980-2000.

Measuring Export Variety

Indexes product varieties by $j \in J_{it}^{h}$. Suppose that the set of exports from countries h and F differ, but have common varieties: $J \equiv \left(J_{it}^{h} \cap J_{it}^{F}\right) \neq \varnothing$.

The inverse measure of export variety from country h is:

$$\lambda_{it}^{h}(J) \equiv \frac{\sum_{j \in J} p_{it}^{h}(j) q_{it}^{h}(j)}{\sum_{j \in J_{it}^{h}} p_{it}^{h}(j) q_{it}^{h}(j)} \leq 1 \; .$$

If country h is selling some goods in period t that are *not sold* by country F, this will make $\lambda_{it}^{h}(J) < 1$, so it is an *inverse measure* of country h export variety.

So use $[\lambda_{it}^{F}(J) / \lambda_{it}^{h}(J)]$ to measure $(M_{it}^{h} / M_{it}^{F})$ in estimating equations.

Measure export variety for 1980 – 1988 using the 7-digit TSUSA system of U.S. imports, and for 1989 – 2000 using the 10-digit HS classification.

Question: What is the comparison country F?

Broda and Weinstein (2005): Use U.S. imports in a base year (1972 or 1989)

Hummels and Klenow (2005): Use worldwide exports in 1995, across countries

Our approach: take the union of all products sold over countries and years,

$J_i^F = \bigcup_{h,t} J_{it}^h$, and average export sales of each product over years, $p_i^F(j)q_i^F(j)$.

Then $J \equiv J_{it}^h \cap J_i^F = J_{it}^h$, so $\lambda_{it}^h(J_{it}^h) = 1$, and export variety by country h is:

$$\Lambda_{ixt}^h \equiv \frac{\lambda_{it}^F(J_{it}^h)}{\lambda_{it}^h(J_{it}^h)} = \frac{\sum_{j \in J_{it}^h} p_i^F(j)q_i^F(j)}{\sum_{j \in J_i^F} p_i^F(j)q_i^F(j)}.$$

A consistent measure of export variety *across countries and over time.*

Table 1: Summary Statistics for Export Variety

	Overall Industry	Agriculture	Textiles & Garments	Wood & Paper	Petroleum & Plastics	Mining & Metals	Machinery & Transport	Electronics
				Export Variety (percent)				
Mean	29.2	23.2	41.2	31.8	29.0	21.6	23.7	29.9
Stan.Dev.	16.5	12.0	21.5	16.9	22.9	17.1	21.3	18.8
Correlation with GDP	0.53	0.34	0.40	0.48	0.34	0.60	0.58	0.42
1980	19.1	21.9	19.7	25.1	20.5	17.4	14.5	18.3
1988	30.2	28.0	36.0	31.0	38.6	21.0	20.7	36.0
1989	26.3	20.8	46.1	30.2	28.7	20.4	24.6	21.9
2000	39.9	22.3	55.9	38.2	33.6	26.2	35.2	43.2
Annual Growth, 1980-1988	5.7	3.1	7.6	2.6	7.9	2.4	4.5	8.4
Annual Growth, 1989-2000	3.8	0.6	1.7	2.1	1.4	2.3	3.2	6.2
Average Growth	4.6	1.7	4.2	2.3	4.2	2.3	3.8	7.1
$\frac{\text{Variety 2000}}{\text{Variety 1980}}$	2.5	1.4	2.3	1.6	2.3	1.6	2.1	4.2

Results:

Export variety grows 4.6% per year or 2.5 times over 1980-2000. More in electronics; less in agriculture, wood & paper, mining & metals.

Table 2: Summary Statistics for Traded Sectors

	Overall Industry	Agriculture	Textiles & Garments	Wood & Paper	Petroleum & Plastics	Mining & Metals	Machinery & Transport	Electronics
				Value Added Share in GDP (percent)				
Mean	2.8	4.0	2.2	2.2	3.6	2.2	2.6	3.0
Stan. Dev.	0.8	1.8	1.5	1.1	1.8	1.1	1.7	2.1
				U.S. Tariffs (percent)				
Mean	3.5	2.6	13.0	2.3	2.3	3.4	2.4	3.2
Stan. Dev.	3.5	3.3	7.5	5.0	3.4	5.5	3.2	5.0
Correlation with Variety	-0.25	-0.13	-0.16	-0.14	-0.19	-0.05	-0.09	-0.21
1980	4.1	3.7	14.7	3.1	2.4	4.4	3.1	5.9
2000	2.1	1.4	10.3	0.7	1.0	1.7	1.0	0.5
Difference	-2.0	-2.3	-4.3	-2.4	-1.5	-2.7	-2.1	-5.4

Tariffs, trade agreement and distance are used as instruments for export variety. The small cuts in U.S. tariffs means that this variable will not be able to account for the large growth in export variety.

Table 3: Industry Share Equations and TFP

	Independent Variables:	(1) Agriculture	(2) Textiles & Garments	(3) Wood & Paper	(4) Petroleum & Plastics	(5) Mining & Basic Metals	(6) Machinery & Transports	(7) Electronics	(8) Adj. TFP
Log of Relative Export Variety in:	Agriculture	**0.117****	0.003	0.020	0.023	-0.021	-0.038	-0.101***	0.160***
		(0.049)	(0.089)	(0.036)	(0.015)	(0.033)	(0.043)	(0.025)	(0.046)
	Textiles & Garments	0.003	**0.333***	-0.323**	-0.063	0.114*	-0.014	-0.045	0.300***
		(0.089)	(0.198)	(0.143)	(0.048)	(0.070)	(0.065)	(0.050)	(0.046)
	Wood & Paper	0.020	-0.323**	**0.245****	0.055**	-0.012	-0.043	0.055	0.619***
		(0.036)	(0.143)	(0.113)	(0.027)	(0.0440	(0.047)	(0.038)	(0.070)
	Petroleum & Plastics	0.023	-0.063	0.055**	**0.017**	-0.008	0.006	-0.025*	0.302***
		(0.015)	(0.048)	(0.027)	(0.015)	(0.022)	(0.027)	(0.013)	(0.055)
	Mining & Basic Metals	-0.021	0.114*	-0.012	-0.008	**0.013**	-0.052	-0.033	0.557***
		(0.033)	(0.070)	(0.0440	(0.022)	(0.054)	(0.064)	(0.023)	(0.046)
	Machinery & Transports	-0.038	-0.014	-0.043	0.006	-0.052	**0.105**	0.035	0.618***
		(0.043)	(0.065)	(0.047)	(0.027)	(0.064)	(0.075)	(0.025)	(0.046)
	Electronics	-0.101***	-0.045	0.055	-0.025*	-0.033	0.035	**0.113*****	0.745***
		(0.025)	(0.050)	(0.038)	(0.013)	(0.023)	(0.025)	(0.020)	(0.048)
	Year Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Country Fixed-Effects								Yes
	R-squared	0.1928	0.0182	0.0026	0.1210	0.0414	0.1317	0.4254	0.8980

(Endowments not shown)

Estimates of $\rho_i = (\sigma_i - 1)/\theta_i\sigma_i$ obtained:

Electronics industry:	0.75
Machinery & transport industry:	0.62
Woods & papers industry:	0.62
Mining & basic metals industry:	0.56
Textiles & garments industry:	0.30
Petroleum & plastics industry:	0.30
Agriculture industry:	0.16

Electronics: $\rho_i = 0.75$ indicates either low σ_i , i.e. *heterogeneous products*, or low θ_i as compared to $(\sigma_i - 1)$, i.e. *high productivity dispersion*. Increasing export variety has the *greatest* impact on country productivity.

Agriculture: $\rho_i = 0.16$ indicates *homogeneous products or low productivity dispersion*. Increasing export variety has the *least* impact on productivity

Hypothesis Tests:

1. GDP is homogeneous of degree one in prices and endowments
2. Symmetry, $\gamma_{ij} = \gamma_{ji}$
3. Overidentifying restrictions (exogeneity of instruments)
4. All together

Table 4: Hypothesis Testing

Null Hypotheses	Degree of Freedom	Test Statistics	P-values
Homogeneity	7	3.339	0.852
Symmetry	21	10.469	0.972
Over Identifying Restrictions	16	9.080	0.910
Overall Specification	44	52.620	0.175

First Stage Regressions of Export variety on IV (*ignoring nonlinearity)*:

Table 5: Export Variety Index

	Independent Variables:	Eq (1) Agriculture	Eq(2) Textiles & Garments	Eq(3) Wood & Paper	Eq(4) Petroleum & Plastics	Eq(5) Mining & Basic Metals	Eq(6) Machinery & Transports	Eq(7) Electronics
Log of 1+ Effective Tariff of :	Agriculture	**-6.625***** (0.963)	3.537*** (0.842)	-0.395 (0.914)	-8.164*** (2.083)	-0.801 (1.133)	0.267 (1.237)	-1.028 (0.980)
	Textiles & Garments	0.850 (0.596)	**0.231** (0.581)	-0.386 (0.591)	-2.877** (1.137)	0.190 (0.642)	-1.597** (0.637)	-1.999*** (0.536)
	Wood & Paper	1.775 (1.290)	-0.250 (1.163)	**-3.053***** (1.029)	-3.048 (2.715)	-3.136** (1.595)	-2.206 (1.481)	-2.589** (1.154)
	Petroleum & Plastics	-7.842*** (1.603)	2.993*** (1.024)	-0.101 (1.072)	**-9.862***** (2.382)	-0.217 (1.383)	1.976 (1.365)	1.897 (1.331)
	Mining & Basic Metals	-1.465 (1.276)	1.615 (1.038)	0.522 (1.015)	-1.754 (2.115)	**-3.256***** (1.243)	4.173*** (1.448)	3.239*** (1.195)
	Machinery & Transports	-1.803 (1.479)	0.760 (1.206)	-2.571* (1.362)	-13.940*** (3.264)	-4.120* (2.351)	**-8.748***** (1.922)	-7.672*** (1.451)
	Electronics	-0.089 (1.482)	-4.894*** (1.692)	1.031 (1.403)	13.652*** (3.052)	3.996** (1.911)	4.922*** (1.780)	**3.037**** (1.452)
	North America Free Trade Agreement	0.271*** (0.090)	0.039 (0.069)	0.049 (0.076)	-0.357** (0.141)	0.160** (0.074)	0.188 (0.136)	0.011 (0.103)
	Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	R-squared	0.5711	0.7110	0.7241	0.6191	0.8023	0.8352	0.7847

Only 8% of the growth in average variety is explained falling U.S. tariffs.

How well does Export variety explain Country Productivity?

1) "Between" regression using country cross-section averages:

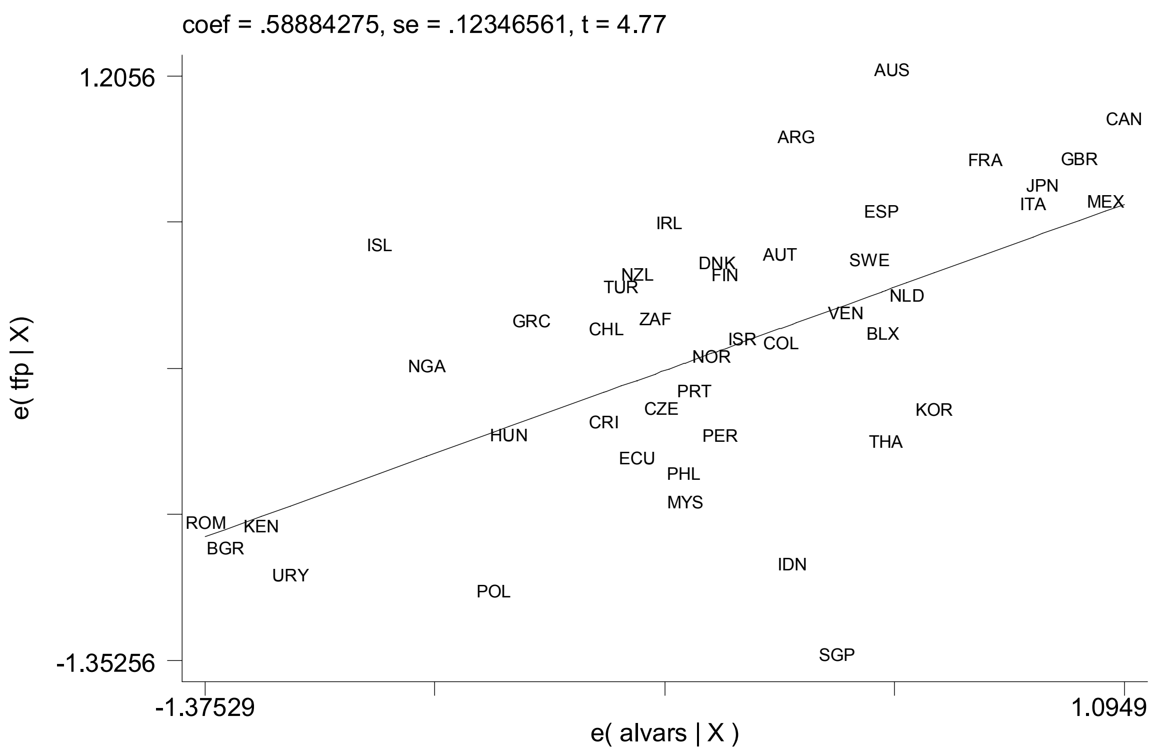


Figure 2: Average Country Productivity versus Export Variety

2) "Within" regressions using country time-series:

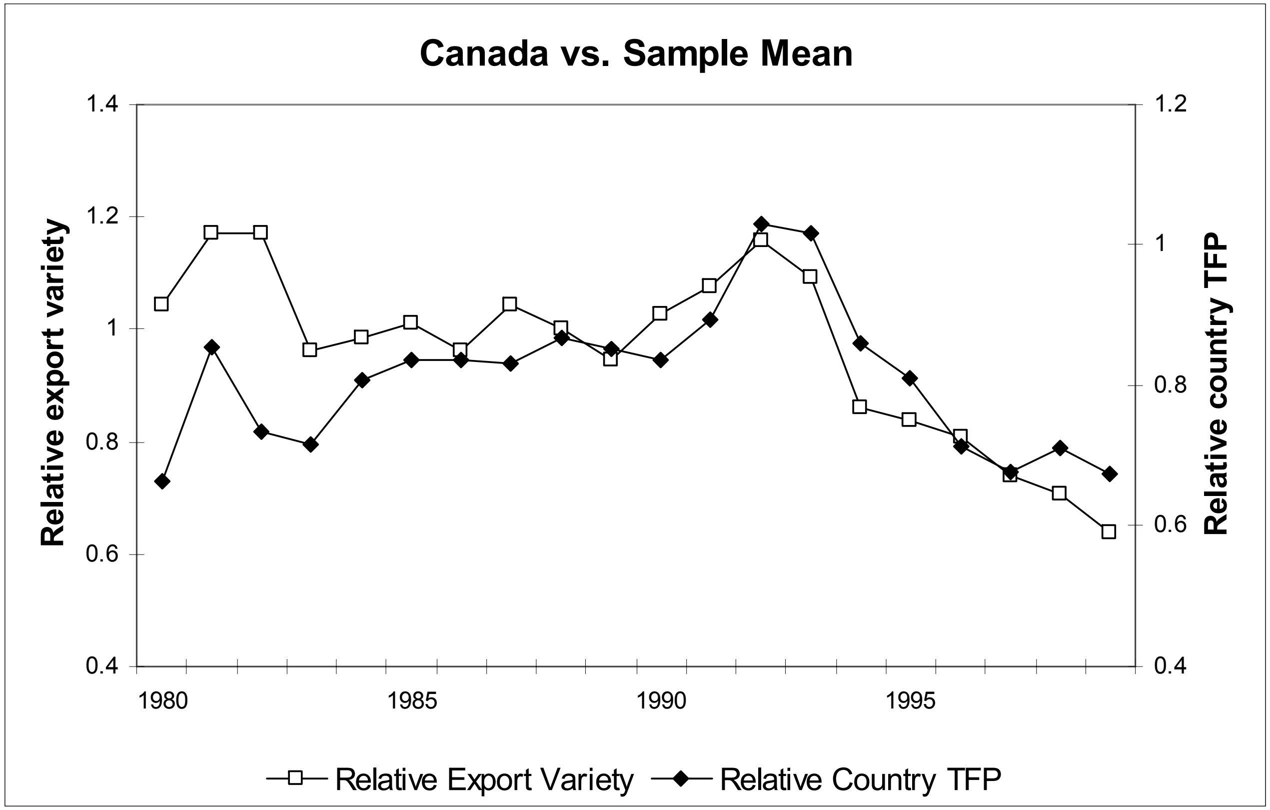


Figure 3: Canada compared to Sample Mean

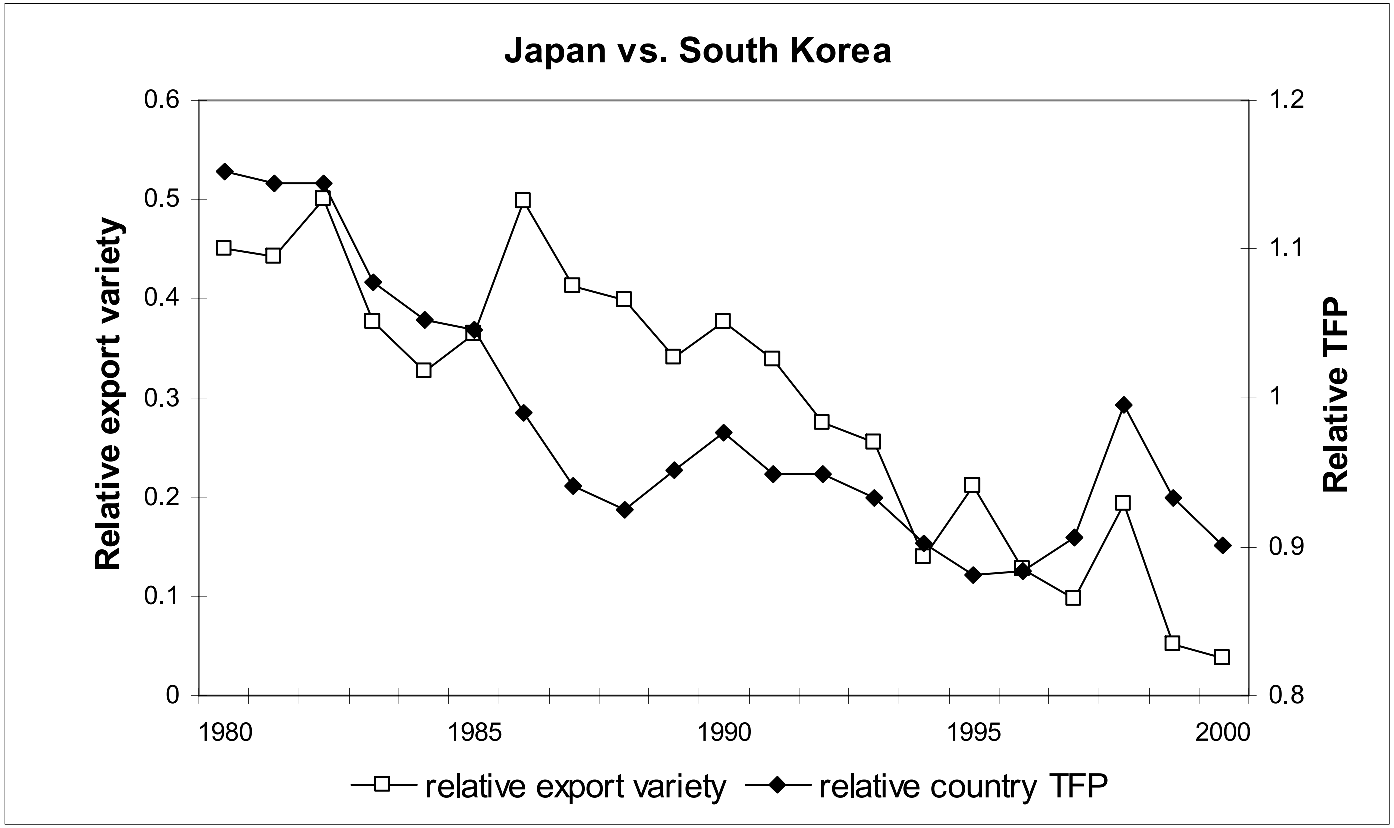


Figure 4: Japan Compared to South Korea

Results from Panel Regressions with country and time fixed effects:

Table 6: Productivity Decompositions

	Overall Variation (in %)		Between-Country Variation (in %)		Within-Country Variation (in %)	
	Full Sample	OECD	Full Sample	OECD	Full Sample	OECD
Variance of Estimated Country TFP	0.368 (100)	0.168 (100)	0.377 (100)	0.149 (100)	0.047 (100)	0.038 (100)
Explained by Country Fixed Effects	0.259 (70.5)	0.079 (47.3)	0.350 (92.8)	0.112 (75.0)		
Explained by Export Variety	0.009 (2.4)	0.018 (10.6)	0.0004 (0.1)	0.006 (4.0)	0.019 (40.4)	0.023 (60.8)

Summary:

In the total sample, export variety can explain 2.4% of the variation in country TFP, along with 40.4% of within-country TFP variation, but only 0.1% of the between-country variation.

For OECD, export variety explains 10.6% of the overall variation in country TFP, and 60.8% of the within-country TFP variation, but just 4.0% of the between-country variation

Conclusions:

1. Monopolistic competition model with endogenous productivity is quite effective at accounting for the time-series variation in productivity within countries *(though the growth in export variety is not explained).*

2. But it cannot explain the large differences in productivity between countries.

3. x% growth in export variety *sustained* over two decades leads to x% growth in exporting country productivity (4.5% at the sample means)

   Highest growth rates of export variety: Turkey, Bulgaria, Iceland, Kenya, Hungary (8 – 11%)
   Lowest growth rates are from by Peru (1.75%), and Canada, U.K., Japan (2.5 – 3%)
   Other cases: Israel (4%), South Korea (4.7%), Ireland (5.5%) and Singapore (5.8%)

4. That estimate exceeds *gains to the U.S.* from increased import variety over 1972-2001, which is 2.6% of GDP in 2001 (Broda and Weinstein, 2005)

Question:

How do the *time-series* and *cross-section* measures of export variety compare?

Example (from Kei-mu Yi): Exports to U.S. from South Korea, 1963-1979

SITC, rev. 1, 5-digit data	**$million Using annual Korean data (time-series)**	**$ million Using average world data (panel)**
Korea's 1963 exports in goods not exported in 1979	2.1	723
Korea's 1963 exports in goods also exported in 1979	22.9	24,328
lambda for 1963	**0.92**	**0.97**
Korea's 1979 exports in goods not exported in 1963	1,570	37,047
Korea's 1979 exports in goods also exported in 1963	2,819	24,328
lambda for 1979	**0.64**	**0.40**
inverse variety measure (lambda1979/lambda1963)	**0.70**	**0.41**
variety measure (lambda1963/lambda1979)	**1.4**	**2.4**
	40% growth	**140% growth**

Is this a general result?

Ignoring sectors, and letting $i \in I_t^h$ denote the goods exported by country h, the Feenstra-Kee (2006) *panel measure* of export variety is:

$$\frac{\lambda_t^F(I_t^h)}{\lambda_t^h(I_t^h)} = \frac{\sum_{i \in I_t^h} p_i^F q_i^F}{\sum_{i \in I^F} p_i^F q_i^F} \;, \quad \text{since} \quad \lambda_t^h(I_t^h) = 1$$

where $I^F = \bigcup_{h,t} I_t^h$ and $p_i^F q_i^F$ sums across countries and averages over time.

Notice that this measure of product variety changes over time or across country *only* due to changes in the set of goods sold by that country, I_t^h. The denominator is constant across countries and time. Therefore, this measure of product variety that is consistent across countries and over time.

Notice that we can take the ratio over time:

$$\frac{\lambda_t^F(I_t^h)}{\lambda_{t-1}^F(I_{t-1}^h)} = \frac{\sum_{i \in I_t^h} p_i^F q_i^F}{\sum_{i \in I^F} p_i^F q_i^F} \Bigg/ \frac{\sum_{i \in I_{t-1}^h} p_i^F q_i^F}{\sum_{i \in I^F} p_i^F q_i^F} = \frac{\sum_{i \in I_t^h} p_i^F q_i^F}{\sum_{i \in I_{t-1}^h \cap I_{t-1}^h} p_i^F q_i^F} \Bigg/ \frac{\sum_{i \in I_{t-1}^h} p_i^F q_i^F}{\sum_{i \in I_{t-1}^h \cap I_{t-1}^h} p_i^F q_i^F} \qquad (1)$$

In this expression, country h is the *exporter*. We can compare this to the Feenstra (1994) *time-series measure*, where country h is the importer:

$$\frac{\lambda_{t-1}^h(I_t^h)}{\lambda_t^h(I_{t-1}^h)} = \frac{\sum_{i \in I_t^h} p_{it}^h q_{it}^h}{\sum_{i \in I_{t-1}^h \cap I_t^h} p_{it}^h q_{it}^h} \Bigg/ \frac{\sum_{i \in I_{t-1}^h} p_{it-1}^h q_{it-1}^h}{\sum_{i \in I_{t-1}^h \cap I_t^h} p_{it-1}^h q_{it-1}^h} \,. \qquad (2)$$

Under what conditions will (1) exceed (2)?

Theorem

The *panel measure* of product variety growth in (1) exceeds the *time-series measure* of product variety growth in (2) if and only if:

$$\frac{\text{World exports in h goods}_t}{\text{World exports in h goods}_{t-1}} = \frac{\sum_{i \in I_t^h} p_i^F q_i^F}{\sum_{i \in I_{t-1}^h} p_i^F q_i^F}$$

$$> \frac{\sum_{i \in I_t^h} p_{it}^h q_{it}^h}{\sum_{i \in I_{t-1}^h} p_{it-1}^h q_{it-1}^h} \Bigg/ \frac{\sum_{i \in I_{t-1}^h \cap I_t^h} p_{it}^h q_{it}^h}{\sum_{i \in I_{t-1}^h \cap I_t^h} p_{it-1}^h q_{it-1}^h} = \frac{\dfrac{\text{Country h exports}_t}{\text{Country h exports}_{t-1}}}{\dfrac{\text{Country h exports in common goods}_t}{\text{Country h exports in common good}_{t-1}}}$$

.

That is, the growth in world exports of goods that country h exports, *exceeds* the (growth in country h exports / growth in h exports of common goods).

Example (from Kei-mu Yi): Exports to U.S. from South Korea, 1963-1979

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Korea's 1963 exports in goods not exported in 1979	2.1	723
Korea's 1963 exports in goods also exported in 1979	22.9	24,328
Total exports in Korean goods for 1963	**25**	**25,050**
Korea's 1979 exports in goods not exported in 1963	1,570	37,047
Korea's 1979 exports in goods also exported in 1963	2,819	24,328
Total exports in Korean goods for 1979	**4,389**	**61,375**
Growth in exports (ratio 1979/1963)	**176**	**2.4**
Growth in common exports (ratio 1979/1963, Korea)	**123**	
	176/123=1.4	

Conclude: If exports of new goods are not growing fast enough, the panel measure will exceed the time-series measure (but will it "catch up"?)

Hummels and Klenow (*AER*, 2005):

They measure export variety from each country h to its partner country j, using the world in 1995 as the comparison. That is, the *"extensive margin"* of exports from country h to j is:

$$EM^{hj}_{t,exp} = \frac{\sum_{i \in I^{hj}_t} p^{Fj}_{it} q^{Fj}_{it}}{\sum_{i \in I^{Fj}_t} p^{Fj}_{it} q^{Fj}_{it}}$$

where F is the world and j denotes the destination country. This is similar to Feenstra-Kee (2006), but *does not* take the intersection/average over years.

Hummels and Klenow define the *intensive margin* of exports as:

$$\mathrm{IM}^{hj}_{t,\exp} = \frac{\sum_{i \in I^{hj}_t} p^{hj}_{it} q^{hj}_{it}}{\sum_{i \in I^{hj}_t} p^{Fj}_{it} q^{Fj}_{it}}$$

It follows that the product of the extensive and intensive margins are:

$$\mathrm{EM}^{hj}_{t,\exp} \times \mathrm{IM}^{hj}_{t,\exp} = \frac{\sum_{i \in I^{hj}_t} p^{hj}_{it} q^{hj}_{it}}{\sum_{i \in I^{Fj}_t} p^{Fj}_{it} q^{Fj}_{it}} = \frac{\text{Country h exports to j}}{\text{Total imports by j}}$$

In order to form the extensive margin of exports from *country h to all destination countries*, Hummels and Klenow take the geometric mean of the extensive margin from h to j, using Sato-Vartia weights.

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

Likewise, we can define the *extensive and intensive margin of imports:*

$$EM_{t,imp}^{hj} = \frac{\sum_{i \in I_t^{hj}} p_{it}^{hF} q_{it}^{hF}}{\sum_{i \in I_t^{hF}} p_{it}^{hF} q_{it}^{hF}}$$

Notice that this measure requires *export data* for country h.

$$IM_{t,imp}^{hj} = \frac{\sum_{i \in I_t^{hj}} p_{it}^{hj} q_{it}^{hj}}{\sum_{i \in I_t^{hj}} p_{it}^{hF} q_{it}^{hF}} \quad \text{, and,}$$

$$EM_{t,imp}^{hj} \times IM_{t,imp}^{hj} = \frac{\sum_{i \in I_t^{hj}} p_{it}^{hj} q_{it}^{hj}}{\sum_{i \in I_t^{hF}} p_{it}^{hF} q_{it}^{hF}} = \frac{\text{Country h exports to j}}{\text{Total exports by h}} \quad .$$