Fourth Summer School in Trade, Industrialisation, and Development 2005

Gargnano, Italy

Trade, Innovation, and Technology Diffusion: Implications for Developing Countries

Lecture 3: A Technological Model of Bilateral Trade

September 2005

The Framework developed in the previous lecture extends very seamlessly to multiple countries.

A Country

1. N countries

2. Factor cost w_i.

3. "Iceberg" transport cost $d_{ni} \geq 1$; $d_{ii} = 1$.

4. For each good j the number of ideas in country i with quality better than q is distributed Poisson with parameter $T_i(j,t)q^{-\theta}$

5. The number of techniques from country i that can deliver good j to country n at unit cost less than c is distributed Poisson with parameter:

$$T_i(w_i d_{ni})^{-\theta} c^{\theta}$$

6. The total number of techniques that can provide country n with unit cost less than c is distributed Poisson with parameter:

$$\Phi_n c^{\theta}$$

where

$$\Phi_n = \sum_{i=1}^{N} T_i(w_i d_{ni})^{-\theta}$$

7. Probability that an idea delivering unit cost less than c is from country i:

$$\pi_{ni} = \frac{T_i(w_i d_{ni})^{-\theta} c^{\theta}}{\Phi_n c^{\theta}} = \frac{T_i(w_i d_{ni})^{-\theta}}{\Phi_n}$$

independent of c! Whatever the cost, a country is equally likely to be the source regardless of c.

Assumption: $p_n(j)$ depends only on $c^{(1)}(j)$, $c^2(j), c^{(3)}(j), ...$ and P_n and X_n (not on identity of suppliers) (True of Perfect competition, Bertrand competition, monopolistic competition, Cournot competition.....)

Implication: Given c, price is independent of source. Since every source has the same conditional cost distribution, π_{ni} is both the probability i is the supplier and i's expected sales. All suppliers who enter look the same. It's just that some sources get more in.

Aggregate Implications

Applying these reasoning across all goods j, all the results from above go through, only with

$$\Phi_n = \sum_{i=1}^{N} T_i (w_i d_{ni})^{-\theta}.$$

The price level is still:

$$P_n = \gamma \Phi_n^{-1/\theta} \tag{1}$$

with γ depending on market structure.

Trade Shares

Since π_{ni} is the probability that country i supplies any particular good j and, conditional on selling, the cost distribution is the same regardless of across the continuum of goods i's trade share in n is::

$$\pi_{ni} = \frac{T_i \left(w_i d_{ni}\right)^{-\theta}}{\Phi_n}. \tag{2}$$

n buys from i, it is the fraction of n's spending that goes to goods from i, linking π_{ni} and data on trade shares.

Gravity

$$\frac{X_{ni}}{X_n} = \frac{T_i(w_i d_{ni})^{-\theta}}{\sum_{h=1}^{N} T_h(w_h d_{nh})^{-\theta}}.$$

Manipulations:

1. Output.

$$Y_i = \sum_{n=1}^{N} X_{ni} = T_i w_i^{-\theta} \sum_{n=1}^{N} \frac{d_{ni}^{-\theta} X_n}{\Phi_n}.$$

Solving for $T_i w_i^{-\theta}$, using $P = \gamma \Phi^{-1/\theta}$:

$$X_{ni} = \frac{(d_{ni}/P_n)^{-\theta}}{\sum_{m=1}^{N} \omega_m (d_{mi}/P_m)^{-\theta}} \frac{X_n Y_i}{X}$$

where $\omega_m = X_m/X$ and X is world spending.

2. Anderson and van Wincoop (2003):

$$X_{ni} = d_{ni}^{-\theta} \left(X_n P_n^{\theta} \right) \frac{Y_i}{\Xi_i}$$

where:

$$\Xi_i = \sum_{m=1}^{N} d_{mi}^{-\theta} \left(X_m P_m^{\theta} \right)$$

country i's *market potential*.

3. Isolating geography:

$$\frac{X_{ni} X_{in}}{X_{ii} X_{nn}} = (d_{ni} d_{in})^{-\theta}.$$

Price Levels and Trade Shares

Write:

$$\begin{aligned}\frac{X_{ni}/X_n}{X_{ii}/X_i} &= \frac{d_{ni}^{-\theta}\left(P_n^{\theta}\right)(Y_i/\Xi_i)}{d_{ii}^{-\theta}P_i^{\theta}(Y_i/\Xi_i)} \\ &= \left(\frac{P_i d_{ni}}{P_n}\right)^{-\theta}.\end{aligned}$$

Gains from Trade

Since:

$$\pi_{ii} = \frac{T_i w_i^{-\theta}}{\Phi_i} = \frac{T_i w_i^{-\theta}}{P_i^{-\theta}}$$

Then:

$$\frac{w_i}{P_i} = \frac{1}{\gamma}\left(\frac{T_i}{\pi_{ii}}\right)^{1/\theta}$$

$\theta = 8$ (close to one of our estimates below) $\pi_{ii} = .8 \longrightarrow 2.8$ percent decline in its real wage from a move to autarky.

Factor-Market Equilibrium: Labor only

(See Alvarez and Lucas (2004) for a more general set up and conditions for uniqueness of the equilibrium wage vector.)

$L_i^P =$ Measure of workers available for production in country i; profit share δ:

$$w_i L_i^P = (1-\delta) \sum_{n=1}^{n} \frac{(w_i d_{ni})^{-\theta} T_i}{\Phi_n} X_n \quad i = 1, ..., N$$

profit share δ:

$$X_n = \frac{1}{1-\delta} w_n L_n^P.$$

Labor-market equilibrium conditions:

$$w_i L_i^P = w_i^{-\theta} T_i \sum_{n=1}^{N} \frac{d_{ni}^{-\theta} w_n L_n^P}{\sum_{k=1}^{N} (w_k d_{nk})^{-\theta} T_k} \quad i = 1, ..., N$$

implying that:

$$w_i = \frac{\Xi_i}{L_i^P}, \quad i = 1, ..., N$$

(not a closed-form solution).

"Frictionless" Trade

$$\frac{w_i}{w_k} = \left(\frac{T_i / L_i^P}{T_k / L_k^P} \right)^{1/(1+\theta)} .$$

(With all $d_{ni} = 1$ price levels are the same everywhere, so this ratio is also the ratio of real wages.) in comparison with closed economy ($d_{ni} \to \infty,\ n \neq i$)

$$\frac{w_i}{w_k} = \left(\frac{T_i}{T_k} \right)^{1/\theta} .$$

Factor-Market Equilibrium with Intermediates

Labor share β and wage v_i:

$$w_i = v_i^{\beta} P_i^{1-\beta}$$

Then:

$$P_n^{-\theta} = \varepsilon \sum_{i=1}^{N} T_i \left(v_i^{\beta} P_i^{1-\beta} d_{ni} \right)^{-\theta} \quad n = 1, ..., N$$

where $\varepsilon = \beta^{-\beta}(1-\beta)^{-(1-\beta)}$.

Condition for labor-market equilibrium:

$$v_i L_i^P = \left(v_i^{\beta} P_i^{1-\beta} \right)^{-\theta} T_i \sum_{n=1}^{N} \frac{d_{ni}^{-\theta} w_n L_n^P}{\sum_{k=1}^{N} \left(v_k^{\beta} P_k^{1-\beta} d_{nk} \right)^{-\theta} T_k} \quad i = 1, ..., N$$

Quantification 1: EK (2002) application to 19 OECD Countries

1. Parameter θ

$$\begin{aligned}\frac{X_{ni}/X_n}{X_{ii}/X_i} &= \frac{d_{ni}^{-\theta}\left(P_n^{\theta}\right)(Y_i/\Xi_i)}{d_{ii}^{-\theta}P_i^{\theta}(Y_i/\Xi_i)} \\ &= \left(\frac{P_i d_{ni}}{P_n}\right)^{-\theta}.\end{aligned}$$

Table 1: Trade, Labor, and Income Data

Country	Imports % of mfg. spending	Imports from 18 % of total	Mfg. wage (U.S. = 1)	Human-Capital Adj. mfg. wage (U.S. = 1)	Human-Capital Adj. mfg. labor (U.S. = 1)	Mfg. labor's % share of GDP
Australia	23.8	75.8	0.61	0.75	0.050	8.6
Austria	40.4	84.2	0.70	0.87	0.036	13.4
Belgium	74.8	86.7	0.92	1.08	0.035	13.2
Canada	37.3	89.6	0.88	0.99	0.087	10.5
Denmark	50.8	85.2	0.80	1.10	0.020	11.5
Finland	31.3	82.2	1.02	1.10	0.022	12.5
France	29.6	82.3	0.92	1.07	0.205	12.6
Germany	25.0	77.3	0.97	1.08	0.421	20.6
Greece	42.9	80.8	0.40	0.50	0.015	6.1
Italy	21.3	76.8	0.74	0.88	0.225	12.4
Japan	6.4	50.0	0.78	0.91	0.686	14.4
Netherlands	66.9	83.0	0.91	1.06	0.043	11.0
New Zealand	36.3	80.9	0.48	0.57	0.011	9.6
Norway	43.6	85.2	0.99	1.18	0.012	8.7
Portugal	41.6	84.9	0.23	0.32	0.033	10.7
Spain	24.5	82.0	0.56	0.65	0.128	11.6
Sweden	37.3	86.3	0.96	1.11	0.043	14.2
United Kingdom	31.3	79.1	0.73	0.91	0.232	14.7
United States	14.5	62.0	1.00	1.00	1.000	12.4

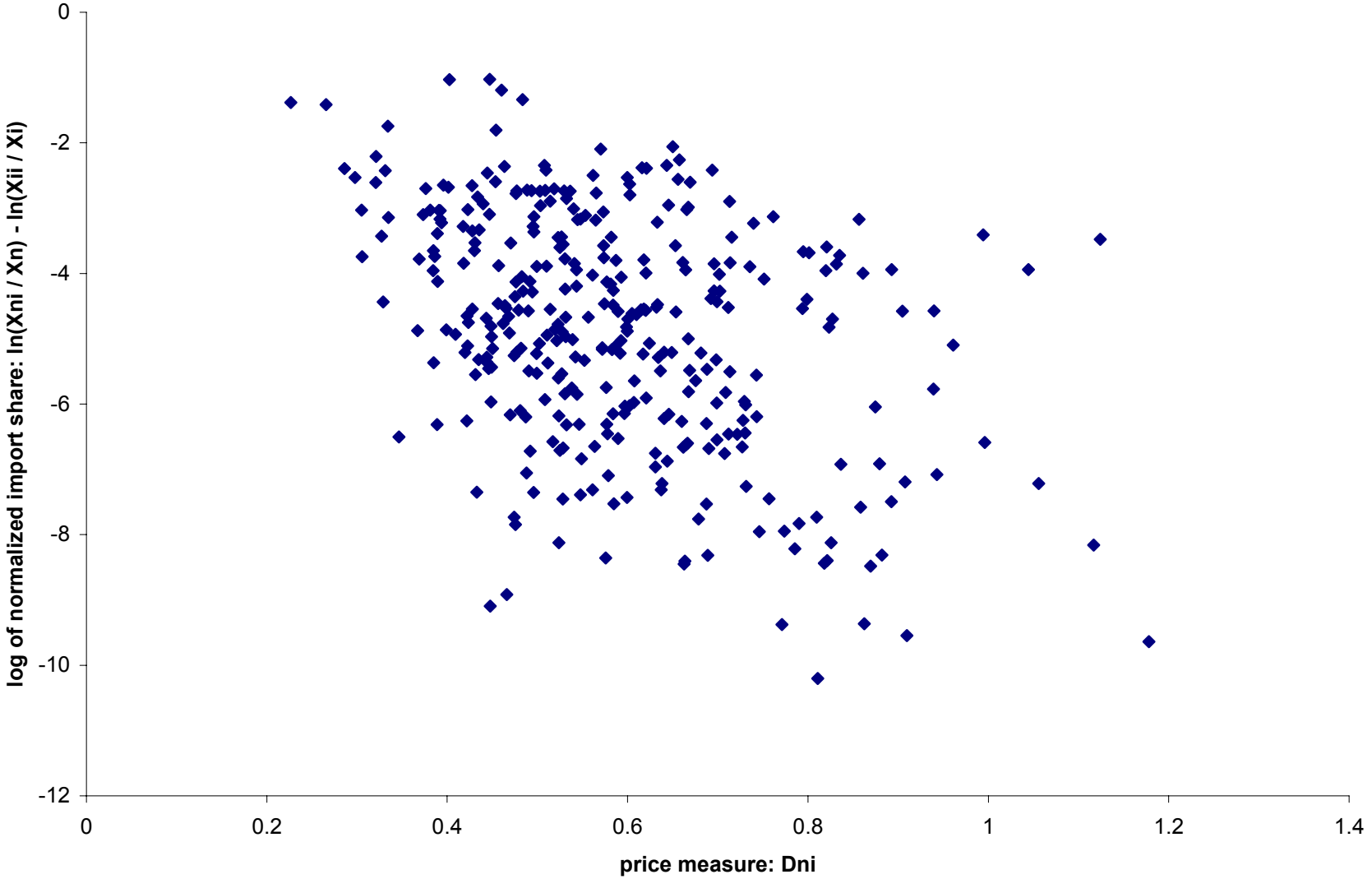
All data except GDP are for the manufacturing sector in 1990. Spending on manufactures is gross manufacturing production less exports of manufactures plus imports of manufactures. Imports from the other 18 excludes imports of manufactures from outside our sample of countries. To adjust the manufacturing wage and manufacturing employment for human capital, we multiply the wage in country i by $e^{-0.06H_i}$ and employment in country i by $e^{0.06H_i}$, where H_i is average years of schooling in country i as measured by Kyriacou (1991). See the appendix for a complete description of all data sources.

Table 2: Price Measure Statistics

Country	Foreign Sources		Foreign Destinations	
	minimum	maximum	minimum	maximum
Australia (AL)	NE (1.44)	PO (2.25)	BE (1.41)	US (2.03)
Austria (AS)	SW (1.39)	NZ (2.16)	UK (1.47)	JP (1.97)
Belgium (BE)	GE (1.25)	JP (2.02)	GE (1.35)	SW (1.77)
Canada (CA)	US (1.58)	NZ (2.57)	AS (1.57)	US (2.14)
Denmark (DK)	FI (1.36)	PO (2.21)	NE (1.48)	US (2.41)
Finland (FI)	SW (1.38)	PO (2.61)	DK (1.36)	US (2.87)
France (FR)	GE (1.33)	NZ (2.42)	BE (1.40)	JP (2.40)
Germany (GE)	BE (1.35)	NZ (2.28)	BE (1.25)	US (2.22)
Greece (GR)	SP (1.61)	NZ (2.71)	NE (1.48)	US (2.27)
Italy (IT)	FR (1.45)	NZ (2.19)	AS (1.46)	JP (2.10)
Japan (JP)	BE (1.62)	PO (3.25)	AL (1.72)	US (3.08)
Netherlands (NE)	GE (1.30)	NZ (2.17)	DK (1.39)	NZ (2.01)
New Zealand (NZ)	CA (1.60)	PO (2.08)	AL (1.64)	GR (2.71)
Norway (NO)	FI (1.45)	JP (2.84)	SW (1.36)	US (2.31)
Portugal (PO)	BE (1.49)	JP (2.56)	SP (1.59)	JP (3.25)
Spain (SP)	BE (1.39)	JP (2.47)	NO (1.51)	JP (3.05)
Sweden (SW)	NO (1.36)	US (2.70)	FI (1.38)	US (2.01)
United Kingdom (UK)	NE (1.46)	JP (2.37)	FR (1.52)	NZ (2.04)
United States (US)	FR (1.57)	JP (3.08)	CA (1.58)	SW (2.70)

The price measure D_{ni} is defined in Equation (13). For destination country n, the minimum Foreign Source is $\min_{i \neq n} \exp D_{ni}$. For source country i, the minimum Foreign Destination is $\min_{n \neq i} \exp D_{ni}$.

Figure 2: Trade and Prices



2. Source Effects and geographic barriers

$$\frac{X_{ni}}{X_{nn}} = \frac{T_i}{T_n}\left(\frac{v_i}{v_n}\right)^{-\theta\beta}\left(\frac{P_i}{P_n}\right)^{-\theta(1-\beta)} d_{ni}^{-\theta}.$$

Use the trade share equation from home to get rid of (P_i/P_n):

$$\frac{P_i}{P_n} = \frac{v_i}{v_n}\left(\frac{T_i}{T_n}\right)^{-1/\theta\beta}\left(\frac{X_i/X_{ii}}{X_n/X_{nn}}\right)^{-1/\theta\beta}.$$

To get, taking logs:

$$\ln\frac{X'_{ni}}{X'_{nn}} = -\theta\ln d_{ni} + \frac{1}{\beta}\ln\frac{T_i}{T_n} - \theta\ln\frac{w_i}{w_n},$$

where $\ln X'_{ni} \equiv \ln X_{ni} - [(1-\beta)/\beta]\ln(X_i/X_{ii})$. Define:

$$S_i \equiv \frac{1}{\beta}\ln T_i - \theta\ln w_i,$$

to get:

$$\ln \frac{X'_{ni}}{X'_{nn}} = -\theta \ln d_{ni} + S_i - S_n.$$

Specify:

$$\ln d_{ni} = d_k + b + l + e_h + m_n + \delta_{ni},$$

Table 3: Bilateral Trade Equation

Variable		est.	s.e.			
Distance [0,375)	$-\theta d_1$	-3.10	(0.16)			
Distance [375,750)	$-\theta d_2$	-3.66	(0.11)			
Distance [750,1500)	$-\theta d_3$	-4.03	(0.10)			
Distance [1500,3000)	$-\theta d_4$	-4.22	(0.16)			
Distance [3000,6000)	$-\theta d_5$	-6.06	(0.09)			
Distance [6000,maximum]	$-\theta d_6$	-6.56	(0.10)			
Shared border	$-\theta b$	0.30	(0.14)			
Shared language	$-\theta l$	0.51	(0.15)			
European Community	$-\theta e_1$	0.04	(0.13)			
EFTA	$-\theta e_2$	0.54	(0.19)			
	Source-country competitiveness			Destination-country geographic barriers		
Country		est.	s.e.		est.	s.e.
Australia	S_1	0.19	(0.15)	$-\theta m_1$	0.24	(0.27)
Austria	S_2	-1.16	(0.12)	$-\theta m_2$	-1.68	(0.21)
Belgium	S_3	-3.34	(0.11)	$-\theta m_3$	1.12	(0.19)
Canada	S_4	0.41	(0.14)	$-\theta m_4$	0.69	(0.25)
Denmark	S_5	-1.75	(0.12)	$-\theta m_5$	-0.51	(0.19)
Finland	S_6	-0.52	(0.12)	$-\theta m_6$	-1.33	(0.22)
France	S_7	1.28	(0.11)	$-\theta m_7$	0.22	(0.19)
Germany	S_8	2.35	(0.12)	$-\theta m_8$	1.00	(0.19)
Greece	S_9	-2.81	(0.12)	$-\theta m_9$	-2.36	(0.20)
Italy	S_{10}	1.78	(0.11)	$-\theta m_{10}$	0.07	(0.19)
Japan	S_{11}	4.20	(0.13)	$-\theta m_{11}$	1.59	(0.22)
Netherlands	S_{12}	-2.19	(0.11)	$-\theta m_{12}$	1.00	(0.19)
New Zealand	S_{13}	-1.20	(0.15)	$-\theta m_{13}$	0.07	(0.27)
Norway	S_{14}	-1.35	(0.12)	$-\theta m_{14}$	-1.00	(0.21)
Portugal	S_{15}	-1.57	(0.12)	$-\theta m_{15}$	-1.21	(0.21)
Spain	S_{16}	0.30	(0.12)	$-\theta m_{16}$	-1.16	(0.19)
Sweden	S_{17}	0.01	(0.12)	$-\theta m_{17}$	-0.02	(0.22)
United Kingdom	S_{18}	1.37	(0.12)	$-\theta m_{18}$	0.81	(0.19)
United States	S_{19}	3.98	(0.14)	$-\theta m_{19}$	2.46	(0.25)
Error Variance:						
Two-way	$\theta^2\sigma_2^2$	0.05				
One-way	$\theta^2\sigma_1^2$	0.16				
Total Sum of Squares		2937				
Sum of squared residuals		71				
Number of observations		342				

Estimated by Generalized Least Squares using 1990 data. The specification is given in equation (30) of the paper. The parameters are normalized so that $\sum_{i=1}^{19} S_i = 0$ and $\sum_{n=1}^{19} m_n = 0$. Standard errors are in parentheses.

Table 4: Data for Alternative Parameters

Country	Research Stock (U.S. = 1)	Years of Schooling (years/person)	Labor Force (HK adjusted) (U.S. = 1)	Density (pop/area) (U.S. = 1)
Australia	0.0087	8.7	0.054	0.08
Austria	0.0063	8.6	0.024	3.43
Belgium	0.0151	9.4	0.029	12.02
Canada	0.0299	10.0	0.094	0.10
Denmark	0.0051	6.9	0.017	4.47
Finland	0.0053	10.8	0.019	0.55
France	0.1108	9.5	0.181	3.88
Germany	0.1683	10.3	0.225	9.50
Greece	0.0005	8.4	0.025	2.87
Italy	0.0445	9.1	0.159	7.16
Japan	0.2492	9.5	0.544	12.42
Netherlands	0.0278	9.5	0.043	13.64
New Zealand	0.0010	9.3	0.010	0.47
Norway	0.0057	9.2	0.015	0.49
Portugal	0.0007	6.5	0.026	4.01
Spain	0.0084	9.7	0.100	2.88
Sweden	0.0206	9.6	0.031	0.71
United Kingdom	0.1423	8.5	0.186	8.76
United States	1.0000	12.1	1.000	1.00

Research stocks, in 1990, are from Coe and Helpman (1995). Average years of schooling H_i, in 1985, are from Kyriacou (1991). Labor forces, in 1990, are from Summers and Heston (1991). They are adjusted for human capital by multiplying the country i figure by $e^{0.06H_i}$. See the appendix for complete definitions.

Table 5: Competitiveness Equation

		Ordinary Least Squares		Two-Stage Least Squares	
		est.	s.e.	est.	s.e.
Constant		3.75	(1.89)	3.82	(1.92)
Research stock, $\ln R_i$	α_R	1.04	(0.17)	1.09	(0.18)
Human capital, $1/H_i$	$-\alpha_H$	-18.0	(20.6)	-22.7	(21.3)
Wage, $\ln w_i$	$-\theta$	-2.84	(1.02)	-3.60	(1.21)
Total Sum of Squares		80.3		80.3	
Sum of squared residuals		18.5		19.1	
Number of observations		19		19	

Estimated using 1990 data. The dependent variable is the estimates $\hat{S}_i$ of source-country competitiveness shown in Table 3. Standard errors are in parentheses.

Table 6: States of Technology

Country	Estimated competitiveness	Implied States of technology		
		$\theta = 8.28$	$\theta = 3.60$	$\theta = 12.86$
Australia	0.19	0.27	0.36	0.20
Austria	-1.16	0.26	0.30	0.23
Belgium	-3.34	0.24	0.22	0.26
Canada	0.41	0.46	0.47	0.46
Denmark	-1.75	0.35	0.32	0.38
Finland	-0.52	0.45	0.41	0.50
France	1.28	0.64	0.60	0.69
Germany	2.35	0.81	0.75	0.86
Greece	-2.81	0.07	0.14	0.04
Italy	1.78	0.50	0.57	0.45
Japan	4.20	0.89	0.97	0.81
Netherlands	-2.19	0.30	0.28	0.32
New Zealand	-1.20	0.12	0.22	0.07
Norway	-1.35	0.43	0.37	0.50
Portugal	-1.57	0.04	0.13	0.01
Spain	0.30	0.21	0.33	0.14
Sweden	0.01	0.51	0.47	0.57
United Kingdom	1.37	0.49	0.53	0.44
United States	3.98	1.00	1.00	1.00

The estimates of source-country competitiveness are the same as those shown in Table 3. For an estimated parameter $\hat{S}_i$, the implied state of technology is $T_i = (e^{\hat{S}_i} w_i^{\theta})^{\beta}$. States of technology are normalized relative to the U.S. value.

Table 7: Geographic Barriers

Source of Barrier	Estimated parameter	Implied Barrier's % effect on cost		
		$\theta = 8.28$	$\theta = 3.60$	$\theta = 12.86$
Distance [0,375)	-3.10	45.39	136.51	27.25
Distance [375,750)	-3.66	55.67	176.74	32.97
Distance [750,1500)	-4.03	62.77	206.65	36.85
Distance [1500,3000)	-4.22	66.44	222.75	38.82
Distance [3000,6000)	-6.06	108.02	439.04	60.25
Distance [6000,maximum]	-6.56	120.82	518.43	66.54
Shared border	0.30	-3.51	-7.89	-2.27
Shared language	0.51	-5.99	-13.25	-3.90
European Community	0.04	-0.44	-1.02	-0.29
EFTA	0.54	-6.28	-13.85	-4.09
Destination country:				
Australia	0.24	-2.81	-6.35	-1.82
Austria	-1.68	22.46	59.37	13.94
Belgium	1.12	-12.65	-26.74	-8.34
Canada	0.69	-7.99	-17.42	-5.22
Denmark	-0.51	6.33	15.15	4.03
Finland	-1.33	17.49	44.88	10.94
France	0.22	-2.61	-5.90	-1.69
Germany	1.00	-11.39	-24.27	-7.49
Greece	-2.36	32.93	92.45	20.11
Italy	0.07	-0.86	-1.97	-0.56
Japan	1.59	-17.43	-35.62	-11.60
Netherlands	1.00	-11.42	-24.33	-7.51
New Zealand	0.07	-0.80	-1.83	-0.52
Norway	-1.00	12.85	32.06	8.10
Portugal	-1.21	15.69	39.82	9.84
Spain	-1.16	14.98	37.85	9.40
Sweden	-0.02	0.30	0.69	0.19
United Kingdom	0.81	-9.36	-20.23	-6.13
United States	2.46	-25.70	-49.49	-17.40

The estimated parameters governing geographic barriers are the same as those shown in Table 3. For an estimated parameter $\hat{d}$, the implied percentage effect on cost is $100(e^{-\hat{d}/\theta} - 1)$.

Table 8: The Gains From Trade: Raising Geographic Barriers

Country	Percentage Change from Baseline to Autarky					
	Mobile labor			Immobile labor		
	welfare	mfg. prices	mfg. labor	welfare	mfg. prices	mfg. wages
Australia	-1.5	11.1	48.7	-3.0	65.6	54.5
Austria	-3.2	24.1	3.9	-3.3	28.6	4.5
Belgium	-10.3	76.0	2.8	-10.3	79.2	3.2
Canada	-6.5	48.4	6.6	-6.6	55.9	7.6
Denmark	-5.5	40.5	16.3	-5.6	59.1	18.6
Finland	-2.4	18.1	8.5	-2.5	27.9	9.7
France	-2.5	18.2	8.6	-2.5	28.0	9.8
Germany	-1.7	12.8	-38.7	-3.1	-33.6	-46.3
Greece	-3.2	24.1	84.9	-7.3	117.5	93.4
Italy	-1.7	12.7	7.3	-1.7	21.1	8.4
Japan	-0.2	1.6	-8.6	-0.3	-8.4	-10.0
Netherlands	-8.7	64.2	18.4	-8.9	85.2	21.0
New Zealand	-2.9	21.2	36.8	-3.8	62.7	41.4
Norway	-4.3	32.1	41.1	-5.4	78.3	46.2
Portugal	-3.4	25.3	25.1	-3.9	53.8	28.4
Spain	-1.4	10.4	19.8	-1.7	32.9	22.5
Sweden	-3.2	23.6	-3.7	-3.2	19.3	-4.3
United Kingdom	-2.6	19.2	-6.0	-2.6	12.3	-6.9
United States	-0.8	6.3	8.1	-0.9	15.5	9.3

All percentage changes are calculated as $100 \ln(x'/x)$ where x' is the outcome under autark ($d_{ni} \to \infty$ for $n \neq i$) and x is the outcome in the baseline.

Table 9: The Gains from Trade: Lowering Geographic Barriers

Country	Percentage Changes in the Case of Mobile Labor					
	Baseline to Zero Gravity			Baseline to Doubled Trade		
	welfare	mfg. prices	mfg. labor	welfare	mfg. prices	mfg. labor
Australia	21.1	-156.7	153.2	2.3	-17.1	-16.8
Austria	21.6	-160.3	141.5	2.8	-20.9	41.1
Belgium	18.5	-137.2	69.6	2.5	-18.6	68.8
Canada	18.7	-139.0	11.4	1.9	-14.3	3.9
Denmark	20.7	-153.9	156.9	2.9	-21.5	72.6
Finland	21.7	-160.7	172.1	2.8	-20.9	44.3
France	18.7	-138.3	-7.0	2.3	-16.8	15.5
Germany	17.3	-128.7	-50.4	1.9	-14.3	12.9
Greece	24.1	-178.6	256.5	3.3	-24.8	29.6
Italy	18.9	-140.3	6.8	2.2	-16.1	5.7
Japan	16.6	-123.5	-59.8	0.9	-6.7	-24.4
Netherlands	18.5	-137.6	67.3	2.5	-18.5	65.6
New Zealand	22.2	-164.4	301.4	2.8	-20.5	50.2
Norway	21.7	-161.0	195.2	3.1	-22.9	69.3
Portugal	22.3	-165.3	237.4	3.1	-22.8	67.3
Spain	20.9	-155.0	77.5	2.4	-18.0	-4.4
Sweden	20.0	-148.3	118.8	2.7	-19.7	55.4
United Kingdom	18.2	-134.8	3.3	2.2	-16.4	28.5
United States	16.1	-119.1	-105.1	1.2	-9.0	-26.2

All percentage changes are calculated as $100 \ln(x'/x)$ where x' is the outcome under lower geographic barriers and x is the outcome in the baseline.

Table 10: The Benefits of Foreign Technology

Country	Welfare consequences of improved technology			
	Higher U.S. state of technology		Higher German state of technology	
	mobile labor	immobile labor	mobile labor	immobile labor
Australia	27.1	14.9	12.3	4.4
Austria	9.3	2.9	61.8	5.4
Belgium	13.2	3.0	50.7	4.8
Canada	87.4	19.9	9.3	1.3
Denmark	12.2	6.2	62.5	7.1
Finland	11.3	4.3	37.5	3.0
France	10.1	4.2	39.2	3.0
Germany	9.7	-11.6	100.0	100.0
Greece	14.0	18.3	38.9	8.0
Italy	9.7	3.9	38.4	3.0
Japan	6.6	-0.8	5.9	-0.2
Netherlands	12.8	6.8	63.5	8.3
New Zealand	33.8	13.5	15.6	3.9
Norway	13.2	11.7	43.8	6.1
Portugal	14.3	8.6	39.6	4.7
Spain	9.6	7.0	27.3	3.3
Sweden	12.8	1.1	42.7	2.3
United Kingdom	14.6	0.5	38.3	1.6
United States	100.0	100.0	9.7	1.4

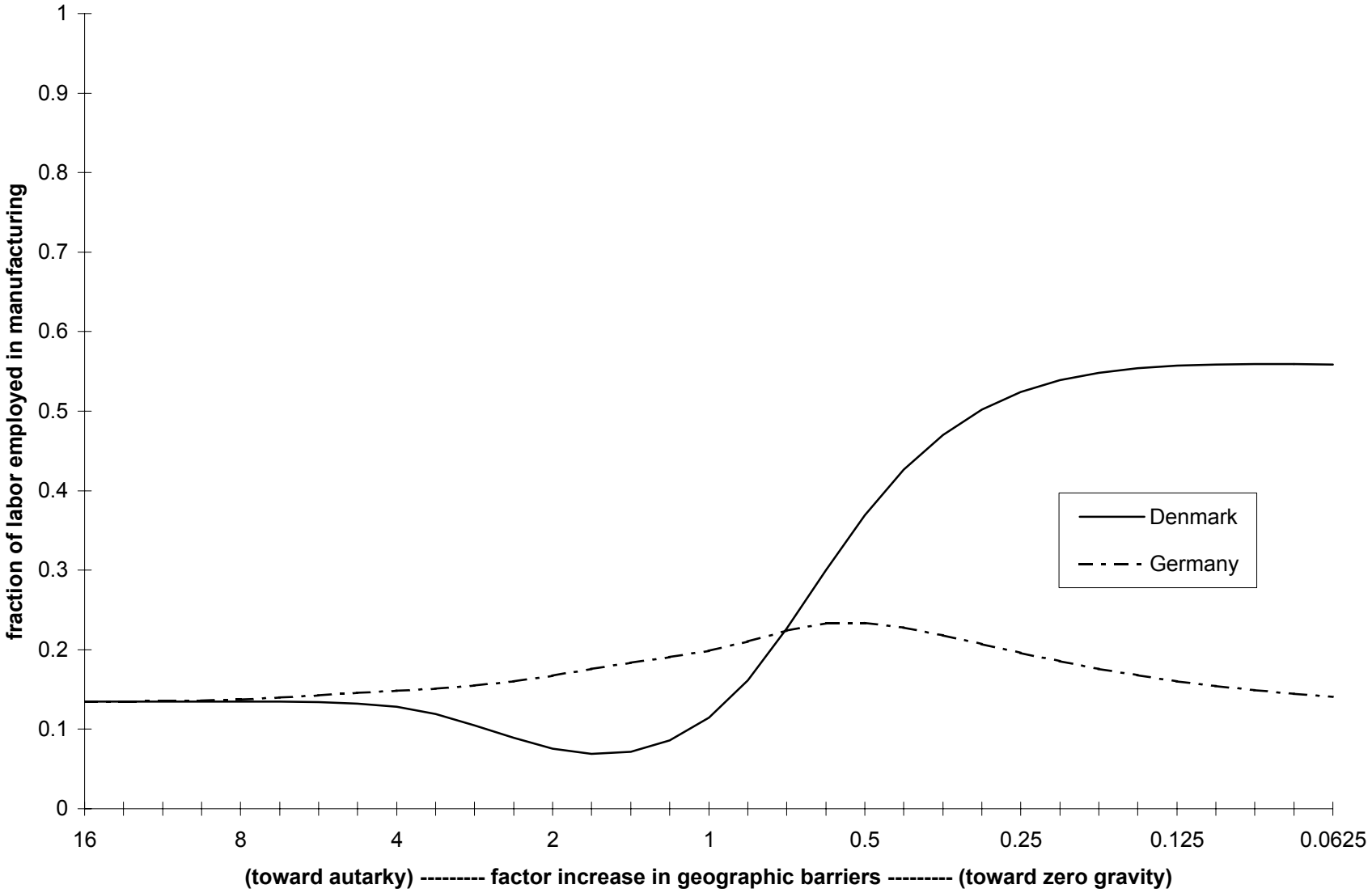
All numbers are expressed relative to the percentage welfare gain in the country whose technology expands. Based on a counterfactual 20 per cent increase in the state of technology for either the United States or Germany.

Table 11: The European Community: Welfare and Trade

Country	Effect of removing all tariffs on intra-EC trade			
	Aggregate Welfare		Imports from the EC	
	mobile labor	immobile labor	mobile labor	immobile labor
Australia	0.13	0.11	27.7	2.8
Austria	0.32	-0.07	-1.9	-3.4
Belgium*	-0.91	0.54	61.3	26.3
Canada	0.01	0.01	28.0	2.2
Denmark*	-0.27	0.18	49.9	30.8
Finland	0.28	-0.02	4.6	-2.9
France*	0.08	0.05	46.3	33.7
Germany*	-0.03	-0.03	58.5	41.9
Greece*	0.28	0.13	30.8	24.0
Italy*	0.14	0.04	44.9	36.4
Japan	0.07	-0.01	32.4	2.3
Netherlands*	-0.58	0.33	56.3	26.9
New Zealand	0.14	0.09	24.1	1.9
Norway	0.34	0.05	3.2	-2.9
Portugal*	0.03	0.10	44.0	32.8
Spain*	0.21	0.05	43.7	34.3
Sweden	0.31	-0.10	2.0	-3.3
United Kingdom*	-0.02	0.02	51.9	36.1
United States	0.10	0.03	27.8	2.2

All numbers are percentage changes from the baseline. In the baseline all trade is subject to a 5 percent tariff. The counterfactual is to remove tariffs between members (as of 1990) of the EC (appearing with a *). Each pair of columns shows the results of peforming the counterfactual first for the case of mobile labor and then for the case of immobile labor.

Figure 3: Specialization, Technology and Geography



Shikher assigns manufactured goods to 8 industries indexed by m, each with its own:

1. Country specific technology parameter T_{im}

2. Capital intensity β_{mK}, labor intensity β_{mL}, and input use from industry m', $\beta_{mm'}$

3. Unit transport costs d_{nim}

Table 6 Estimated relative import barriers for 1989

	Food	Textile	Wood	Paper	Chemicals	Nonmet.	Metals	Machinery
Australia	1.28	1.51	1.92	1.43	1.45	1.62	1.29	1.51
Austria	2.20	1.41	2.31	1.57	1.74	1.73	1.81	1.62
Canada	1.25	1.28	1.26	1.07	1.42	1.42	1.05	1.38
Finland	2.59	1.74	2.02	1.46	1.77	2.00	1.62	1.80
France	1.34	1.22	1.70	1.35	1.29	1.38	1.37	1.40
Germany	1.48	1.09	1.43	1.13	1.20	1.24	1.24	1.21
Greece	1.72	1.80	2.73	2.18	2.37	1.93	1.88	2.61
Italy	1.39	1.10	1.40	1.33	1.35	1.30	1.50	1.41
Japan	1.50	1.22	1.55	1.37	1.18	1.19	1.16	1.29
Korea	1.64	0.96	1.82	1.44	1.28	1.49	1.18	1.38
Mexico	1.77	1.81	2.10	2.11	1.67	1.81	1.70	1.86
New Zeal.	1.27	1.59	2.04	1.48	1.52	1.91	1.34	1.88
Norway	1.76	1.73	2.33	1.81	1.58	2.01	1.41	1.90
Portugal	1.91	1.14	2.39	1.73	2.25	1.80	1.80	1.86
Spain	1.58	1.59	1.95	1.54	1.61	1.60	1.63	1.72
Sweden	1.87	1.30	1.80	1.30	1.48	1.54	1.41	1.36
Turkey	2.37	2.09	3.29	2.98	2.28	2.11	1.98	2.83
U.K.	1.36	1.19	1.59	1.20	1.26	1.35	1.28	1.27
U.S.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Av. non-US	1.68	1.43	1.98	1.58	1.60	1.63	1.48	1.68

Table 7 Country rankings according to their estimated relative import barriers

Food	Textile	Wood	Paper	Chemicals	Nonmet.	Metals	Machinery
U.S.	Korea	U.S.	U.S.	U.S.	U.S.	U.S.	U.S.
Canada	U.S.	Canada	Canada	Japan	Japan	Canada	Germany
New Zeal.	Germany	Italy	Germany	Germany	Germany	Japan	U.K.
Australia	Italy	Germany	U.K.	U.K.	Italy	Korea	Japan
France	Portugal	Japan	Sweden	Korea	U.K.	Germany	Sweden
U.K.	U.K.	U.K.	Italy	France	France	U.K.	Canada
Italy	France	France	France	Italy	Canada	Australia	Korea
Germany	Japan	Sweden	Japan	Canada	Korea	New Zeal.	France
Japan	Canada	Korea	Australia	Australia	Sweden	France	Italy
Spain	Sweden	Australia	Korea	Sweden	Spain	Norway	Australia
Korea	Austria	Spain	Finland	New Zeal.	Australia	Sweden	Austria
Greece	Australia	Finland	New Zeal.	Norway	Austria	Italy	Spain
Norway	New Zeal.	New Zeal.	Spain	Spain	Portugal	Finland	Finland
Mexico	Spain	Mexico	Austria	Mexico	Mexico	Spain	Portugal
Sweden	Norway	Austria	Portugal	Austria	New Zeal.	Mexico	Mexico
Portugal	Finland	Norway	Norway	Finland	Greece	Portugal	New Zeal.
Austria	Greece	Portugal	Mexico	Portugal	Finland	Austria	Norway
Turkey	Mexico	Greece	Greece	Turkey	Norway	Greece	Greece
Finland	Turkey	Turkey	Turkey	Greece	Turkey	Turkey	Turkey

Table 8 Technology parameters and capital-labor ratios, relative to the United States

	Technology parameters								
	Food	Textile	Wood	Paper	Chemicals	Nonmet.	Metals	Machinery	Capital
Australia	0.253	0.098	0.018	0.040	0.048	0.045	0.408	0.054	0.524
Austria	0.027	0.154	0.029	0.087	0.063	0.201	0.137	0.073	0.604
Canada	0.266	0.292	0.503	0.753	0.153	0.139	0.914	0.149	0.799
Finland	0.013	0.080	0.089	0.434	0.056	0.048	0.238	0.072	0.641
France	0.368	0.702	0.138	0.260	0.372	0.792	0.587	0.318	0.921
Germany	0.215	0.676	0.220	0.332	0.522	0.914	0.683	0.521	0.894
Greece	0.043	0.044	0.001	0.003	0.008	0.033	0.040	0.002	0.202
Italy	0.178	1.435	0.339	0.206	0.249	1.387	0.369	0.356	0.884
Japan	0.080	0.776	0.119	0.309	0.571	1.491	1.007	1.228	0.979
Korea	0.032	0.319	0.008	0.017	0.069	0.043	0.148	0.061	0.263
Mexico	0.010	0.009	0.001	0.001	0.017	0.010	0.022	0.003	0.121
New Zeal.	0.358	0.058	0.020	0.042	0.031	0.009	0.056	0.015	0.380
Norway	0.101	0.032	0.030	0.123	0.084	0.036	0.313	0.053	0.684
Portugal	0.018	0.028	0.004	0.011	0.006	0.024	0.011	0.004	0.171
Spain	0.117	0.140	0.026	0.058	0.080	0.211	0.193	0.048	0.428
Sweden	0.033	0.067	0.076	0.255	0.088	0.092	0.248	0.135	0.644
Turkey	0.014	0.019	0.000	0.000	0.007	0.015	0.027	0.001	0.090
U.K.	0.232	0.320	0.055	0.166	0.256	0.342	0.352	0.197	0.624
U.S.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 9 Country rankings according to their technology parameters and capital-labor ratios

	Technology parameters								
Food	Textile	Wood	Paper	Chemicals	Nonmet.	Metals	Machinery	Capital
U.S.	Italy	U.S.	U.S.	U.S.	Japan	Japan	Japan	U.S.
France	U.S.	Canada	Canada	Japan	Italy	U.S.	U.S.	Japan
New Zeal.	Japan	Italy	Finland	Germany	U.S.	Canada	Germany	France
Canada	France	Germany	Germany	France	Germany	Germany	Italy	Germany
Australia	Germany	France	Japan	U.K.	France	France	France	Italy
U.K.	U.K.	Japan	France	Italy	U.K.	Australia	U.K.	Canada
Germany	Korea	Finland	Sweden	Canada	Spain	Italy	Canada	Norway
Italy	Canada	Sweden	Italy	Sweden	Austria	U.K.	Sweden	Sweden
Spain	Austria	U.K.	U.K.	Norway	Canada	Norway	Austria	Finland
Norway	Spain	Norway	Norway	Spain	Sweden	Sweden	Finland	U.K.
Japan	Australia	Austria	Austria	Korea	Finland	Finland	Korea	Austria
Greece	Finland	Spain	Spain	Austria	Australia	Spain	Australia	Australia
Sweden	Sweden	New Zeal.	New Zeal.	Finland	Korea	Korea	Norway	Spain
Korea	New Zeal.	Australia	Australia	Australia	Norway	Austria	Spain	New Zeal.
Austria	Greece	Korea	Korea	New Zeal.	Greece	New Zeal.	New Zeal.	Korea
Portugal	Norway	Portugal	Portugal	Mexico	Portugal	Greece	Portugal	Greece
Turkey	Portugal	Greece	Greece	Greece	Turkey	Turkey	Mexico	Portugal
Finland	Turkey	Mexico	Mexico	Turkey	Mexico	Mexico	Greece	Mexico
Mexico	Mexico	Turkey	Turkey	Portugal	New Zeal.	Portugal	Turkey	Turkey

Trade Accounting (Counterfactuals)

1. Remove interindustry comparative advantage $\longrightarrow$ Trade declines by 5%

2. No factor intensity differences $\longrightarrow$ No effect on aggregate trade.

3. No intraindustry heterogeneity $\longrightarrow$ Trade diminishes by 93%!!!

4. Implication: the predominant motive for trade in manufactures, at least within a broad swath of the OECD, is heterogeneity among very fine units (Whirlpool).