International Trade and Finance

Timothy J. Kehoe
University of Minnesota
and Federal Reserve Bank of Minneapolis

Universitat Autònoma de Barcelona
Spring 2013

www.econ.umn.edu/~tkehoe

Outline:

1. Standard theory (hybrid Heckscher-Ohlin/New Trade Theory) does not well when matched with the data on the growth and composition of trade.

2. Applied general equilibrium models that put the standard theory to work do not well in predicting the impact of trade liberalization experiences like NAFTA.

3. Much of the growth of trade after a trade liberalization experience is growth on the extensive margin. Models need to allow for corner solutions or fixed costs.

4. Fixed costs seem better than Ricardian corner solutions for reconciling time series data on real exchange rate fluctuations with data on trade growth after liberalization experiences.

5. Models of trade with heterogeneous firms typically impose fixed costs on firms that decide to export. The focus is on the decision to export. The theory and the data indicate that there is a lot of room for focusing on the decision to import.

6. Models with uniform fixed cost across firms with heterogeneous productivity have implications that are sharply at odds with micro data. A model with increasing costs of accessing a fraction of a market has many of features of models with fixed costs without these undesirable properties.

7. Growth theory needs to be reconsidered in the light of trade theory. In particular, a growth model that includes trade can have the opposite convergence properties from a model of closed economies.

8. Favorable changes in the terms of trade and/or reductions tariffs make it easier to import intermediate goods. Although this is often interpreted as an increase in productivity, it does not show up as such in productivity measures that use real GDP as a measure of output.

9. In models with heterogeneous firms (for example, Melitz, Chaney), trade liberalization can cause resources to shift from less productive firms to more productive firms. Although this is often interpreted as an increase in productivity, it does not show up as such in productivity measures that use real GDP as a measure of output.

TRADE THEORY AND TRADE FACTS

- Some recent trade facts
- A “New Trade Theory” model
- Accounting for the facts
- Intermediate goods?
- Policy?

How important is the quantitative failure of the New Trade Theory?

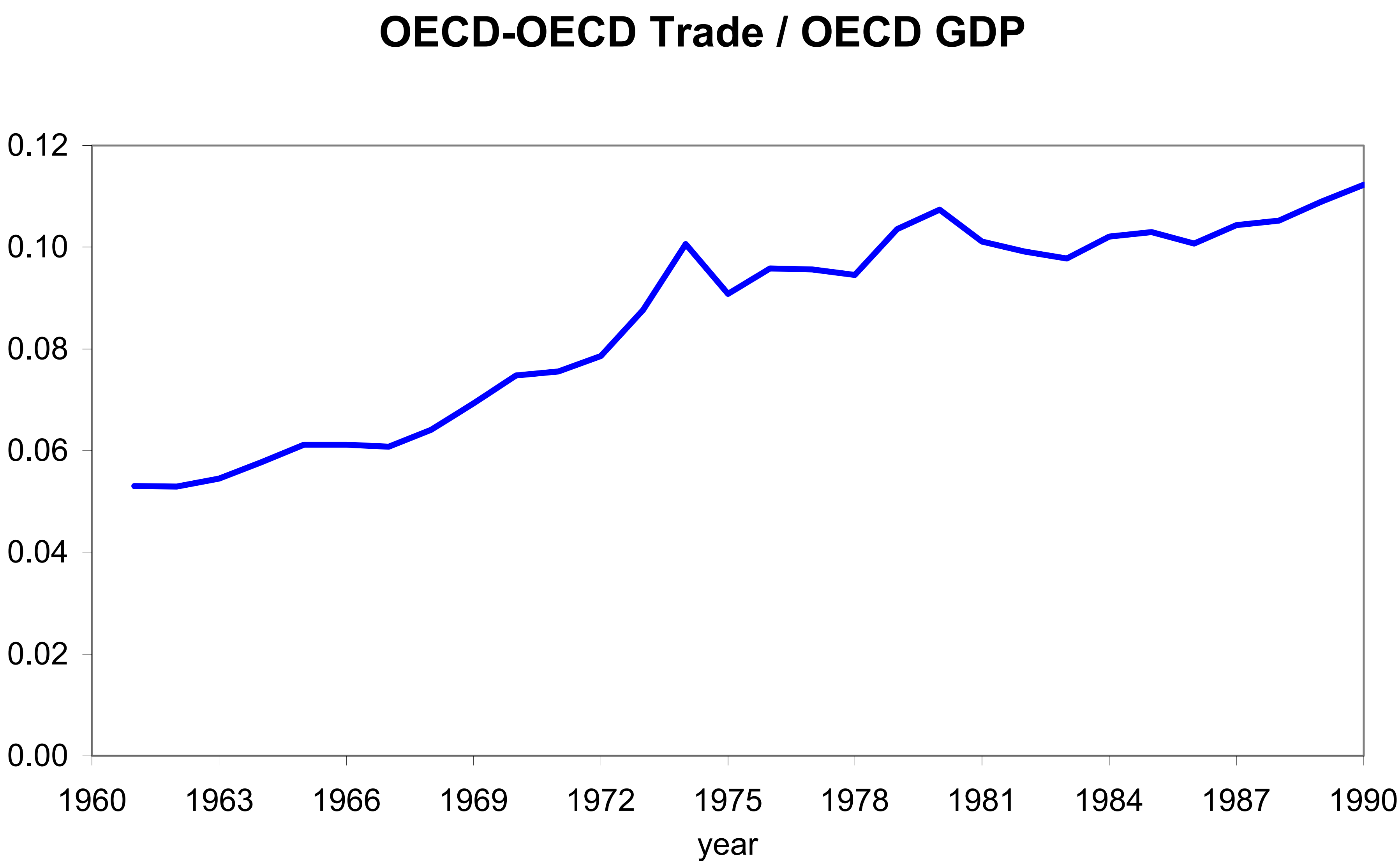
Where should trade theory and applications go from here?

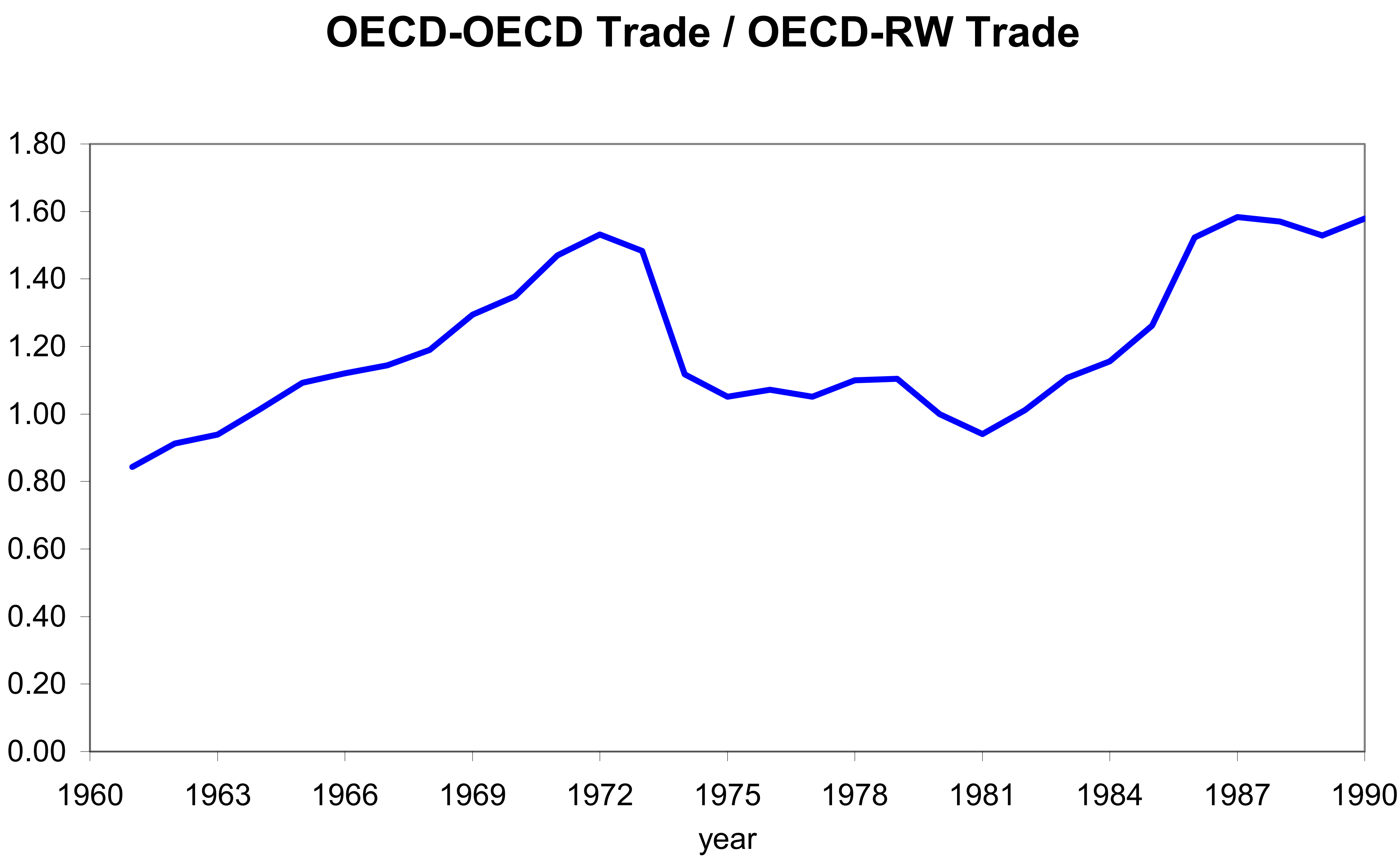
SOME RECENT TRADE FACTS

- **The ratio of trade to product has increased.**
  World trade/world GDP increased by 59.3 percent 1961-1990.
  OECD-OECD trade/OECD GDP increased by 111.5 percent 1961-1990.

- **Trade has become more concentrated among industrialized countries**
  OECD-OECD trade/OECD-RW trade increased by 87.1 percent 1961-1990.

- **Trade among industrialized countries is mostly intraindustry trade**
  Grubel-Lloyd index for OECD-OECD trade in 1990 is 68.4.
  Grubel-Lloyd index for OECD-RW trade in 1990 is 38.1.


OECD-OECD Trade / OECD GDP
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
year


OECD-OECD Trade / OECD-RW Trade
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
year

Helpman and Krugman (1985):

"These....empirical weaknesses of conventional trade theory...become understandable once economies of scale and imperfect competition are introduced into our analysis."

Markusen, Melvin, Kaempfer, and Maskus (1995):

"Thus, nonhomogeneous demand leads to a decrease in North-South trade and to an increase in intraindustry trade among the northern industrialized countries. These are the stylized facts that were to be explained."

Goal: To measure how much of the increase in the ratio of trade to output in the OECD and of the concentration of world trade among OECD countries can be accounted for by the "New Trade Theory."

PUNCHLINE

In a calibrated general equilibrium model, the New Trade Theory cannot account for the increase in the ratio of trade to output in the OECD.

Back-of-the-envelope calculations:

Suppose that the world consists of the OECD and the only trade is manufactures.

With Dixit-Stiglitz preferences, country j exports all of its production of manufactures Y_m^j except for the fraction $s^j = Y^j / Y^{oe}$ that it retains for domestic consumption.

World imports:

$$M = \sum_{j=1}^{n} \left(1 - s^j\right) Y_m^j .$$

World trade/GDP:

$$\frac{M}{Y^{oe}} = \frac{M}{Y_m^{oe}} \frac{Y_m^{oe}}{Y^{oe}} = \left(1 - \sum_{j=1}^{n} (s^j)^2\right) \frac{Y_m^{oe}}{Y^{oe}} .$$

World trade/GDP:

$$\frac{M}{Y^{oe}} = \frac{M}{Y_m^{oe}} \frac{Y_m^{oe}}{Y^{oe}} = \left(1 - \sum_{j=1}^{n} (s^j)^2\right) \frac{Y_m^{oe}}{Y^{oe}}.$$

$\left(1 - \sum_{j=1}^{n} (s^j)^2\right)$ goes from 0.663 in 1961 to 0.827 in 1990.

Y_m^{oe} / Y^{oe} goes from 0.295 in 1961 to 0.222 in 1990.

$$0.663 \times 0.295 = 0.196 \approx 0.184 = 0.827 \times 0.222.$$

Effects cancel!

A "NEW TRADE THEORY" MODEL

Environment:

- Static: endowments of factors are exogenous
- 2 regions: OECD and rest of world
- 2 traded goods: homogeneous — primaries (CRS) and differentiated — manufactures (IRS)
- 1 nontraded good — services (CRS)
- 2 factors: (effective) labor and capital
- Identical technologies and preferences (love for variety) across regions
- Primaries are inferior to manufactures

We only consider merchandise trade in both the data and in the model.

Key Features of the Model

Consumers' problem:

$$\max \quad \frac{\beta_p (c_p^j + \gamma_p)^\eta + \beta_m \left(\int_{D^w} c_m^j(z)^\rho \, dz_p \right)^{\eta/\rho} + \beta_s (c_s^j + \gamma_s)^\eta - 1}{\eta}$$

$$\text{s.t.} \quad q_p c_p^j + \int_{D^w} q_m(z) c_m^j(z) dz_p + q_s^j c_s^j \le r^j k^j + w^j h^j .$$

Firms' problems

Primaries and Services: Standard CRS problems.

$$Y_p^j = \theta_p (K_p^j)^{\alpha_p} (H_p^j)^{1-\alpha_p}$$

$$Y_s^j = \theta_s (K_s^j)^{\alpha_s} (H_s^j)^{1-\alpha_s}$$

Manufactures: Standard (Dixit-Stiglitz) monopolistically competitive problem:

- Fixed cost.

$$Y_m(z) = \max\left[\theta_m K_m(z)^{\alpha_m} H_m(z)^{1-\alpha_m} - F, 0\right]$$

- Firm z sets its price $q_m(z)$ to max profits given all of the other prices.

$$Y_m(z) = \sum_{j=1}^{n} C_m^j(z) + C_m^{rw}(z).$$

$$C_m^j(z) = \frac{\beta_m^{\frac{1}{1-\eta}}(r^j K^j + w^j H^j + q_p \gamma_p N^j + q_s^j \gamma_s N^j)}{q_m(z)^{\frac{1}{1-\rho}} \left[\int_{D^w} q_m(z')^{\frac{-\rho}{1-\rho}} dz' \right]^{\frac{\rho-\eta}{\rho(1-\eta)}} \Delta}$$

$$\Delta = \beta_p^{\frac{1}{1-\eta}} q_p^{-\frac{\eta}{1-\eta}} + \beta_m^{\frac{1}{1-\eta}} \left[\left(\int_{D^w} q_m(z')^{\frac{-\rho}{1-\rho}} dz' \right)^{\frac{-(1-\rho)}{\rho}} \right]^{\frac{-\eta}{1-\eta}} + \beta_s^{\frac{1}{1-\eta}} q_s^{-\frac{\eta}{1-\eta}}$$

- Every firm is uniquely associated with only one variety (symmetry).
- Free entry.
- $D^w = [0, d^w]$ with d^w finite and endogenously determined.

Volume of Trade

Let s^j be the share of country j, $j = 1,\ldots,n,\ rw$, in the world production of manufactures,

$$s^j = \int_{D^j} Y_m(z)dz \ / \int_{D^w} Y_m(z)dz \ = Y_m^j / Y_m^w.$$

The imports by country j from the OECD are

$$M_{oe}^j = (1 - s^{rw} - s^j)C_m^j$$
$$M_{oe}^{rw} = (1 - s^{rw})C_m^{rw}.$$

Total imports in the OECD from the other OECD countries are

$$M_{oe}^{oe} = \sum_{j=1}^{n} M_{oe}^j (1 - s^{rw} - \sum_{j=1}^{n} (s^j)^2 / (1 - s^{rw}))C_m^{oe}.$$

OECD in 1990

Country	Share of GDP %	Country	Share of GDP %
Australia	1.79	Japan	18.04
Austria	0.97	Netherlands	1.72
Belgium-Lux	1.26	New Zealand	0.26
Canada	3.45	Norway	0.70
Denmark	0.78	Portugal	0.41
Finland	0.81	Spain	3.00
France	7.26	Sweden	1.40
Germany	9.96	Switzerland	0.17
Greece	0.50	Turkey	0.91
Iceland	0.04	United Kingdom	5.92
Ireland	0.28	United States	33.72
Italy	6.64		

ACCOUNTING FOR THE FACTS

Compare the changes that the model predicts for 1961-1990 with what actually took place.

Focus on key variables:

- OECD-OECD Trade/OECD GDP
- OECD-OECD Trade/OECD-RW Trade
- OECD Manfacturing GDP/OECD GDP

Calibrate to 1990 data.

Backcast to 1961 by imposing changes in parameters:

- relative sizes of countries in the OECD
- populations
- sectoral productivities
- endowments

ACCOUNTING FOR THE FACTS

Benchmark 1990 OECD Data Set
(Billion U.S. dollars)

	Primaries	Manufactures	Services	Total
H_i^{oe}	228	2,884	8,644	11,756
K_i^{oe}	441	775	3,497	4,713
Y_i^{oe}	669	3,659	12,141	16,469
C_i^{oe}	862	3,466	12,141	16,469
$Y_i^{oe} - C_i^{oe}$	-193	193	0	0

ACCOUNTING FOR THE FACTS

Benchmark 1990 Rest of the World Data Set
(Billion U.S. dollars)

	Primaries	Manufactures	Services	Total
Y_i^{rw}	1,223	1,159	3,447	5,829
C_i^{rw}	1,030	1,352	3,447	5,829
$Y_i^{rw} - C_i^{rw}$	193	-193	0	0

ACCOUNTING FOR THE FACTS

- $N^{oe} = 854$, $N^{rw} = 4,428$.
- $\sum_{i=p,m,s} Y_i^{rw} = \sum_{i=p,m,s} C_i^{rw} = 5,829$.
- Set $q_p = q_m(z) = q_s = w = r = 1$ (quantities are 1990 values).
- $\rho = 1/1.2$ (Morrison 1990, Martins, Scarpetta, and Pilat 1996).
- Normalize $d^w = 100$.
- Calibrate H^{rw}, K^{rw} so that benchmark data set is an equilibrium.

- Alternative calibrations of utility parameters γ_p, γ_s, and η.

OECD in 1961

Country	Share of GDP %	Country	Share of GDP %
Austria	0.75	Netherlands	1.37
Belgium-Lux	1.25	Norway	0.60
Canada	4.22	Portugal	0.32
Denmark	0.70	Spain	1.38
France	6.99	Sweden	1.62
Germany	9.71	Switzerland	1.07
Greece	0.50	Turkey	0.83
Iceland	0.03	United Kingdom	8.08
Ireland	0.21	United States	55.74
Italy	4.64		

Numerical Experiments

Calculate equilibrium in 1961:

$$\theta_{p,1961} = \theta_{p,1990}$$
$$\theta_{m,1961} = \theta_{m,1990}/1.014^{29}, \; F_{1961} = F_{1990}/1.014^{29}$$
$$\theta_{s,1961} = \theta_{s,1990}/1.005^{29} \text{ (Echevarria 1997)}$$

$$N^{oe} = 536, \; N^{rw} = 2,545$$

Numerical Experiments

Choose H_{1961}^{oe}, K_{1961}^{oe}, H_{1961}^{rw}, K_{1961}^{rw} so that

$$\frac{\sum_{i=p,m,s} Y_{i,1990}^{oe} / N_{1990}^{oe}}{\sum_{i=p,m,s} Y_{i,1961}^{oe} / N_{1961}^{oe}} = 2.400$$

$$\frac{\sum_{i=p,m,s} Y_{i,1990}^{rw} / N_{1990}^{rw}}{\sum_{i=p,m,s} Y_{i,1961}^{rw} / N_{1961}^{rw}} = 2.055$$

$$\frac{K_{1961}^{oe}}{H_{1961}^{oe}} = \frac{K_{1990}^{oe}}{H_{1990}^{oe}}$$

$$\frac{q_{p,1961}(Y_{p,1961}^{rw} - C_{p,1961}^{rw})}{\sum_{i=p,m,s} q_{i,1961} Y_{i,1961}^{rw}} = 0.050$$

How Can the Model Work in Matching the Facts?

- The ratio of trade to product has increased:

  The size distribution of countries has become more equal (Helpman-Krugman).

- Trade has become more concentrated among industrialized countries:

  OECD countries have comparative advantage in manufactures, while the RW has comparative advantage in primaries. Because they are inferior to manufactures, primaries become less important in trade as the world becomes richer (Markusen).

How Can the Model Work in Matching the Facts?

- Trade among industrialized countries is largely intraindustry trade:

  OECD countries export manufactures. Because of taste for variety, every country consumes some manufactures from every other country (Dixit-Stiglitz).

- The different total factor productivity growth rates across sectors imply that the price of manufactures relative to primaries and services has fallen sharply between 1961 and 1990. If price elasticities of demand are not equal to one, a lot can happen.

Experiment 1

$\gamma_p = \gamma_p = \eta = 0$

	1961	1990	Change
Data			
OECD-OECD Trade/OECD GDP	0.053	0.112	111.5%
OECD-OECD Trade/OECD-RW Trade	0.844	1.579	87.1%
OECD Manf GDP/OECD GDP	0.295	0.222	–24.6%
1. $\gamma_p = 0$, $\gamma_s = 0$, $\eta = 0$			
OECD-OECD Trade/OECD GDP	0.108	0.136	25.8%
OECD-OECD Trade/OECD-RW Trade	0.893	1.169	30.9%
OECD Manf GDP/OECD GDP	0.223	0.222	–0.4%

Experiment 2

$\gamma_p = -169.5$, $\gamma_s = 314.7$ to match consumption in RW in 1990, $\eta = 0$

	1961	1990	Change
Data			
OECD-OECD Trade/OECD GDP	0.053	0.112	111.5%
OECD-OECD Trade/OECD-RW Trade	0.844	1.579	87.1%
OECD Manf GDP/OECD GDP	0.295	0.222	–24.6%
2. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = 0$			
OECD-OECD Trade/OECD GDP	0.103	0.132	28.1%
OECD-OECD Trade/OECD-RW Trade	0.739	1.060	43.6%
OECD Manf GDP/OECD GDP	0.225	0.222	–1.4%

Experiment 3

$\gamma_p = -169.5$, $\gamma_s = 314.7$,
$\eta = 0.559$ to match growth in OECD-OECD Trade/OECD GDP

	1961	1990	Change
Data			
OECD-OECD Trade/OECD GDP	0.053	0.112	111.5%
OECD-OECD Trade/OECD-RW Trade	0.844	1.579	87.1%
OECD Manf GDP/OECD GDP	0.295	0.222	–24.6%
3. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = 0.559$			
OECD-OECD Trade/OECD GDP	0.063	0.132	111.5%
OECD-OECD Trade/OECD-RW Trade	0.738	1.060	43.7 %
OECD Manf GDP/OECD GDP	0.137	0.222	62.7%

Experiments 4 and 5

$\gamma_p = -169.5$, $\gamma_s = 314.7$, reasonable values of η $(0.5 \geq 1/(1-\eta) \geq 0.1)$

	1961	1990	Change
Data			
OECD-OECD Trade/OECD GDP	0.053	0.112	111.5%
OECD-OECD Trade/OECD-RW Trade	0.844	1.579	87.1%
OECD Manf GDP/OECD GDP	0.295	0.222	–24.6%
4. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = -1$			
OECD-OECD Trade/OECD GDP	0.118	0.132	11.7%
OECD-OECD Trade/OECD-RW Trade	0.739	1.060	43.5%
OECD Manf GDP/OECD GDP	0.259	0.222	–14.1%
5. $\gamma_p = -169.5$, $\gamma_s = 314.7$, $\eta = -9$			
OECD-OECD Trade/OECD GDP	0.118	0.132	1.6%
OECD-OECD Trade/OECD-RW Trade	0.739	1.060	43.5%
OECD Manf GDP/OECD GDP	0.284	0.222	–21.8%

Sensitivity Analysis:
Alternative Calibration Methodologies

- Alternative specifications of nonhomogeneity
- Gross imports calibration
- Alternative RW endowment calibration
- Alternative RW growth calibration
- Intermediate goods

INTERMEDIATE GOODS?

$$Y_p^j = \min\left[\frac{X_{pp}^j}{a_{pp}}, \frac{\int_{D^w} X_{mp}^j(z)dz}{a_{mp}}, \frac{X_{sp}^j}{a_{sp}}, \theta_p \left(K_p^j\right)^{\alpha_p} \left(H_p^j\right)^{1-\alpha_p}\right]$$

$$Y_m(z) = \min\left[\begin{array}{l}\dfrac{X_{pm}^j(z)}{a_{pm}}, \dfrac{\int_{D^w} X_{mm}^j(z,z')dz'}{a_{mm}}, \dfrac{X_{sm}^j(z)}{a_{sm}}, \\ \theta_m \left(K_m(z)\right)^{\alpha_m} \left(H_m(z)\right)^{1-\alpha_m} - F\end{array}\right]$$

$$Y_s^j = \min\left[\frac{X_{ps}^j}{a_{ps}}, \frac{\int_{D^w} X_{ms}^j(z)dz}{a_{ms}}, \frac{X_{ss}^j}{a_{ss}}, \theta_s \left(K_s^j\right)^{\alpha_s} \left(H_s^j\right)^{1-\alpha_s}\right]$$

Results for Model with Intermediate Goods

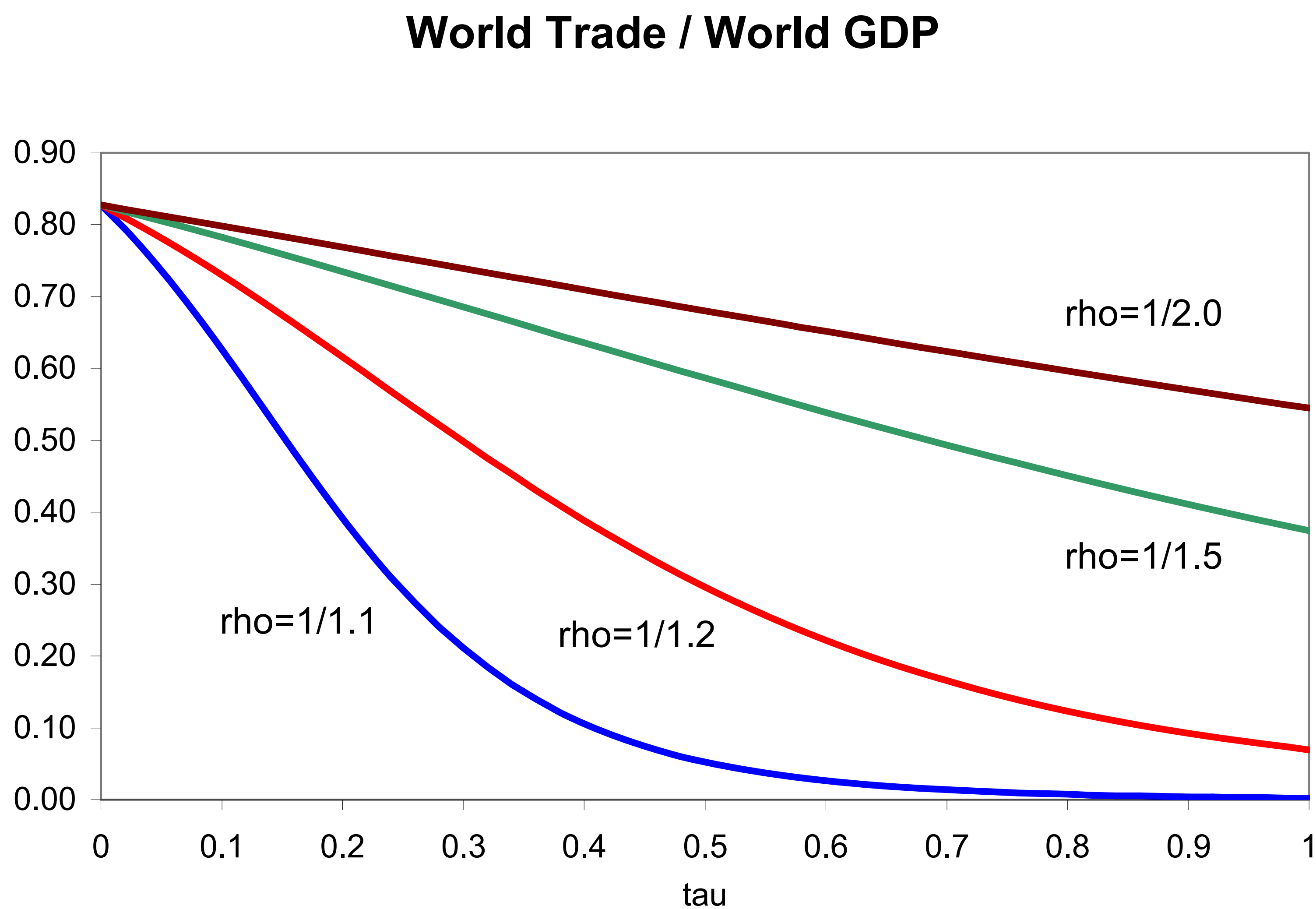
	1961	1990	Change
Data			
OECD-OECD Trade/OECD GDP	0.053	0.112	111.5%
OECD-OECD Trade/OECD-RW Trade	0.844	1.579	87.1%
OECD Manf GDP/OECD GDP	0.295	0.222	–24.6%
4. $\gamma_p = -307.8$, $\gamma_s = 262.2$, $\eta = -1$			
OECD-OECD Trade/OECD GDP	0.323	0.370	14.5%
OECD-OECD Trade/OECD-RW Trade	0.994	1.305	31.3%
OECD Manf GDP/OECD GDP	0.263	0.222	–15.6%
5. $\gamma_p = -307.8$, $\gamma_s = 262.2$, $\eta = -9$			
OECD-OECD Trade/OECD GDP	0.337	0.370	9.7%
OECD-OECD Trade/OECD-RW Trade	0.933	1.305	39.9%
OECD Manf GDP/OECD GDP	0.307	0.222	–27.5%

POLICY?

In a version of our model with n OECD countries, a manufacturing sector, and a uniform ad valorem tariff τ, the ratio of exports to income is given by

$$\frac{M}{Y} = \frac{(n-1)C_f}{Y} = \frac{n-1}{n-1+(1+\tau)^{1/(1-\rho)}}$$

Fixing n to replicate the size distribution of national incomes in the OECD, and setting $\rho = 1/1.2$, a fall in τ from 0.45 to 0.05 produces an increase in the ratio of trade to output as seen in the data.



World Trade / World GDP
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
tau
rho=1/2.0
rho=1/1.5
rho=1/1.1
rho=1/1.2

2. Applied general equilibrium models that put the standard theory to work do not well in predicting the impact of trade liberalization experiences like NAFTA.

Applied general equilibrium models were the only analytical game in town when it came to analyzing the impact of NAFTA in 1992-1993.

Typical sort of model: Static applied general equilibrium model with large number of industries and imperfect competition (Dixit-Stiglitz or Eastman-Stykolt) and finite number of firms in some industries. In some numerical experiments, new capital is placed in Mexico owned by consumers in the rest of North America to account for capital flows.

Examples:
Brown-Deardorff-Stern model of Canada, Mexico, and the United States
Cox-Harris model of Canada
Sobarzo model of Mexico

T. J. Kehoe, "An Evaluation of the Performance of Applied General Equilibrium Models of the Impact of NAFTA," in T. J. Kehoe, T. N. Srinivasan, and J. Whalley, editors, *Frontiers in Applied General Equilibrium Modeling: Essays in Honor of Herbert Scarf*, Cambridge University Press, 2005, 341-77.

Research Agenda:

- Compare results of numerical experiments of models with data.

- Determine what shocks — besides NAFTA policies — were important.

- Construct a simple applied general equilibrium model and perform experiments with alternative specifications to determine what was wrong with the 1992-1993 models.

Applied GE Models Can Do a Good Job!

Spain: Kehoe-Polo-Sancho (1992) evaluation of the performance of the Kehoe-Manresa-Noyola-Polo-Sancho-Serra MEGA model of the Spanish economy: A Shoven-Whalley type model with perfect competition, modified to allow government and trade deficits and unemployment (Kehoe-Serra). Spain's entry into the European Community in 1986 was accompanied by a fiscal reform that introduced a value-added tax (VAT) on consumption to replace a complex range of indirect taxes, including a turnover tax applied at every stage of the production process. What would happen to tax revenues? Trade reform was of secondary importance.

Canada-U.S.: Fox (1999) evaluation of the performance of the Brown-Stern (1989) model of the 1989 Canada-U.S. FTA.

Other changes besides policy changes are important!

Changes in Consumer Prices in the Spanish Model
(Percent)

sector	data 1985-1986	model policy only	model shocks only	model policy&shocks
food and nonalcoholic beverages	1.8	-2.3	4.0	1.7
tobacco and alcoholic beverages	3.9	2.5	3.1	5.8
clothing	2.1	5.6	0.9	6.6
housing	-3.3	-2.2	-2.7	-4.8
household articles	0.1	2.2	0.7	2.9
medical services	-0.7	-4.8	0.6	-4.2
transportation	-4.0	2.6	-8.8	-6.2
recreation	-1.4	-1.3	1.5	0.1
other services	2.9	1.1	1.7	2.8
weighted correlation with data		-0.08	0.87	0.94
variance decomposition of change		0.30	0.77	0.85
regression coefficient *a*		0.00	0.00	0.00
regression coefficient *b*		-0.08	0.54	0.67

Measures of Accuracy of Model Results

1. Weighted correlation coefficient.
2. Variance decomposition of the (weighted) variance of the changes in the data:

$$vardec(y^{data}, y^{model}) = \frac{var(y^{model})}{var(y^{model}) + var(y^{data} - y^{model})}.$$

3, 4. Estimated coefficients a and b from the (weighted) regression

$$x_i^{data} = a + bx_i^{model} + e_i.$$

Changes in Value of Gross Output/GDP in the Spanish Model (Percent)

sector	data 1985-1986	model policy only	model shocks only	model policy&shocks
agriculture	-0.4	-1.1	8.3	6.9
energy	-20.3	-3.5	-29.4	-32.0
basic industry	-9.0	1.6	-1.8	-0.1
machinery	3.7	3.8	1.0	5.0
automobile industry	1.1	3.9	4.7	8.6
food products	-1.8	-2.4	4.7	2.1
other manufacturing	0.5	-1.7	2.3	0.5
construction	5.7	8.5	1.4	10.3
commerce	6.6	-3.6	4.4	0.4
transportation	-18.4	-1.5	1.0	-0.7
services	8.7	-1.1	5.8	4.5
government services	7.6	3.4	0.9	4.3
weighted correlation with data		0.16	0.80	0.77
variance decomposition of change		0.11	0.73	0.71
regression coefficient *a*		-0.52	-0.52	-0.52
regression coefficient *b*		0.44	0.75	0.67

Changes in Trade/GDP in the Spanish Model (Percent)

direction of exports	data 1985-1986	model policy only	model shocks only	model policy&shocks
Spain to rest of E.C.	-6.7	-3.2	-4.9	-7.8
Spain to rest of world	-33.2	-3.6	-6.1	-9.3
rest of E.C. to Spain	14.7	4.4	-3.9	0.6
rest of world to Spain	-34.1	-1.8	-16.8	-17.7
weighted correlation with data		0.69	0.77	0.90
variance decomposition of change		0.02	0.17	0.24
regression coefficient *a*		-12.46	2.06	5.68
regression coefficient *b*		5.33	2.21	2.37

Changes in Composition of GDP in the Spanish Model (Percent of GDP)

variable	data 1985-1986	model policy only	model shocks only	model policy&shocks
wages and salaries	-0.53	-0.87	-0.02	-0.91
business income	-1.27	-1.63	0.45	-1.24
net indirect taxes and tariffs	1.80	2.50	-0.42	2.15
correlation with data		0.998	-0.94	0.99
variance decomposition of change		0.93	0.04	0.96
regression coefficient *a*		0.00	0.00	0.00
regression coefficient *b*		0.73	-3.45	0.85
private consumption	-0.81	-1.23	-0.51	-1.78
private investment	1.09	1.81	-0.58	1.32
government consumption	-0.02	-0.06	-0.38	-0.44
government investment	-0.06	-0.06	-0.07	-0.13
exports	-3.40	-0.42	-0.69	-1.07
-imports	3.20	-0.03	2.23	2.10
correlation with data		0.40	0.77	0.83
variance decomposition of change		0.20	0.35	0.58
regression coefficient *a*		0.00	0.00	0.00
regression coefficient *b*		0.87	1.49	1.24

Public Finances in the Spanish Model
(Percent of GDP)

variable	data 1985-1986	model policy only	model shocks only	model policy&shocks
indirect taxes and subsidies	2.38	3.32	-0.38	2.98
tariffs	-0.58	-0.82	-0.04	-0.83
social security payments	0.04	-0.19	-0.03	-0.22
direct taxes and transfers	-0.84	-0.66	0.93	0.26
government capital income	-0.13	-0.06	0.02	-0.04
correlation with data		0.99	-0.70	0.92
variance decomposition of change		0.93	0.08	0.86
regression coefficient *a*		-0.06	0.35	-0.17
regression coefficient *b*		0.74	-1.82	0.80

Models of NAFTA
Did Not Do a Good Job!

Ex-post evaluations of the performance of applied GE models are essential if policy makers are to have confidence in the results produced by this sort of model.

Just as importantly, they help make applied GE analysis a scientific discipline in which there are well-defined puzzles and clear successes and failures for alternative hypotheses.

For the past three decades, the tool of choice for analyzing the impact of trade policy has been the multisectoral applied GE model.

At a conference organized by the U.S. International Trade Commission, held in February 1992 at the request of the U.S. Congress, to which all economists studying the impact of NAFTA had been invited, 10 of the 12 studies presented used applied GE models.

This is still the sort of model used to analyze policies like the U.S.-Central America-Dominican Republic Free Trade Agreement and the U.S.-Korea Free Trade Agreement.

Typical sort of model: Static applied general equilibrium model with 20-40 industries, imperfect competition (Dixit-Stiglitz or Eastman-Stykolt) in some industries, perfect competition and Armington aggregators in others.

Comparison of predictions of model with changes that occurred over 1988–2006 (1988–2006 for Mexico-United States)

Brown-Deardorff-Stern model of Canada, Mexico, and the United States

Cox-Harris model of Canada

Sobarzo model of Mexico

Methodology for comparing results of models with data

Kehoe, Polo, and Sancho (1995), Kehoe (2005)

For exports by country i of industry j to country k, x_{ij}^{k},

$$z_{ij}^{k} = 100\left(\frac{x_{ijT_1}^{k} / y_{iT_1}}{x_{ijT_0}^{k} / y_{iT_0}} - 1 \right)$$

where y_{it} is the current price GDP in country i in year t

To compare the predictions of the model with the changes in data, we calculate the weighted correlation coefficient and the coefficients a and b from the weighted regression

$$\min_{a,b} \sum_{j=1}^{n} \alpha_j \left(a + b z_j^{model} - z_j^{data} \right)^2$$

How to turn least traded products data into predictions:

Predict that least traded products will have their exports grow $a+b$ percent faster than the exporting country's GDP and other products grow a percent faster.

For a particular industry, this prediction becomes

$$a(1-s_i)+(a+b)s_i = a+bs_i,$$

where s_i is the fraction of the industry's exports made up of least traded products in the base year.

Notice that this method does not make use of the products with 0 recorded trade.

Product-industry detail

Use concordance between the ISIC and the SITC based on those in the World Bank's Trade and Production Database (Nicita and Olarreaga, 2001, 2006)

Canadian exports of chemicals to the United States grew 113.5 percent while the BDS model predicted −3.1 percent.

88 complete 4-digit SITC categories — 80 least traded.

Parts of another 27 categories — 11 least traded.

Compared to Canadian GDP, the 22 percent of 1988 exports of chemicals that are least traded increase by 212 percent, while the other 78 percent increase by only 32 percent.

Compared to Canadian GDP

Exports of 5823 (Alkyds and Other Polyesters) increases by 1,285 percent

Exports of 5832 (Polypropylene) increases by 738 percent

Exports of 5121 (Acyclic Alcohols and their Halogenated and Derivatives) decreases by 37 percent.

Changes in Canadian Exports relative to Canadian GDP (percent)

sector	Canada to Mexico 1988–2006 data	Canada to Mexico BDS model	Canada to Mexico 1988 least traded	Canada to United States 1988–2006 data	Canada to United States BDS model	Canada to United States 1988 least traded
agriculture 166.3		3.1	0.05	37.3	3.4	0.34
mining and quarrying	-17.9	-0.3	0.00	257.2	0.4	0.03
food 160.1		2.2	0.07	69.8	8.9	0.26
textiles 180.8		-0.9	1.00	131.5	15.3	1.00
clothing 1478.9		1.3	1.00	76.3	45.3	0.53
leather products	72367.2	1.4	1.00	-0.4	11.3	1.00
footwear —		3.7	—	37.8	28.3	1.00
wood products	2128.6	4.7	1.00	33.9	0.1	0.05
furniture and fixtures	2009.4	2.7	1.00	125.8	12.5	0.03
paper products	56.6	-4.3	0.05	-48.8	-1.8	0.04
printing and publishing	1186.7	-2.0	1.00	43.1	-1.6	0.07
chemicals 371.5		-7.8	0.15	113.5	-3.1	0.22
petroleum and products	8453.5	-8.5	0.99	161.9	0.5	0.72
rubber products	14.8	-1.0	0.57	71.5	9.5	0.11
nonmetal mineral products	103.2	-1.8	1.00	28.9	1.2	0.42
glass products	-66.7	-2.2	1.00	32.8	30.4	0.41
iron and steel	210.1	-15.0	0.03	30.7	12.9	0.31
nonferrous metals	2019.0	-64.7	1.00	28.7	18.5	0.03
metal products	232.9	-10.0	0.51	74.8	15.2	0.19
nonelectrical machinery	218.8	-8.9	0.18	43.2	3.3	0.24
electrical machinery	707.2	-26.2	0.28	95.7	14.5	0.27
transportation equipment	624.8	-4.4	0.02	-0.7	10.7	0.01
misc. manufactures	674.1	-12.1	1.00	72.0	-2.1	0.42
weighted correlation with data		-0.32	0.29	-0.23		0.29
regression coefficient *a*		178.63	192.29	64.83		29.74
regression coefficient *b*		-16.75	759.76	-2.70		144.11

Changes in Mexican Exports relative to Mexican GDP (percent)

sector	Mexico to Canada 1988–2006 data	BDS model	1988 least traded	Mexico to United States 1989–2006 data	BDS model	1989 least traded
agriculture	13.6	-4.1	0.06	34.7	2.5	0.09
mining and quarrying	102.9	27.3	0.07	-3.7	26.9	0.02
food	-5.6	10.8	0.52	196.3	7.5	0.35
textiles	92.9	21.6	0.26	43.6	11.8	0.63
clothing	1082.2	19.2	1.00	-70.2	18.6	0.28
leather products	789.1	36.2	1.00	-69.6	11.7	0.42
footwear	-52.5	38.6	1.00	-64.6	4.6	0.00
wood products	221.8	15.0	1.00	68.7	-2.7	0.26
furniture and fixtures	1852.0	36.2	0.09	-62.4	7.6	0.01
paper products	38.7	32.9	0.06	207.8	13.9	0.17
printing and publishing	1375.5	15.0	1.00	3.2	3.9	1.00
chemicals	209.6	36.0	0.68	98.7	17.0	0.52
petroleum and products	116.2	32.9	0.01	46.7	34.1	0.07
rubber products	2437.9	-6.7	1.00	-5.3	-5.3	1.00
nonmetal mineral products	40.4	5.7	0.42	1.6	3.7	0.34
glass products	12.2	13.3	0.16	64.3	32.3	0.29
iron and steel	-51.4	19.4	0.40	-34.1	30.8	0.43
nonferrous metals	24.8	138.1	0.24	113.3	156.5	0.10
metal products	487.8	41.9	0.51	103.3	26.8	0.29
nonelectrical machinery	120.7	17.3	0.09	34.2	18.5	0.18
electrical machinery	326.1	137.3	0.06	120.0	178.0	0.01
transportation equipment	103.5	3.3	0.01	128.5	6.2	0.02
misc. manufactures	1265.1	61.1	0.62	34.7	43.2	0.19
weighted correlation with data		0.45	0.24	-0.14		0.003
regression coefficient *a*		100.02	136.33	49.49		73.29
regression coefficient *b*		1.80	313.80	-0.10		1.56

Changes in U.S. Exports relative to U.S. GDP (percent)

sector	United States to Canada			United States to Mexico		
	1988–2006 data	**BDS model**	**1988 least traded**	**1989–2006 data**	**BDS model**	**1989 least traded**
agriculture -8.6		5.1	0.29	11.3	7.9	0.10
mining and quarrying	83.7	1.0	0.19	60.9	0.5	0.21
food 68.8		12.7	0.37	108.9	13	0.19
textiles -4.2		44.0	0.43	265.9	18.6	0.49
clothing 55.7		56.7	1.00	-14.9	50.3	0.27
leather products	-59.3	7.9	1.00	342.8	15.5	0.60
footwear -56.1		45.7	1.00	-72.3	35.4	0.00
wood products	1.7	6.7	0.37	10.3	7.0	0.19
furniture and fixtures	114.7	35.6	0.01	29.5	18.6	0.02
paper products	41.9	18.9	0.13	32.8	-3.9	0.03
printing and publishing	-0.1	3.9	0.04	77.6	-1.1	0.17
chemicals 69.2		21.8	0.23	167.3	-8.4	0.15
petroleum and products	133.4	0.8	0.73	242.7	-7.4	0.01
rubber products	26.8	19.1	0.05	176.0	12.8	0.11
nonmetal mineral products	-15.3	11.9	0.63	94.1	0.8	0.75
glass products	-9.7	4.4	0.25	104.6	42.3	0.72
iron and steel	139.0	11.6	0.27	96.9	-2.8	0.25
nonferrous metals	16.1	-6.7	0.15	220.0	-55.1	0.09
metal products	25.6	18.2	0.17	159.1	5.4	0.12
nonelectrical machinery	-23.0	9.9	0.07	135.4	-2.9	0.11
electrical machinery	-14.9	14.9	0.04	109.9	-10.9	0.01
transportation equipment	-11.7	-4.6	0.01	137.0	9.9	0.05
misc. manufactures	8.6	11.5	0.18	77.0	-9.4	0.17
weighted correlation with data		0.37	0.57	-0.29		0.16
regression coefficient *a*		-3.35	-11.44	117.50		125.30
regression coefficient *b*		1.28	153.31	-1.26		95.50

Changes in North American trade relative to exporter’s GDP

		BDS model			fraction least traded		
trade flow	**period**	**correlation**	***a***	***b***	**correlation**	***a***	***b***
Canada to Mexico	88–06	-0.32	178.63	-16.75	0.29	192.29	759.76
Canada to U.S.	88–06	-0.23	64.83	-2.70	0.29	29.74	144.11
Mexico to Canada	88–06	0.45	100.02	1.80	0.24	136.33	313.80
Mexico to U.S.	89–06	-0.14	49.49	-0.10	0.003	73.29	1.56
U.S. to Canada	88–06	0.37	-3.35	1.28	0.57	-11.44	153.31
U.S. to Mexico	89–06	-0.29	117.50	-1.26	0.16	125.30	95.50
weighted average -0.01			45.73	-0.83	0.33	33.03	125.09
pooled regression 0.02			46.19	0.04	0.23	33.27	123.87

In 1993 Ross Perot said

The reason that most U.S. policymakers are so blind to the job shifting that will occur if NAFTA is ratified is that they rely on dozens of "reputable" academic studies that say it won't happen. Yet these studies are based on unrealistic assumptions and flawed mathematical models…Let's be clear about this: these studies certainly do not provide a basis on which Congress can make an informed decision about NAFTA.

Ross Perot with Pat Choate, *Save Your Job, Save Our Country: Why NAFTA Must Be Stopped — Now!* 1993.

What Do We Learn from these Evaluations?

The Spanish model seems to have been far more successful in predicting the consequences of policy changes than the three models of NAFTA, but

- Kehoe, Polo, and Sancho (KPS) knew the structure of their model well enough to precisely identify the relationships between the variables in their model with those in the data;

- KPS were able to use the model to carry out numerical exercises to incorporate the impact of exogenous shocks.

KPS had an incentive to show their model in the best possible light.

Armington aggregator

$$x_i^{mex} = \theta_i \left(\alpha_{i,can}^{mex} x_{i,can}^{mex\ \rho} + \alpha_{i,mex}^{mex} x_{i,mex}^{mex\ \rho} + \alpha_{i,us}^{mex} x_{i,us}^{mex\ \rho} + \alpha_{i,rw}^{mex} x_{i,rw}^{mex\ \rho} \right)^{1/\rho}$$

Dixit-Stiglitz/Ethier aggregator

$$x_i^{mex} = \theta_i \left(\sum_{j=1}^{n_i} x_{i,j}^{mex\ \rho} \right)^{1/\rho}$$

modified to allow for home country bias

$$\begin{aligned} x_i^{mex} = \theta_i \Bigg(& \alpha_{i,can}^{mex} \sum_{j=1}^{n_{i,can}} x_{i,j,can}^{mex\ \rho} + \alpha_{i,mex}^{mex} \sum_{j=1}^{n_{i,mex}} x_{i,j,mex}^{mex\ \rho} \\ & + \alpha_{i,us}^{mex} \sum_{j=1}^{n_{i,us}} x_{i,j,us}^{mex\ \rho} + \alpha_{i,rw}^{mex} \sum_{j=1}^{n_{i,rw}} x_{i,j,rw}^{mex\ \rho} \Bigg)^{1/\rho} \end{aligned}$$

3. Much of the growth of trade after a trade liberalization experience is growth on the extensive margin. Models need to allow for corner solutions or fixed costs.

T. J. Kehoe and K. J. Ruhl, "How Important is the New Goods Margin in International Trade?" Federal Reserve Bank of Minneapolis, 2002.

What happens to the **least-traded** goods:

Over the business cycle?
During trade liberalization?

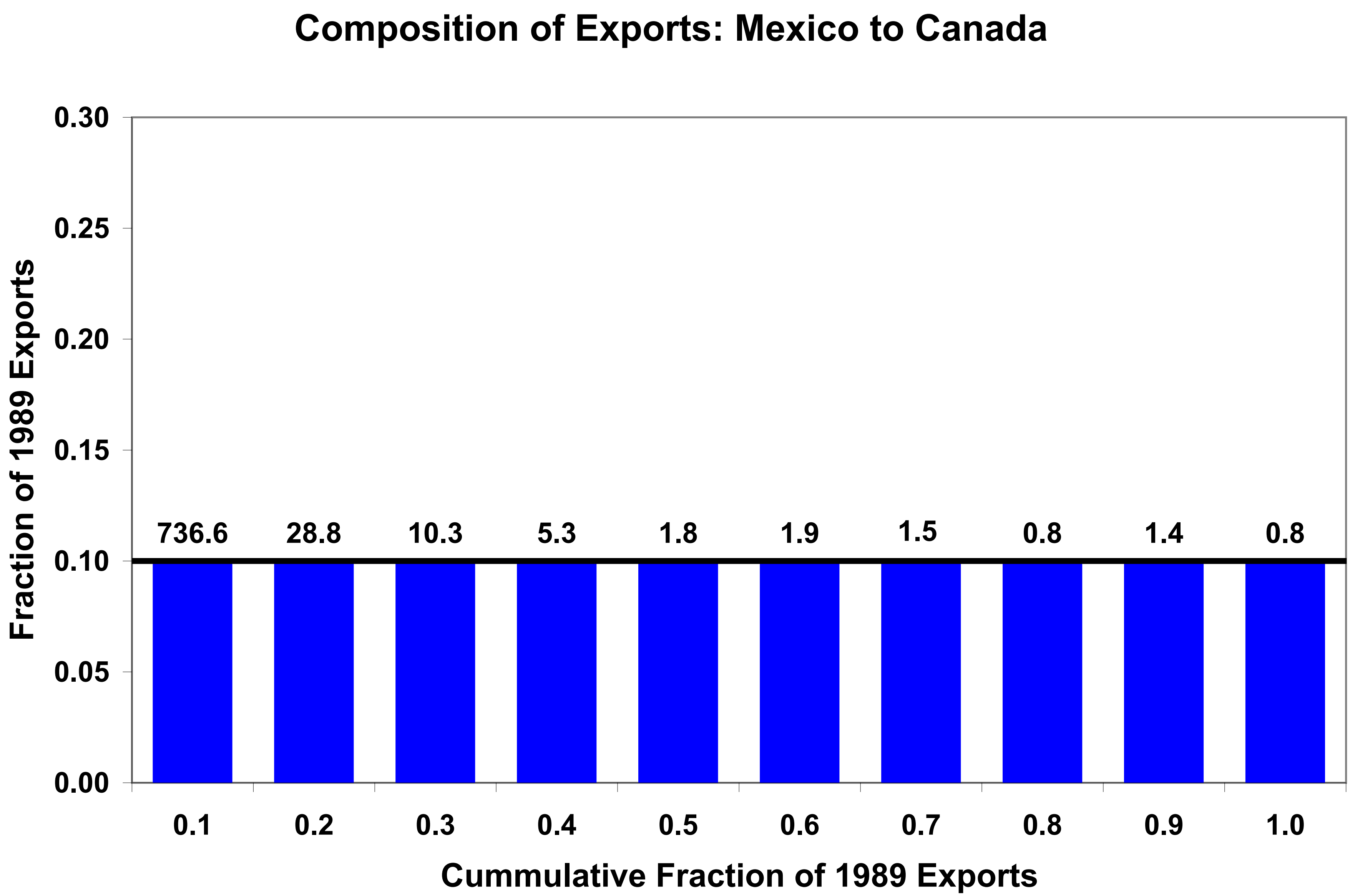
Indirect evidence on the extensive margin

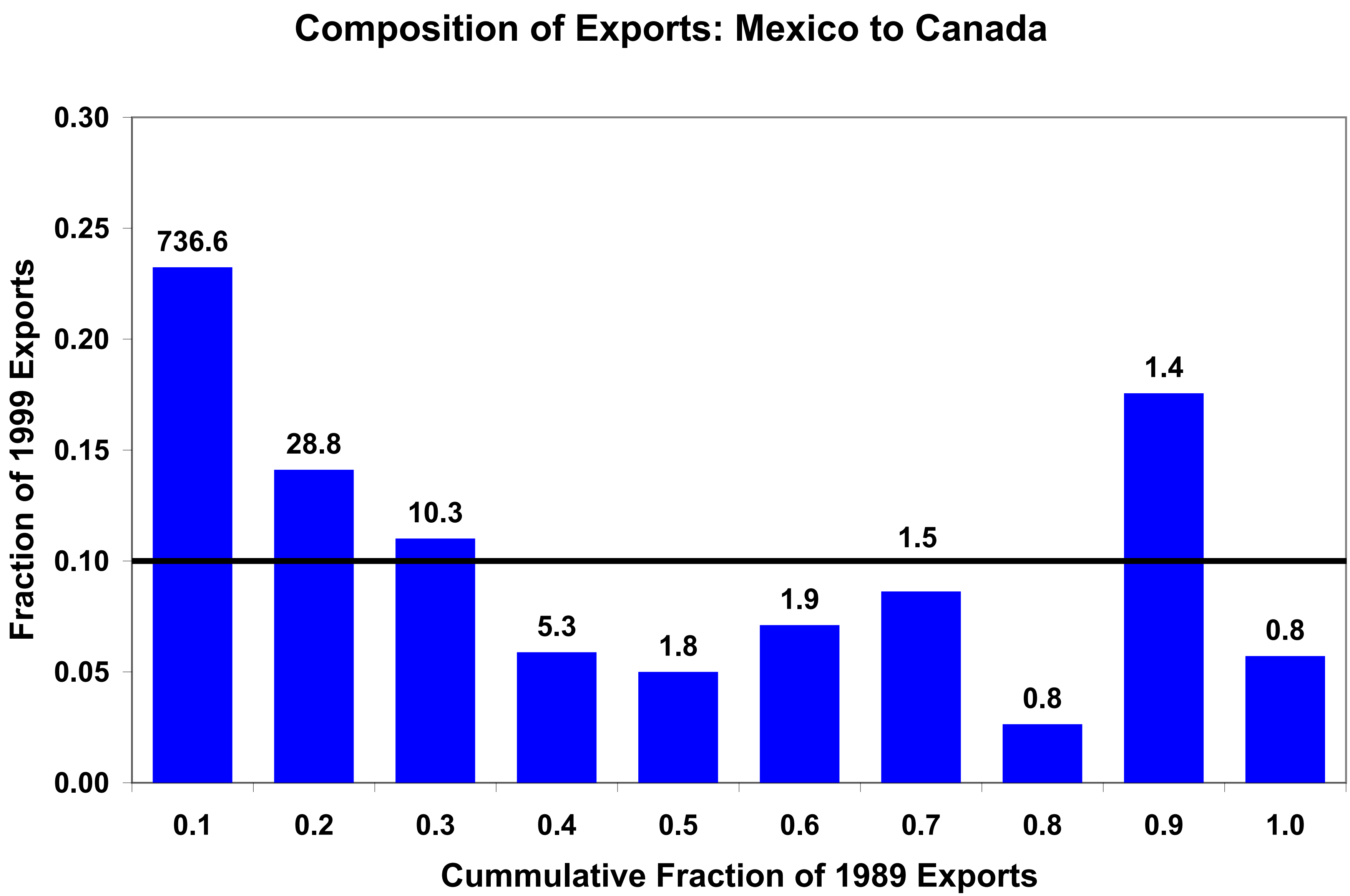
Evidence on the Extensive Margin

- Data
    - 4 digit SITC bilateral trade data (OECD)
    - 789 codes in revision 2

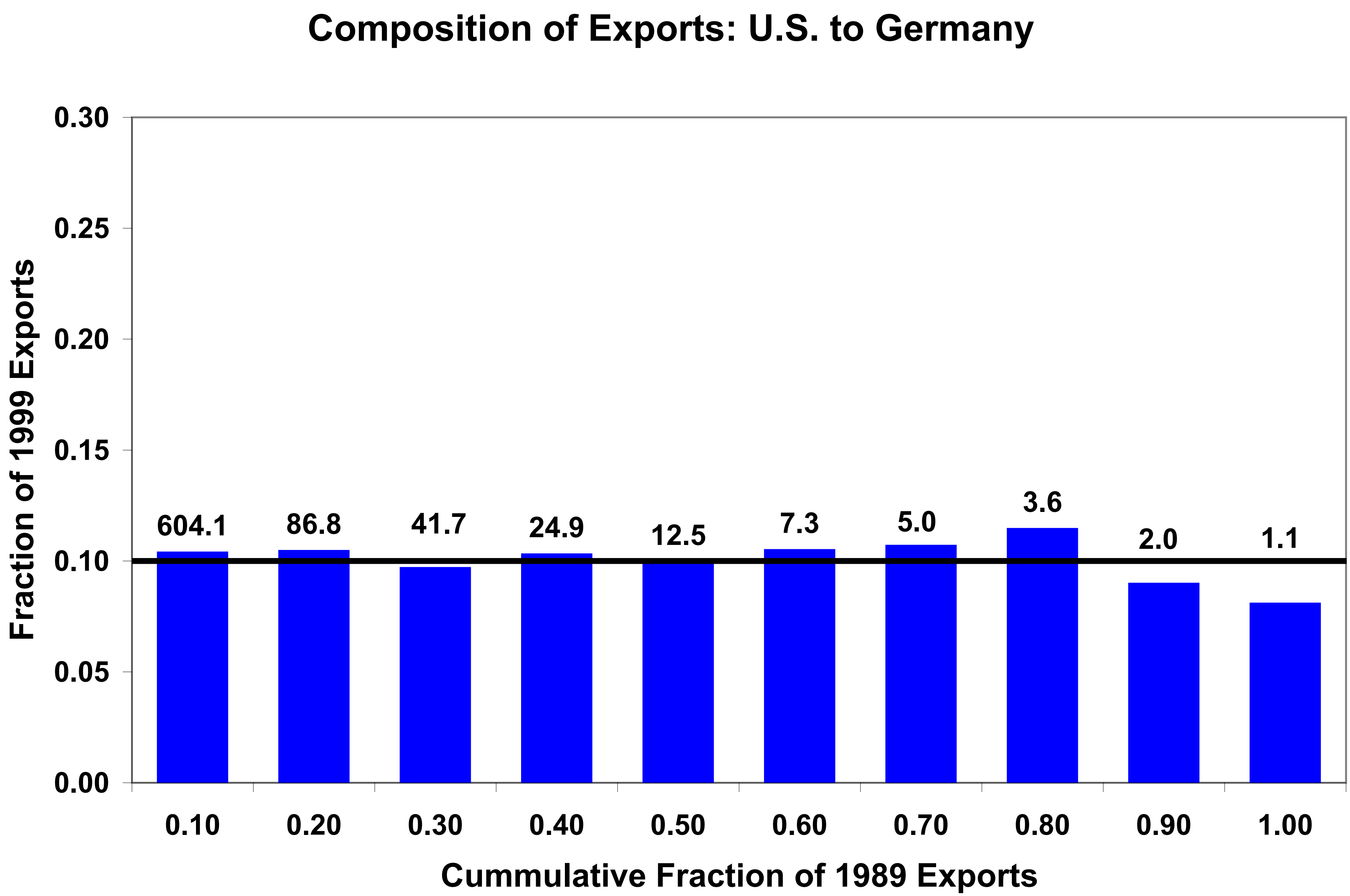
- Least Traded Goods
    - Look 5 years before trade agreement
    - Rank codes from lowest value of exports to highest based on average of first 3 years in sample
    - Lowest decile of codes = least-traded goods

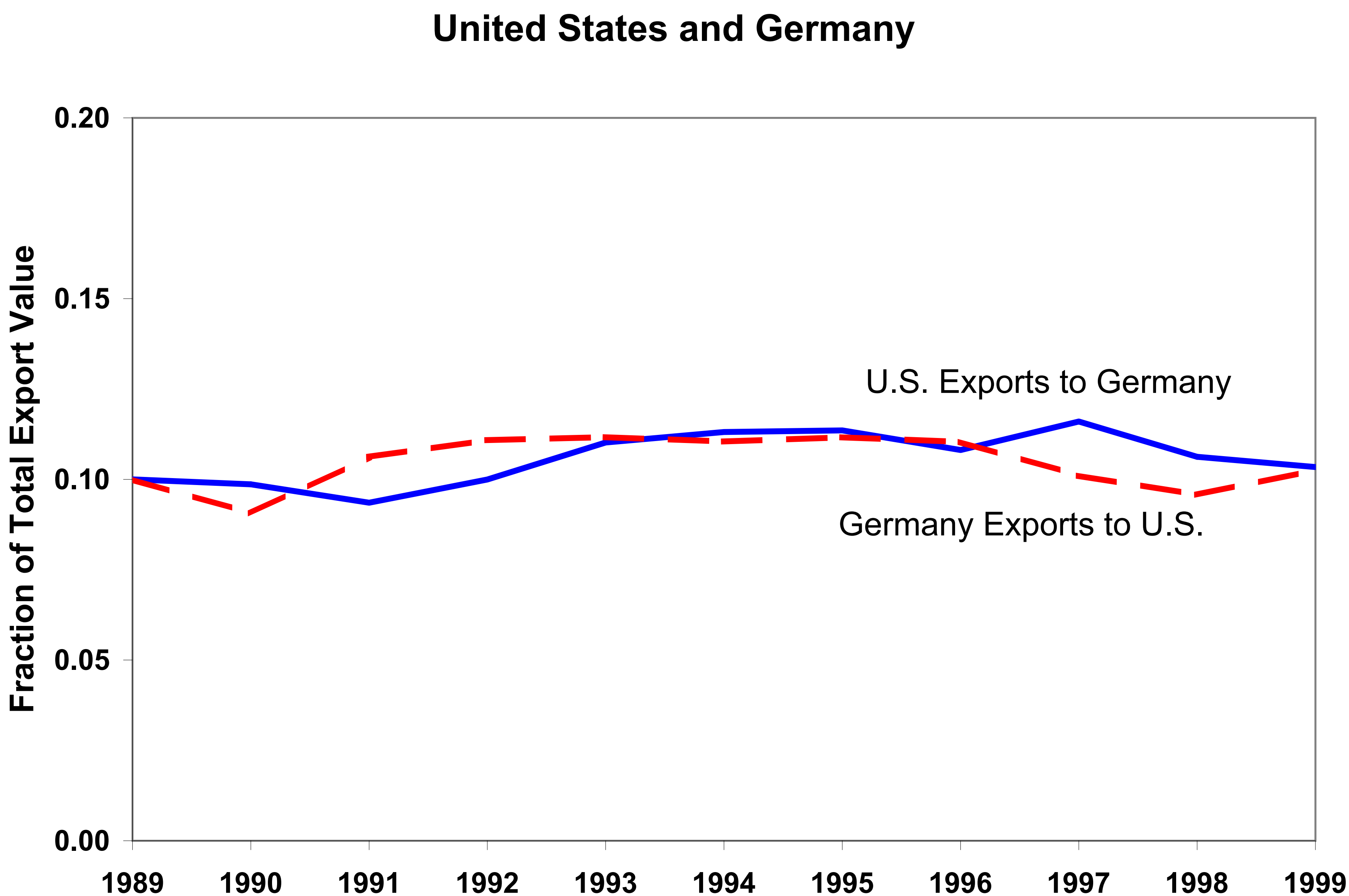
- Two Episodes
    - Canada-Mexico during NAFTA
    - United States-Germany in 1990s


Composition of Exports: Mexico to Canada
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Fraction of 1989 Exports
736.6
28.8
10.3
5.3
1.8
1.9
1.5
0.8
1.4
0.8
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Cummulative Fraction of 1989 Exports


Composition of Exports: Mexico to Canada
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Fraction of 1999 Exports
736.6
28.8
10.3
5.3
1.8
1.9
1.5
0.8
1.4
0.8
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Cummulative Fraction of 1989 Exports

Exports: Mexico to the Canada
Fraction of Total Export Value
0.30
0.20
0.10
0.00
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999


Composition of Exports: U.S. to Germany
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Fraction of 1999 Exports
604.1
86.8
41.7
24.9
12.5
7.3
5.0
3.6
2.0
1.1
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Cummulative Fraction of 1989 Exports

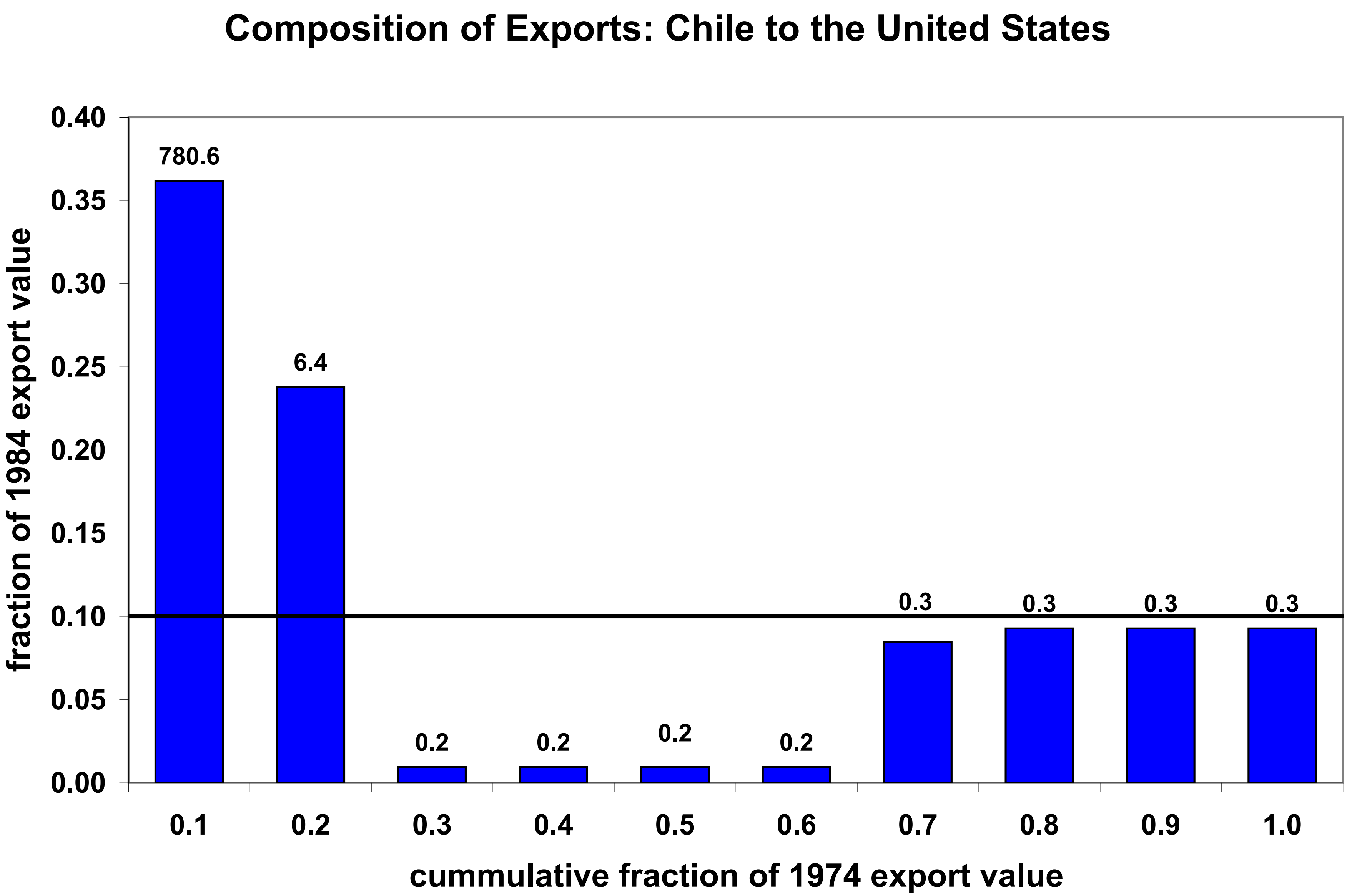

United States and Germany
Fraction of Total Export Value
0.20
0.15
0.10
0.05
0.00
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
U.S. Exports to Germany
Germany Exports to U.S.

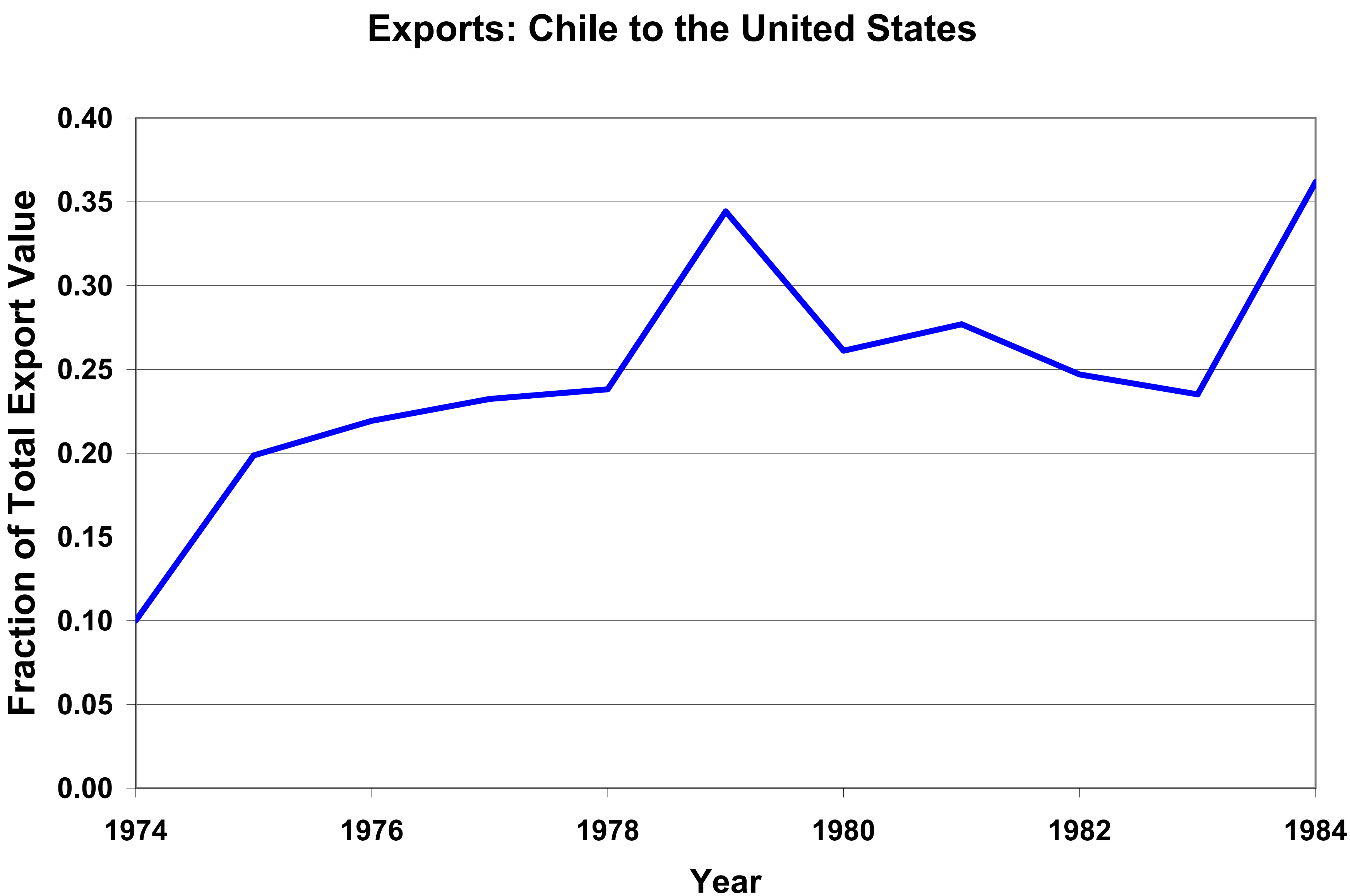
Lessons from data

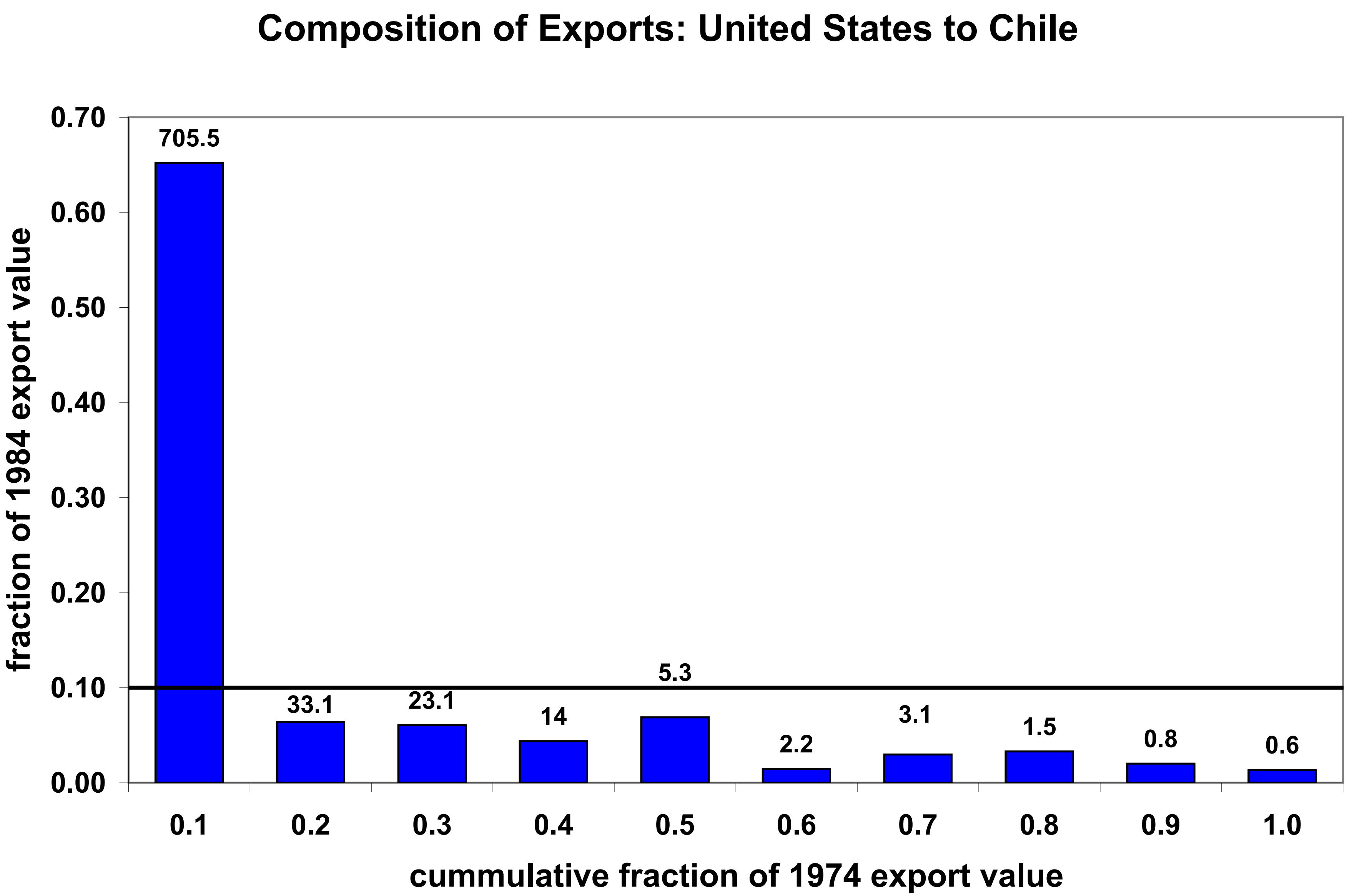
Trade liberalization increases trade on the extensive margin, business cycle fluctuations do not.

Structural changes may increase trade on the extensive margin.

A country increasing its exports on the extensive margin because of trade liberalization may increase its exports on the extensive margin to other countries.

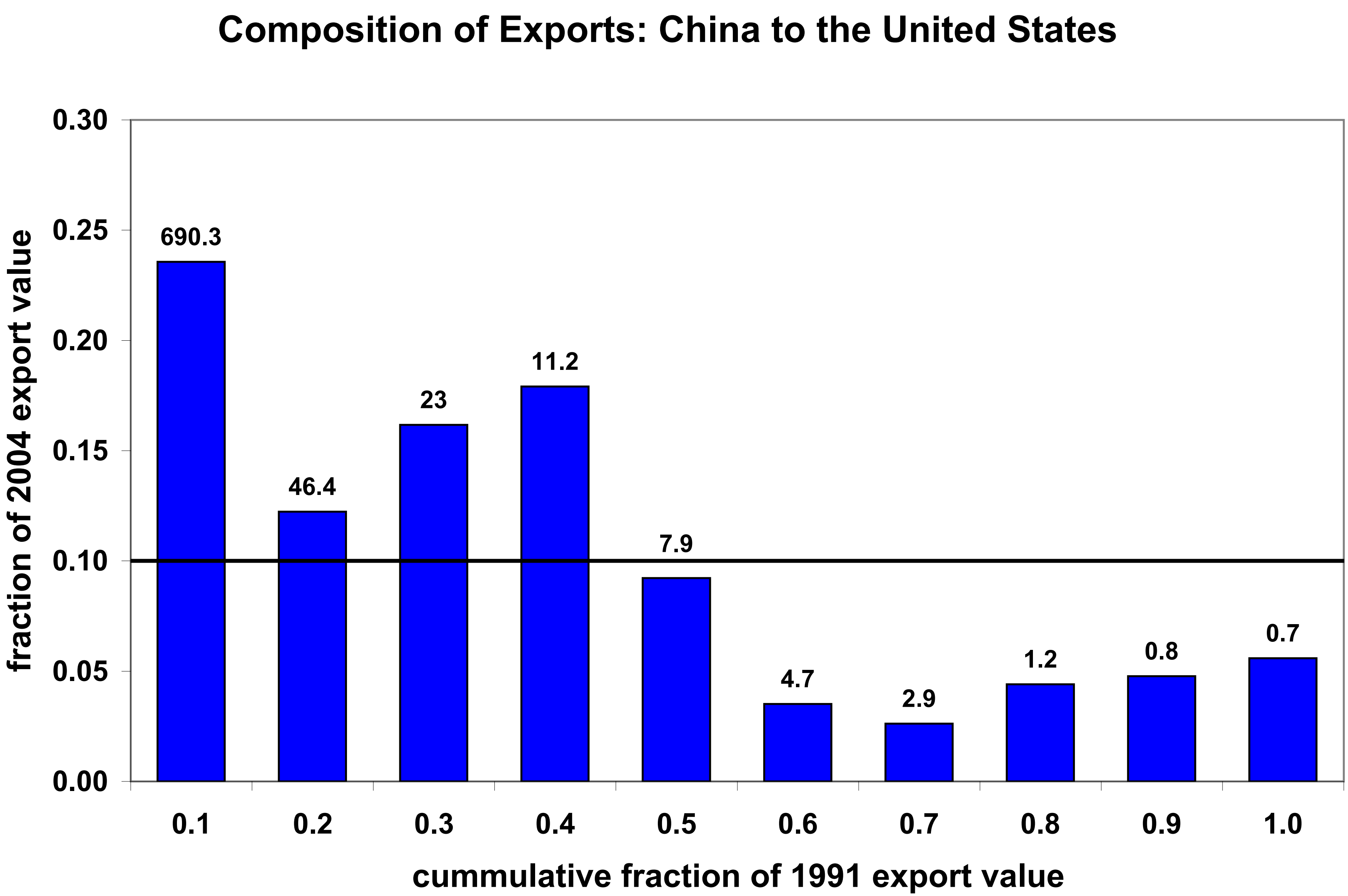

Composition of Exports: Chile to the United States
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
fraction of 1984 export value
780.6
6.4
0.2
0.2
0.2
0.2
0.3
0.3
0.3
0.3
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
cummulative fraction of 1974 export value

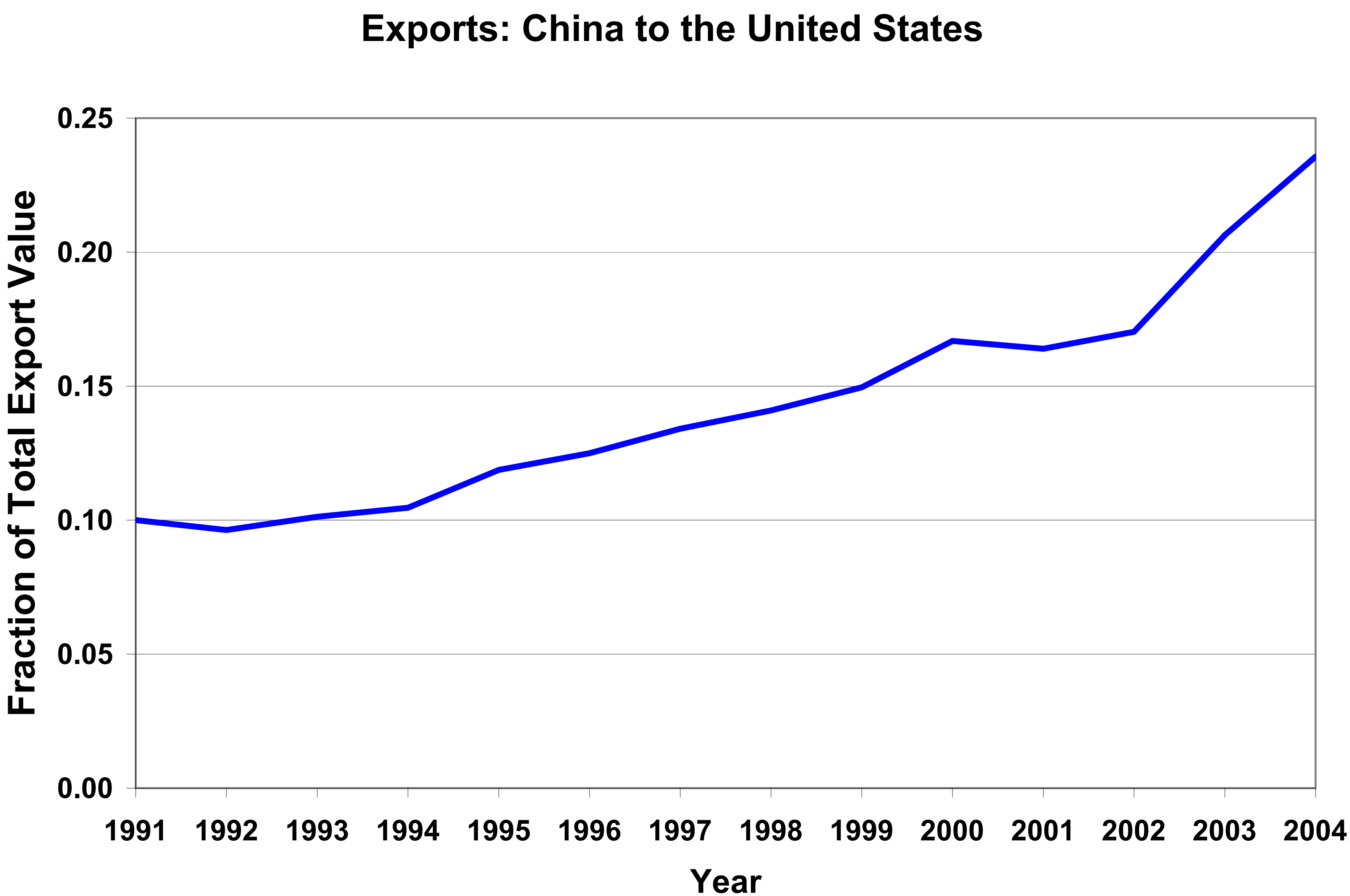

Exports: Chile to the United States
Fraction of Total Export Value
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1974
1976
1978
1980
1982
1984
Year

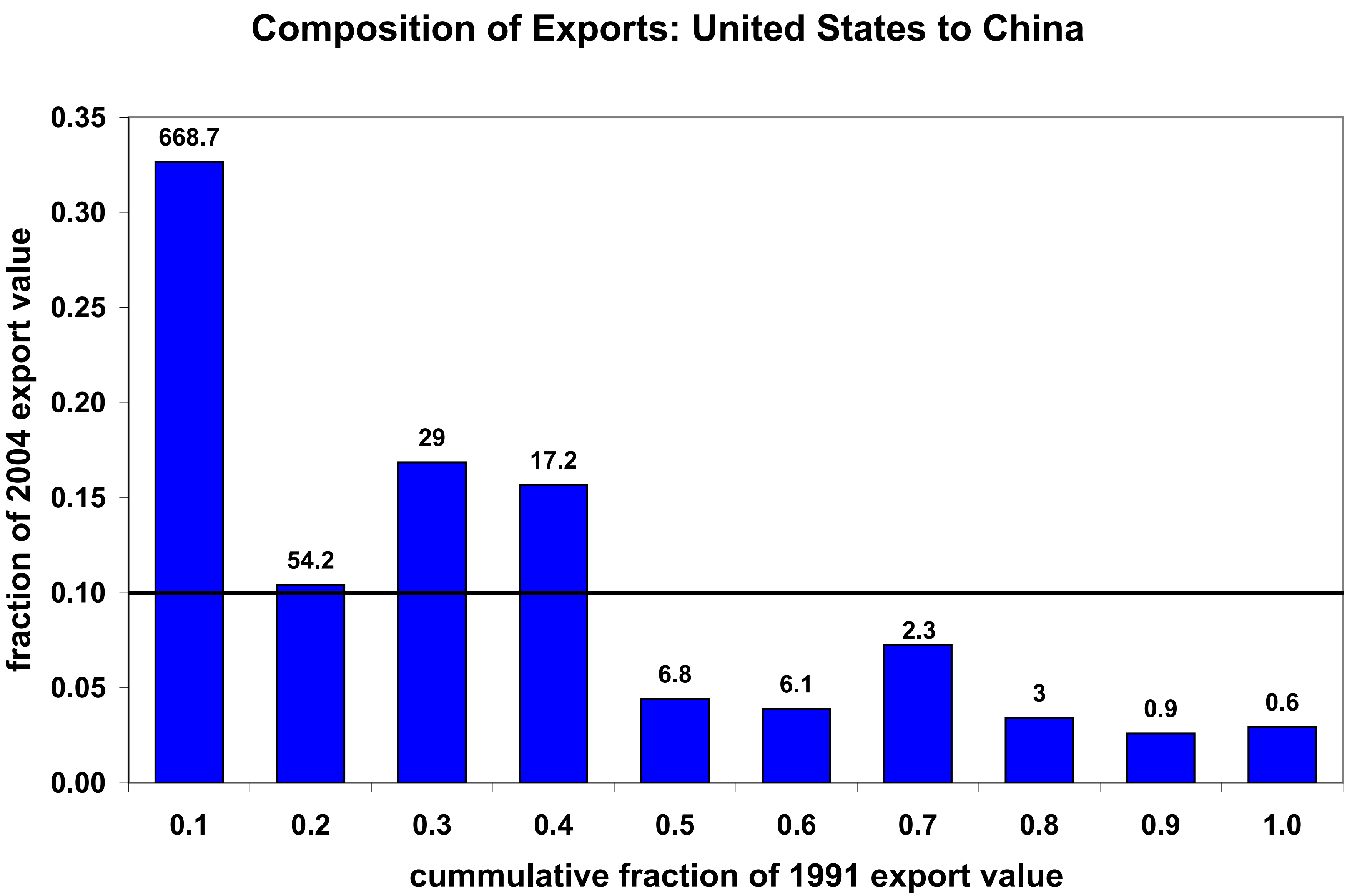


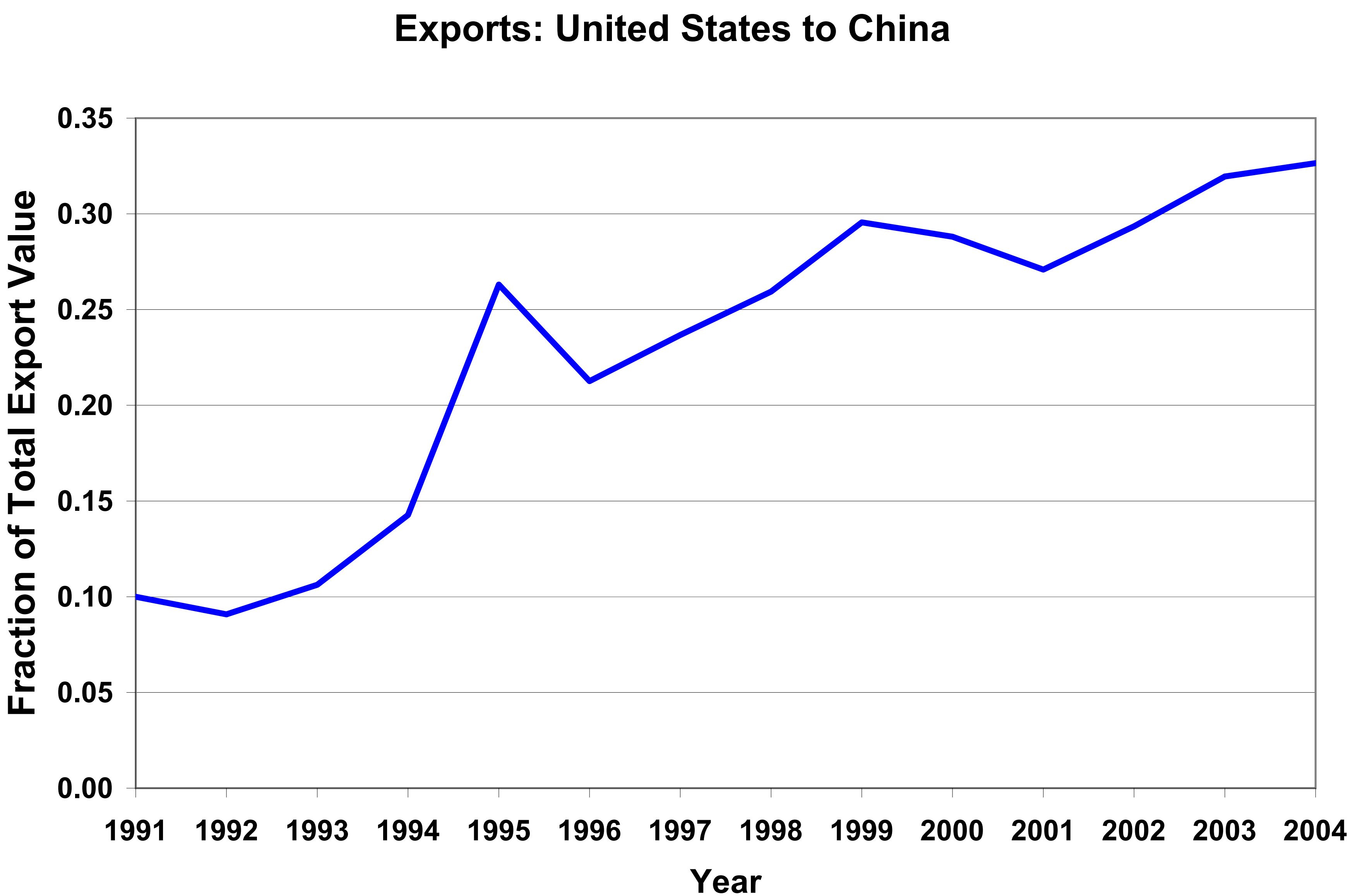
Composition of Exports: United States to Chile
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
fraction of 1984 export value
705.5
33.1
23.1
14
5.3
2.2
3.1
1.5
0.8
0.6
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
cummulative fraction of 1974 export value

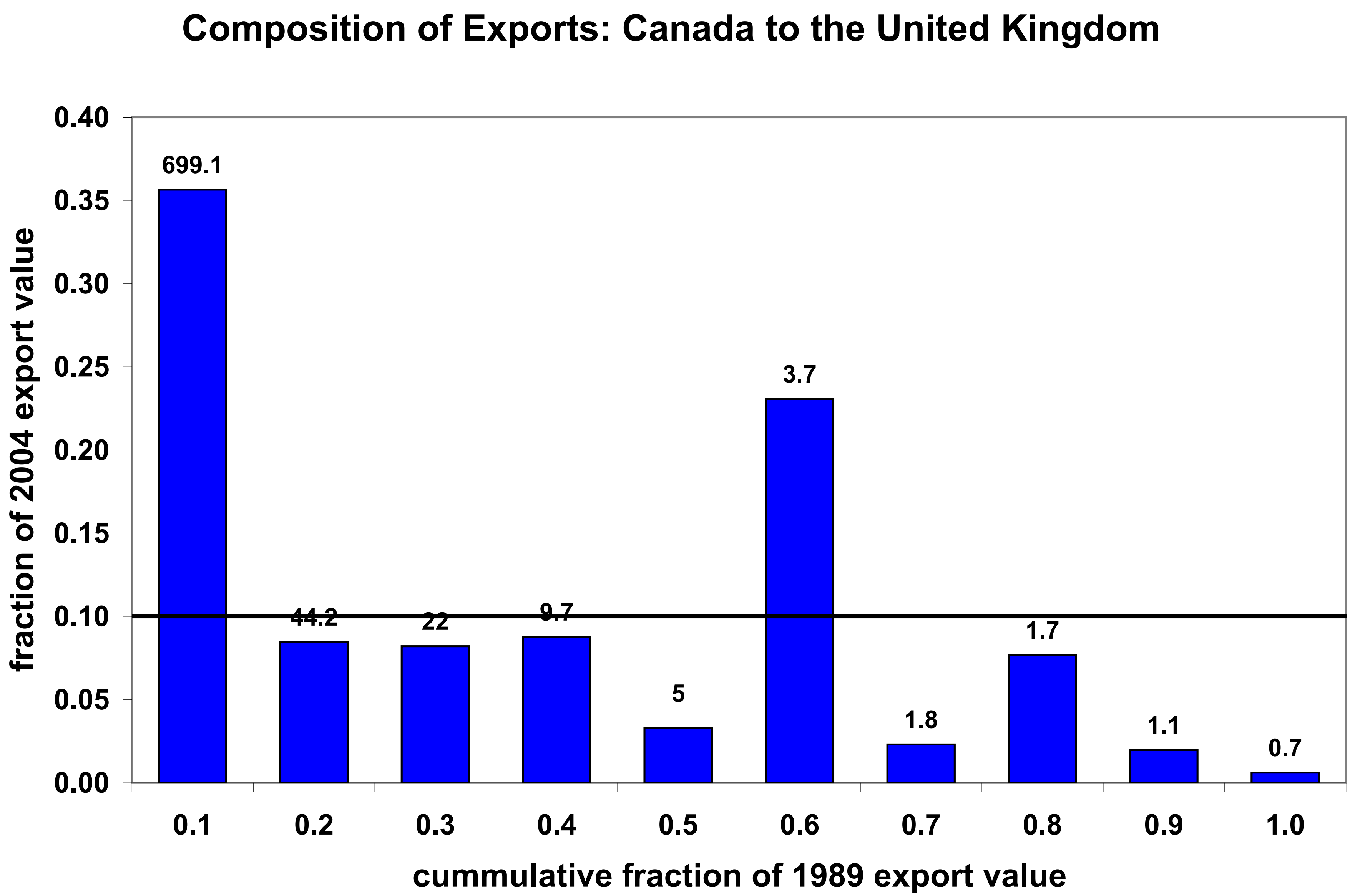
Exports: United States to Chile
Fraction of Total Export Value
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1974
1976
1978
1980
1982
1984
Year


Composition of Exports: China to the United States
0.30
0.25
0.20
0.15
0.10
0.05
0.00
fraction of 2004 export value
690.3
46.4
23
11.2
7.9
4.7
2.9
1.2
0.8
0.7
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
cummulative fraction of 1991 export value

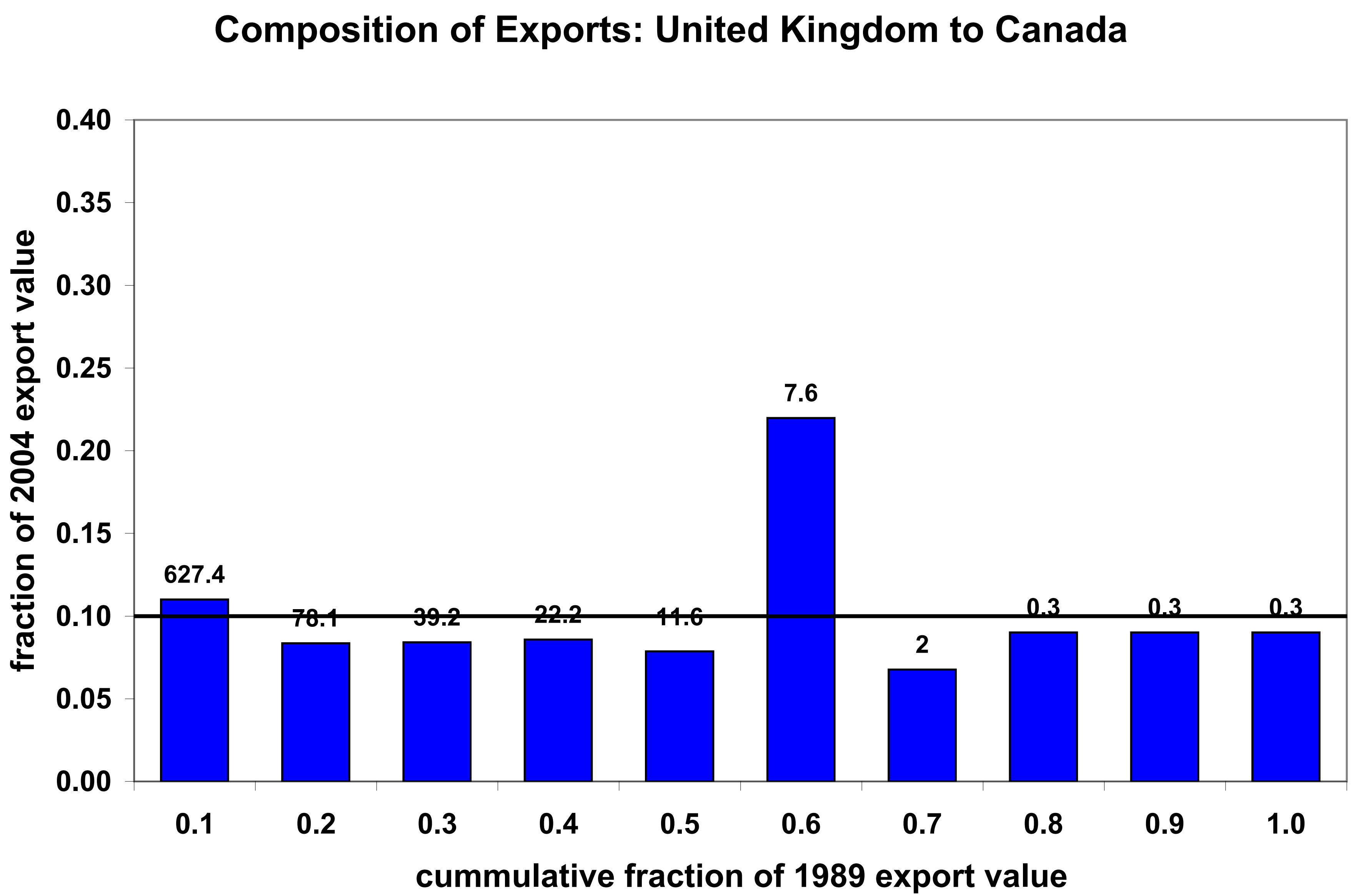

Exports: China to the United States
Fraction of Total Export Value
0.25
0.20
0.15
0.10
0.05
0.00
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Year


Composition of Exports: United States to China
fraction of 2004 export value
cummulative fraction of 1991 export value
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
668.7
54.2
29
17.2
6.8
6.1
2.3
3
0.9
0.6

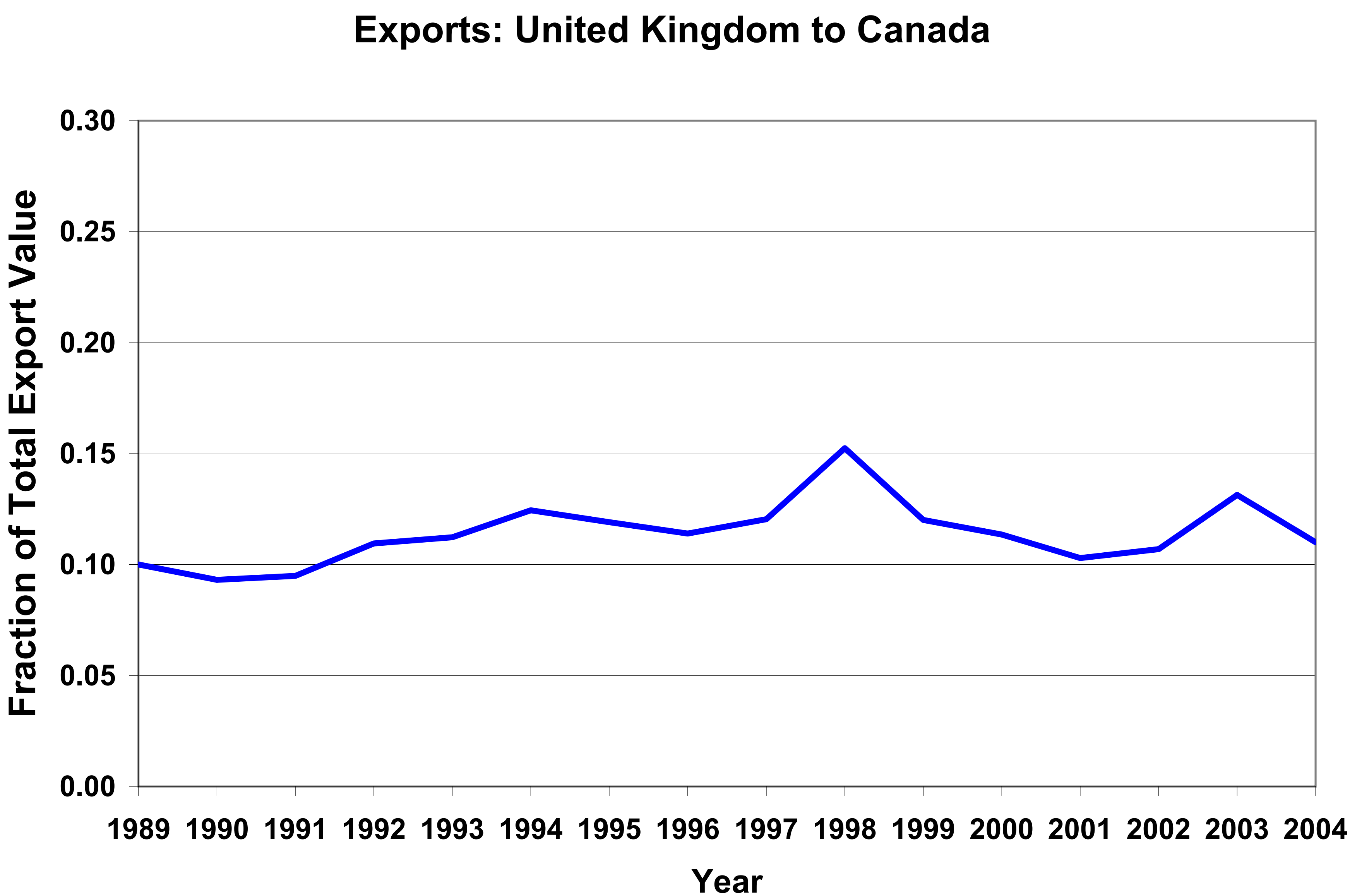

Exports: United States to China
Fraction of Total Export Value
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Year


Composition of Exports: Canada to the United Kingdom
fraction of 2004 export value
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
699.1
44.2
22
9.7
5
3.7
1.8
1.7
1.1
0.7
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
cummulative fraction of 1989 export value


Exports: Canada to the United Kingdom
Fraction of Total Export Value
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
Year



Composition of Exports: United Kingdom to Canada
fraction of 2004 export value
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
627.4
78.1
39.2
22.2
11.6
7.6
2
0.3
0.3
0.3
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
cummulative fraction of 1989 export value



Exports: United Kingdom to Canada
Fraction of Total Export Value
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Year

Ricardian model with a continuum of goods $x \in [0,1]$

production technologies $y(x) = \ell(x)/a(x)$, $y^*(x) = \ell^*(x)/a^*(x)$

ad valorem tariffs τ, τ^*

$$(1+\tau^*)wa(x) < w^* a^*(x) \Leftrightarrow \frac{a(x)}{a^*(x)} < \frac{w^*}{(1+\tau^*)w}$$

$\Rightarrow$home country produces good and exports it to the foreign country.

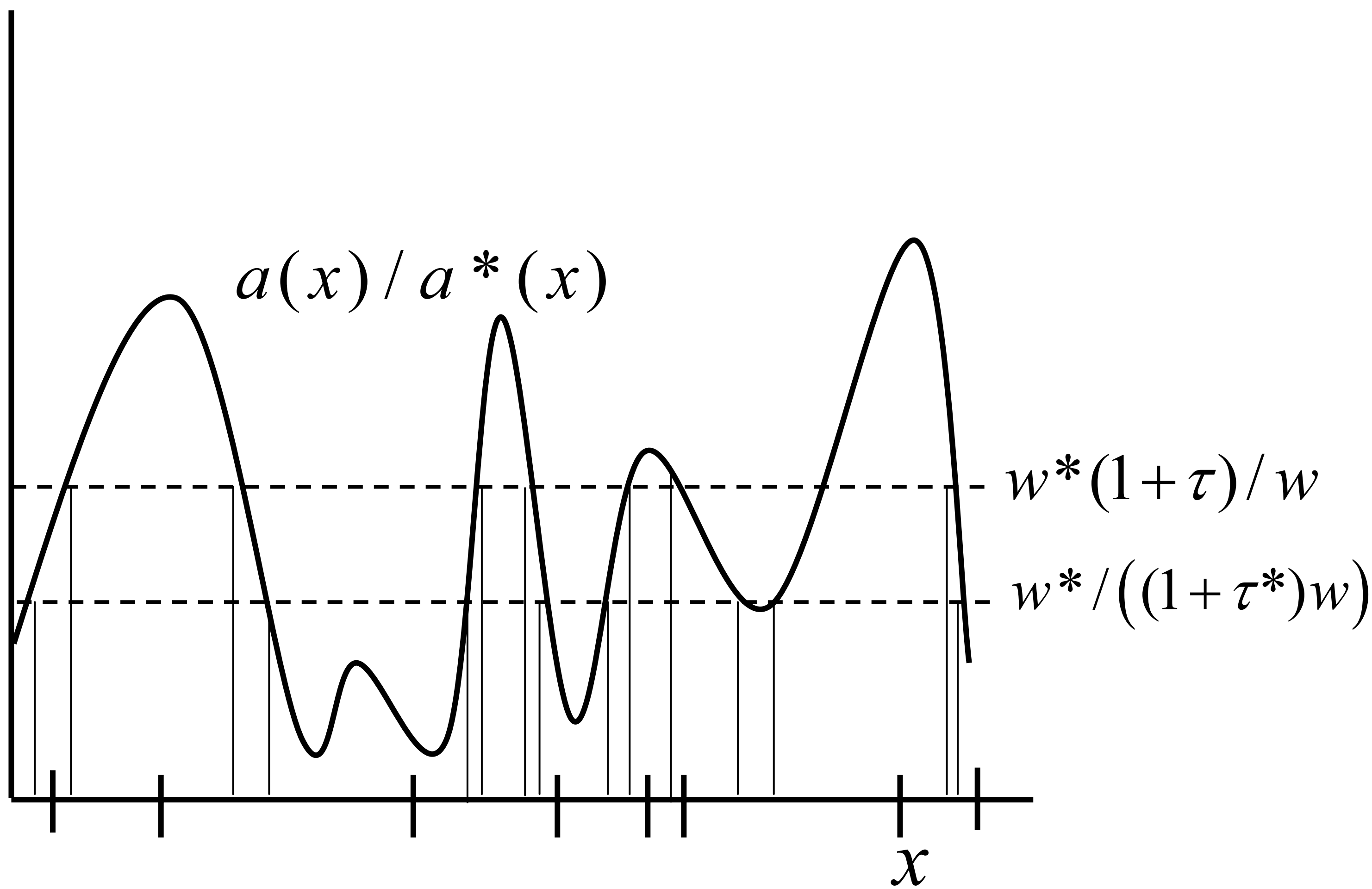
$$\frac{a(x)}{a^*(x)} > \frac{(1+\tau)w^*}{w}$$

$\Rightarrow$foreign country produces good and exports it to the home country.

$$\frac{(1+\tau)w^*}{w} > \frac{a(x)}{a^*(x)} > \frac{w^*}{(1+\tau^*)w}$$

$\Rightarrow$ good is not traded.

Lowering tariffs generates trade in previously nontraded goods.



4. Fixed costs seem better than Ricardian corner solutions for reconciling time series data on real exchange rate fluctuations with data on trade growth after liberalization experiences.

K. J. Ruhl, "Solving the Elasticity Puzzle in International Economics," University of Texas at Austin, 2005.

The "Armington" Elasticity

- Elasticity of substitution between domestic and foreign goods

- Crucial elasticity in international economic models

- International Real Business Cycle (IRBC) models:
    - Terms of trade volatility
    - Net exports and terms of trade co-movements

- Applied General Equilibrium (AGE) Trade models:
    - Trade response to tariff changes

The Elasticity Puzzle

- Time series (Business Cycles):
  - Estimates are low
  - Relative prices volatile
  - Quantities less volatile

- Panel studies (Trade agreement):
  - Estimates are high
  - Small change in tariffs (prices)
  - Large change in quantities

Time Series Estimates: Low Elasticity (1.5)

Study	Range
Reinert and Roland Holst (1992)	$\left[0.1, 3.5\right]$
Reinert and Shiells (1993)	$\left[0.1, 1.5\right]$
Gallaway et al. (2003)	$\left[0.2, 4.9\right]$

Trade Liberalization Estimates: High Elasticity (9.0)

Study	Range
Clausing (2001)	$\left[8.9, 11.0\right]$
Head and Reis (2001)	$\left[7.9, 11.4\right]$
Romalis (2002)	$\left[4.0, 13.0\right]$

Why do the Estimates Differ?

- Time series – no liberalization:
  - Change in trade volume from goods already traded
  - Change mostly on the *intensive margin*

- Trade liberalization:
  - Change in intensive margin *plus*
  - New types of goods being traded
  - Change on the *extensive margin*

Modeling the Extensive Margin

- Model: extensive margin from export entry costs
- Empirical evidence of entry costs
  - Roberts and Tybout (1997)
  - Bernard and Wagner (2001)
  - Bernard and Jensen (2003)
  - Bernard, Jensen and Schott (2003)

The Effects of Entry Costs

- Business cycle shocks:
  - Small extensive margin effect

- Trade liberalization:
  - Big extensive margin effect

- Asymmetry creates different empirical elasticities

Model Overview

- Two countries: $\{h, f\}$, with labor L
- Infinitely lived consumers
- No international borrowing/lending
- Continuum of traded goods plants in each country
    - Differentiated goods
    - Monopolistic competitors
    - Heterogeneous productivity
- Export entry costs
    - Differs across plants: second source of heterogeneity
- Non-traded good, competitive market: A
- Tariff on traded goods (iceberg): τ

Uncertainty

- At date t, H possible events, $\eta_t = 1,\ldots,\mathrm{H}$
- Each event is associated with a vector of productivity shocks:

$$z_t = \left[z_h(\eta_t), z_f(\eta_t) \right]$$

- First-order Markov process with transition matrix Λ

$$\lambda_{\eta\eta'} = \mathrm{pr}\left(\eta_{t+1} = \eta' \middle| \eta_t = \eta\right)$$

Traded Good Plants

- Traded good technology:

$$y(\phi,\kappa) = z\phi\, l$$

- Plant heterogeneity (ϕ,κ)
  - constant, idiosyncratic productivity: ϕ
  - export entry cost: κ
  - plant of type (ϕ,κ)

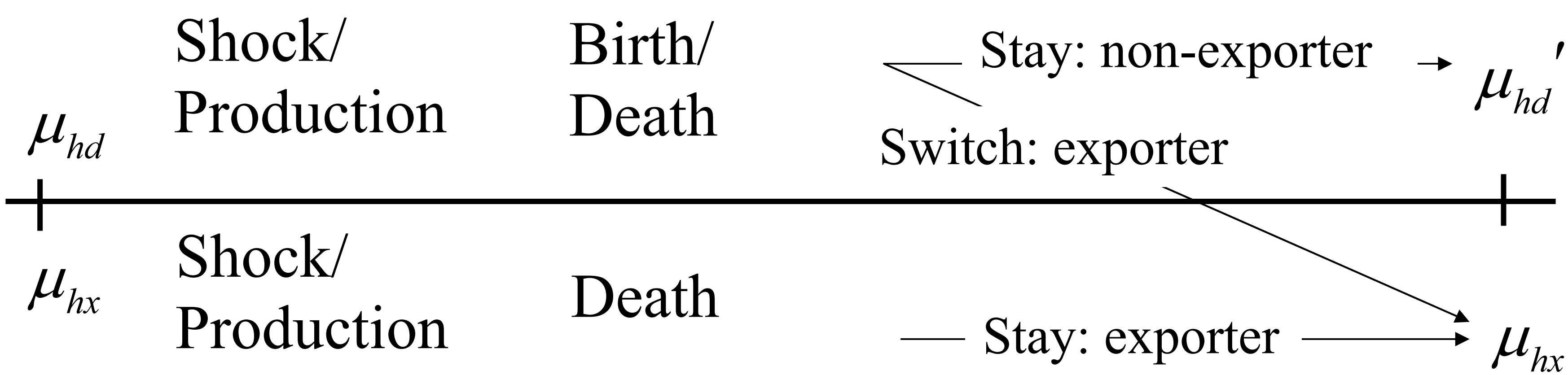
- ν plants born each period with distribution $F(\phi,\kappa)$
- Fraction δ of plants exogenously die each period

Timing

$\mu_{hx}(\phi,\kappa)$: plants of type (ϕ,κ) who paid entry cost

$\mu_{hd}(\phi,\kappa)$: plants of type (ϕ,κ) who have not paid entry cost

$\mu = (\mu_{hd}, \mu_{hx}, \mu_{fd}, \mu_{fx})$



Consumers

$$\max_{q, c_h^h(\imath), c_f^h(\imath)} \gamma \log\left(C\right) + \left(1-\gamma\right) \log\left(A\right)$$

s.t.

$$C = \left[\int_{\imath \in \mathrm{I}_h^h(\mu)} c_h^h\left(\imath\right)^{\rho} d\imath + \int_{\imath \in \mathrm{I}_f^h(\mu)} c_f^h\left(\imath\right)^{\rho} d\imath \right]^{\frac{1}{\rho}}$$

$$\int_{\imath \in \mathrm{I}_h^h(\mu)} p_h^h\left(\imath\right) c_h^h\left(\imath\right) d\imath + \int_{\imath \in \mathrm{I}_f^h(\mu)} \left(1+\tau\right) p_f^h\left(\imath\right) c_f^h\left(\imath\right) d\imath + p_{hA} A = L + \Pi_h$$

Non-traded Good

$$\max \; p_{hA}(\eta,\mu)A - l$$
$$\text{s.t. } A = z_h(\eta)l$$

Normalize $w_h = 1$, implying $p_{hA}(\eta,\mu) = z_h(\eta)$

Traded Goods: Static Profit Maximization

$$\pi_d\left(p_h^h, l; \phi, \kappa, \eta, \mu\right) = \max_{p_h^h,\, l} \; p_h^h z(\eta)\phi l - l$$

$$\text{s.t.} \qquad z(\eta)\phi l = \tilde{c}_h^h\left(p_h^h; \eta, \mu\right)$$

$$\pi_x\left(p_h^f, l; \phi, \kappa, \eta, \mu\right) = \max_{p_h^f,\, l} \; p_h^f z(\eta)\phi l - l$$

$$\text{s.t.} \qquad z(\eta)\phi l = \tilde{c}_h^f\left(p_h^f; \eta, \mu\right)$$

Pricing rules:

$$p_h^h(\phi, \kappa, \eta, \mu) = p_h^f(\phi, \kappa, \eta, \mu) = \frac{1}{\rho\phi z(\eta)}$$

Dynamic Choice: Export or Sell Domestically

- Exporter's Value Function:

$$V_x(\phi,\kappa,\eta,\mu) = d(\eta,\mu)\Big(\pi_d(\phi,\kappa,\eta,\mu) + \pi_x(\phi,\kappa,\eta,\mu)\Big)$$
$$+(1-\delta)\beta\sum_{\eta'} V_x(\phi,\kappa,\eta',\mu')\lambda_{\eta\eta'}$$

s.t. $\mu' = \mathrm{M}(\eta,\mu)$

- $d(\eta,\mu)$ = multiplier on budget constraint

• Non-exporter's Value Function:

$$
\begin{aligned}
V_d(\phi,\kappa,\eta,\mu) = & \\
& \max\Big\{\pi_d(\phi,\kappa,\eta,\mu)\,d(\eta,\mu)+\beta(1-\delta)\sum_{\eta'}V_d(\phi,\kappa,\eta',\mu')\lambda_{\eta\eta'}, \\
& \quad \big[\pi_d(\phi,\kappa,\eta,\mu)-\kappa\big]d(\eta,\mu)+\beta(1-\delta)\sum_{\eta'}V_x(\phi,\kappa,\eta',\mu')\lambda_{\eta\eta'}\Big\}
\end{aligned}
$$

s.t. $\mu' = \mathrm{M}(\eta,\mu)$

Equilibrium

- Cutoff level of productivity for each value of the entry cost
- For a plant of type (ϕ, κ)

$$\text{If } \phi \geq \hat{\phi}_{\kappa}(\eta, \mu) \text{ export and sell domestically}$$

$$\text{If } \phi < \hat{\phi}_{\kappa}(\eta, \mu) \text{ only sell domestically}$$

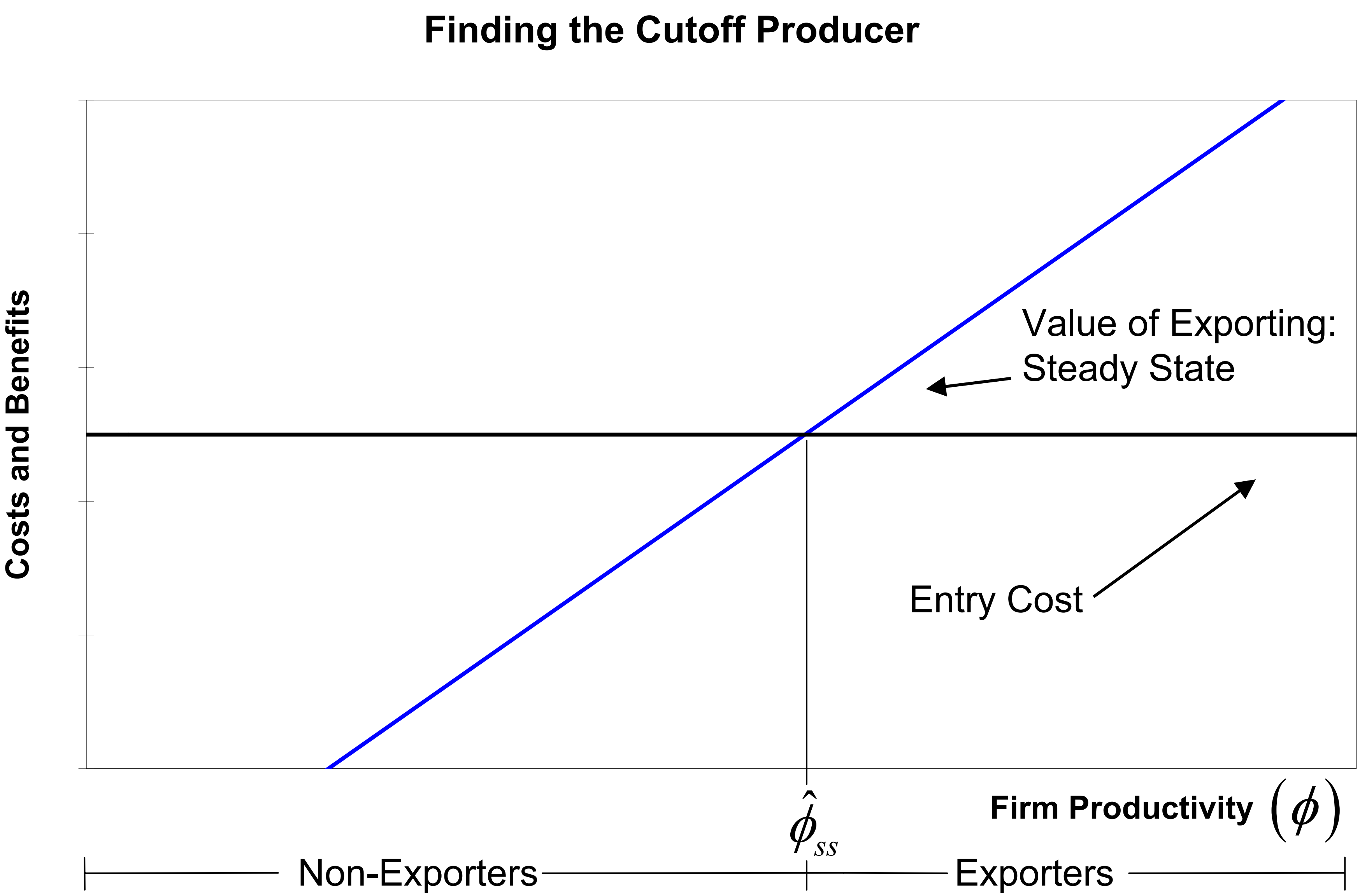
- In Equilibrium
  - "Low" productivity/"high" entry cost plants sell domestic
  - "High" productivity/"low" entry cost plants also export
  - Similar to Melitz (2003)

Determining Cutoffs

- For the cutoff plant:
  - entry cost = discounted, expected value of exporting

- $\hat{\phi}_\kappa(\eta,\mu)$ is the level of productivity, ϕ, that solves:

$$\underbrace{d\,(\eta,\mu)\kappa}_{\text{entry cost}} = \underbrace{(1-\delta)\beta\left[\sum_{\eta'} V_x(\phi,\kappa,\eta',\mu')\lambda_{\eta\eta'} - \sum_{\eta'} V_d(\phi,\kappa,\eta',\mu')\lambda_{\eta\eta'}\right]}_{\text{expected value of exporting}}$$


Finding the Cutoff Producer
Costs and Benefits
Value of Exporting:
Steady State
Entry Cost
Firm Productivity (ϕ)
$\hat{\phi}_{ss}$
Non-Exporters
Exporters

Choosing Parameters

- Set $\sigma = \dfrac{1}{1-\rho} = 2$ and $\tau = 0.15$
- Calibrate to the United States (1987) and a symmetric partner.

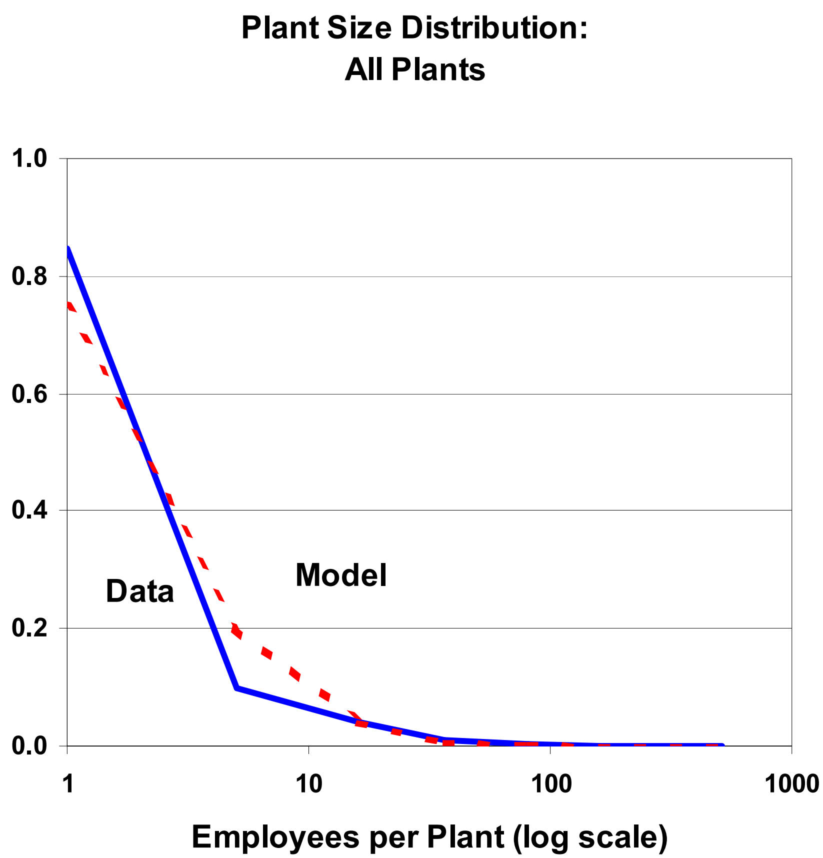
Parameters	
β	Annual real interest rate (4%)
γ	Share of manufactures in GDP (18%)
δ	Annual loss of jobs from plant deaths as percentage of employment (Davis et. al., 1996) (6%)

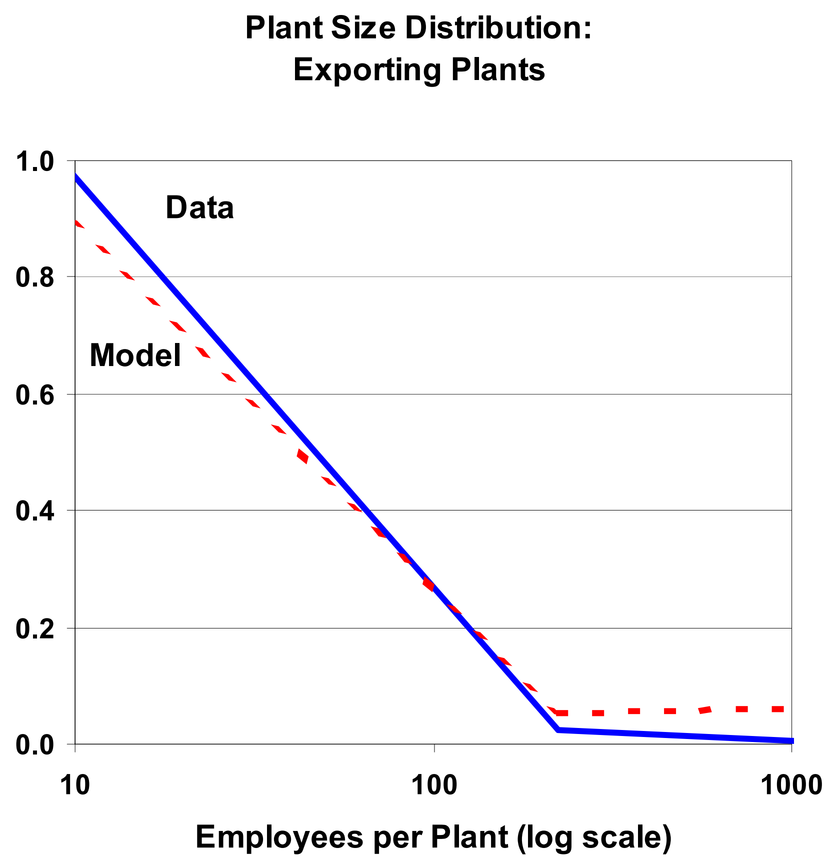
Other Parameters

- Distribution over new plants:

$$F_{\kappa}(\phi) = \frac{1}{\phi^{\theta_{\phi}}} \qquad\qquad F_{\phi}(\kappa) = \frac{1}{\left(\bar{\kappa} - \kappa\right)^{\theta_{\kappa}}}$$

- $\bar{\kappa}$, $\bar{\phi}$, ν, $\theta_{\phi}, \theta_{\kappa}$ jointly determine:
    - Average plant size (12 employees)
    - Standard deviation of plant sizes (892)
    - Average exporting plant size (15 employees)
    - Standard deviation of exporting plant sizes (912)
    - Fraction of production that is exported (9%)


Plant Size Distribution:
All Plants
1.0
0.8
0.6
0.4
0.2
0.0
1
10
100
1000
Data
Model
Employees per Plant (log scale)


Plant Size Distribution:
Exporting Plants
1.0
0.8
0.6
0.4
0.2
0.0
10
100
1000
Data
Model
Employees per Plant (log scale)

Productivity Process

- Two shocks, low and high:

$$z_i = 1 - \varepsilon$$

$$z_i = 1 + \varepsilon$$

- Countries have symmetric processes with Markov Matrix

$$\Lambda_i = \begin{bmatrix} \bar{\lambda} & 1-\bar{\lambda} \\ 1-\bar{\lambda} & \bar{\lambda} \end{bmatrix}$$

- ε: standard deviation of the U.S. Solow Residuals (1.0%)
- $\bar{\lambda}$: autocorrelation of the U.S. Solow Residuals (0.90)

How does Trade Liberalization Differ from Business Cycles?

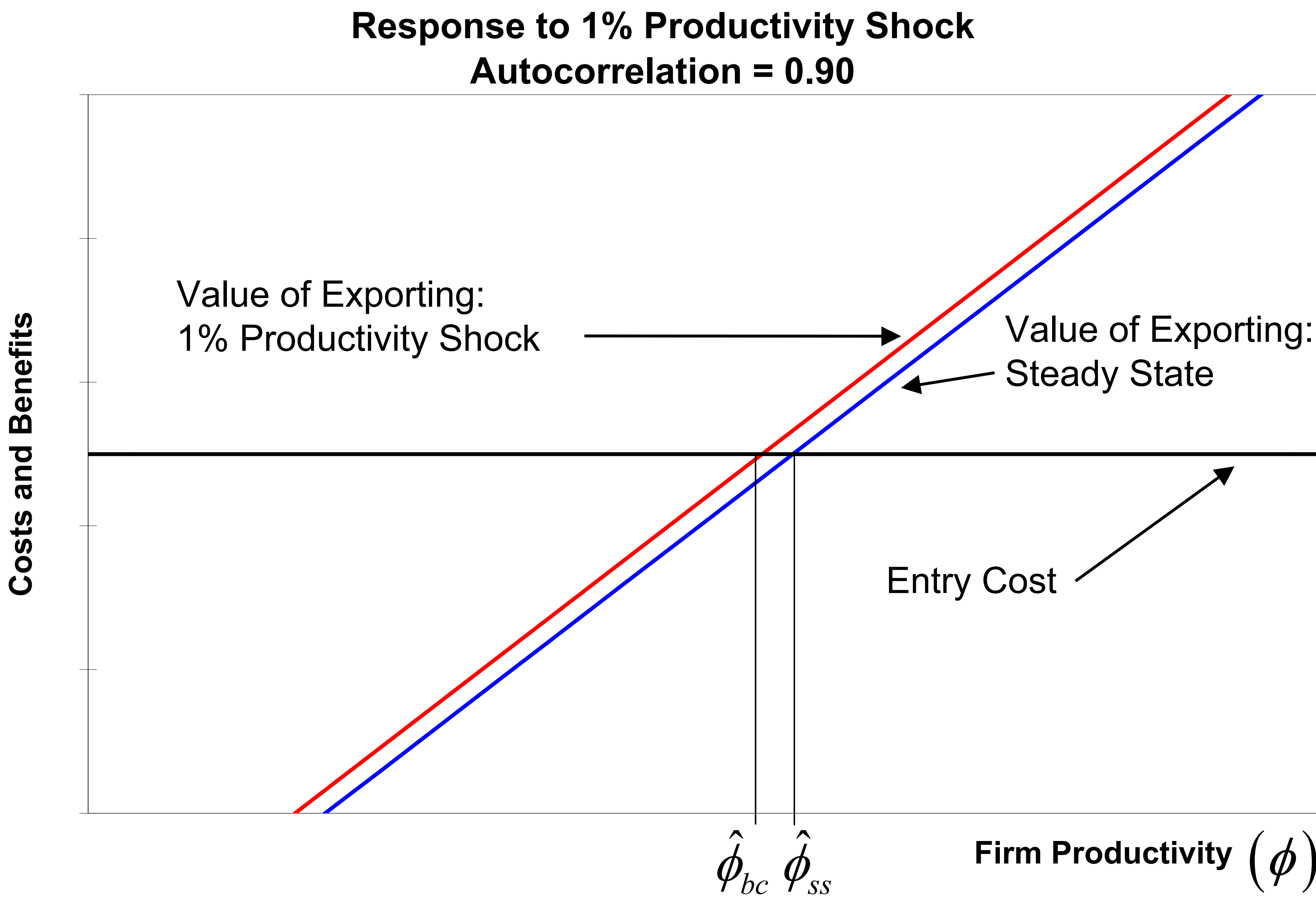
- Trade liberalization
  - Permanent changes
  - Large magnitudes

- Business cycles
  - Persistent, but not permanent changes
  - Small magnitudes

Developing Intuition: Persistent vs. Permanent Shocks

- 1% positive productivity shock in foreign country
  - Shock is persistent – autocorrelation of 0.90

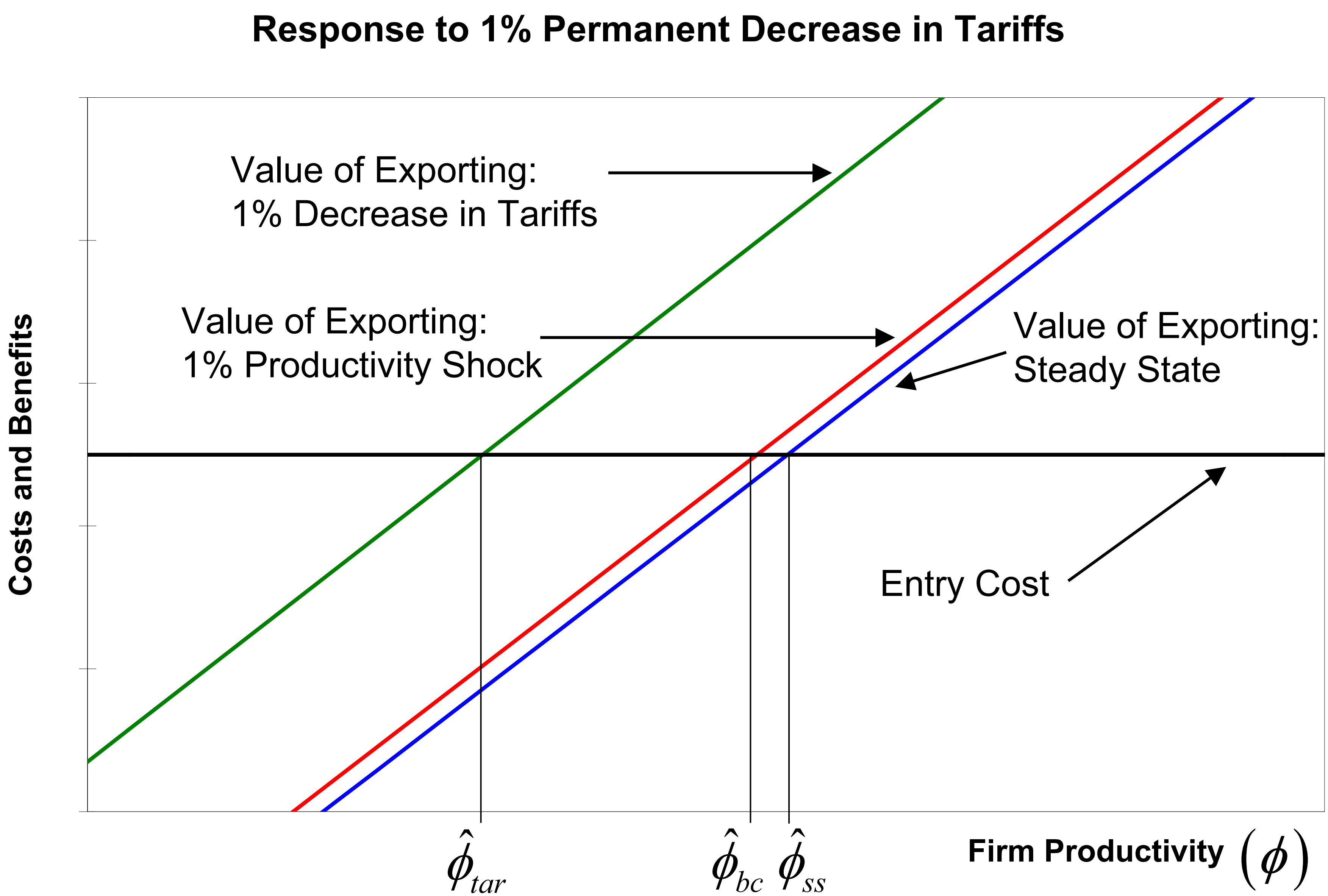
- 1% decrease in tariffs
  - Change in tariffs is permanent


Response to 1% Productivity Shock
Autocorrelation = 0.90
Costs and Benefits
Value of Exporting:
1% Productivity Shock
Value of Exporting:
Steady State
Entry Cost
$\hat{\phi}_{bc}$ $\hat{\phi}_{ss}$
Firm Productivity (ϕ)

Response to a 1% Foreign Productivity Shock

Increase in imports on intensive margin	=	1.89%
Increase in imports on extensive margin	=	0.16%
Total increase in imports	=	2.05%
Change in consumption of home goods	=	-0.10%

$$\frac{\text{\% Change Imports/Dom. Cons.}}{\text{\% Change Price}} = \frac{2.17}{0.99} = 2.19$$


Response to 1% Permanent Decrease in Tariffs
Value of Exporting:
1% Decrease in Tariffs
Value of Exporting:
1% Productivity Shock
Value of Exporting:
Steady State
Entry Cost
Costs and Benefits
$\hat{\phi}_{tar}$
$\hat{\phi}_{bc}$
$\hat{\phi}_{ss}$
Firm Productivity (ϕ)

Response to a 1% Tariff Reduction

Increase in imports on intensive margin	=	1.42%
Increase in imports on extensive margin	=	3.04%
Total increase in imports	=	4.46%
Change in consumption of home goods	=	-0.33%

$$\frac{\text{\% Change Imports/Dom. Cons.}}{\text{\% Change Tariff}} = \frac{4.81}{1.00} = 4.81$$

Quantitative Results

- Two experiments

- Trade liberalization
    - Eliminate 15% tariff
    - Compute elasticity across tariff regimes

- Time series regressions
    - Use model to generate simulated data
    - Estimate elasticity as in the literature

Trade Liberalization Elasticity

Variable	Entry Costs (% change)	No Entry Costs (% change)
Exports	87.1	30.5
Imports/Dom. Cons.	93.0	32.2
Exporting Plants	37.7	0.0
Implied Elasticity	6.2	2.1

Elasticity in the Time Series

- Simulate: produce price/quantity time series
- Regress:

$$\log\left(C_{f,t} / C_{h,t}\right) = \alpha + \sigma \log\left(p_{h,t} / p_{f,t}\right) + \varepsilon_t$$

Parameter	Estimate
α (standard error)	-0.015 (6.36e-04)
σ (standard error)	1.39 (0.06)
R- squared	0.30

Conclusion

- Gap between dynamic macro models and trade models
  - Partially closes the gap
  - Modeling firm behavior as motivated by the data
  - Step towards better modeling of trade policy

- Single model can account for the elasticity puzzle
  - Time series elasticity of 1.4
  - Trade liberalization elasticity of 6.2

5. Models of trade with heterogeneous firms imposed fixed costs on firms that decide to export. The focus is on the decision to export. The theory and the data indicate that there is a lot of room for focusing on the decision to import.

A. Ramanarayanan, "International Trade Dynamics with Intermediate Inputs," University of Minnesota, 2006. http://www.econ.umn.edu/~tkehoe/papers/Ramanarayan.pdf.

Motivation

Dynamics of international trade flows

Long-run: Large, gradual changes
(tariff reform)

Short-run: Small changes
(fluctuations in relative prices)

Standard Theory: does not capture difference

Constant elasticity of substitution between imports and domestic goods

Question

What accounts for slow-moving dynamics of international trade flows?

This Paper's Answer

Trade in intermediate inputs

Costly, irreversible importing decision at producer-level

Previous Literature's Answers

Lags or costs of adjustment: contracting / distribution
Parameterize to generate slow-moving dynamics

This paper's contribution:
Model mechanism based on micro-level evidence

> Quantitative test of theory:
> Endogenous aggregate dynamics in line with data

Significance of Results

Effects of trade reform
1. Timing and magnitude of trade growth
2. Welfare gains

Data: Aggregate Dynamics

Armington (1969) elasticity: elasticity of substitution between aggregate imported and domestic goods

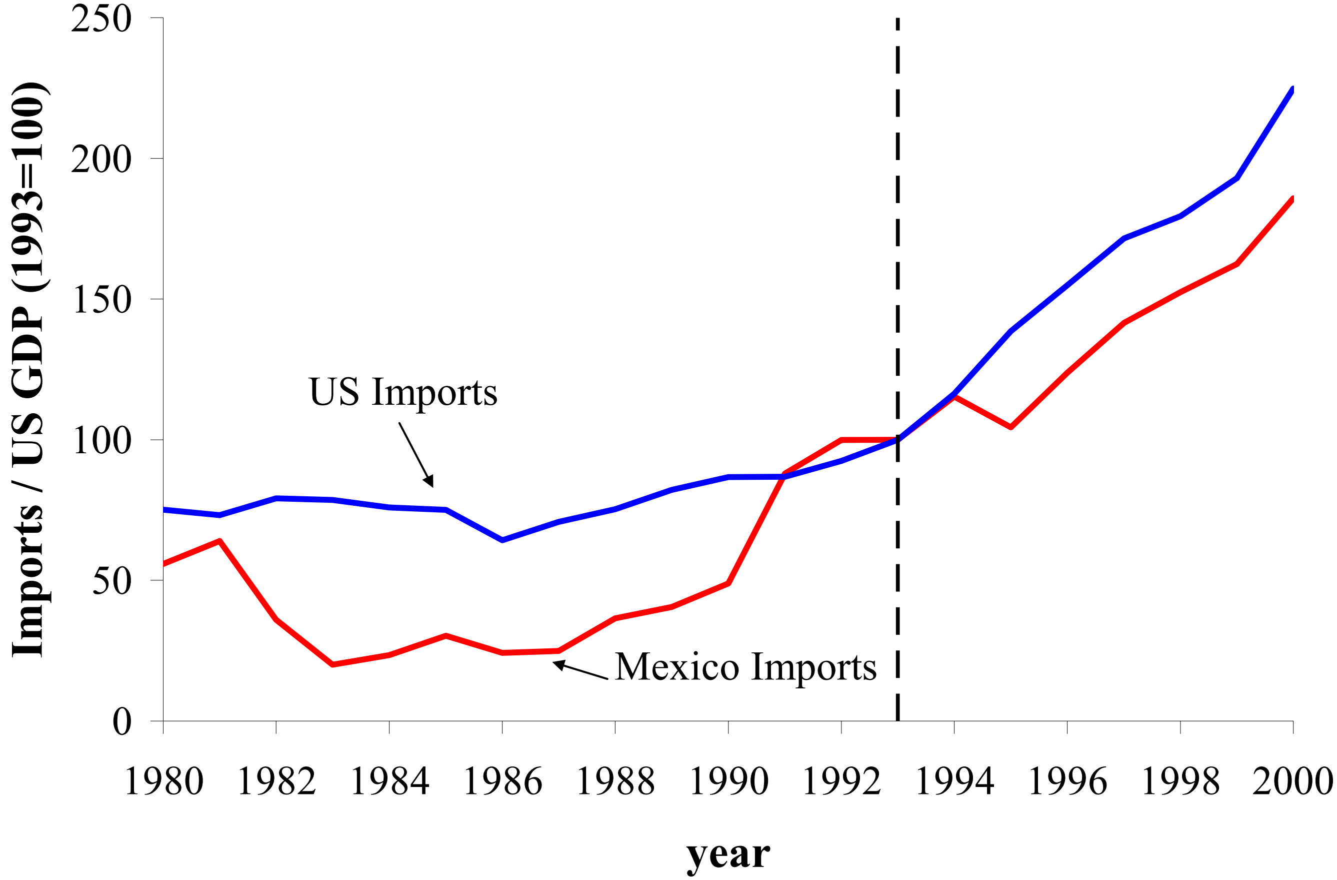
Low estimates from time-series data (< 2)

High estimates from trade liberalization (> 6)

Data: Aggregate Dynamics

Gradual increase in trade after liberalization

NAFTA (Jan 1, 1994)



Data: Plant-level

Cross-section

Not all plants use imported intermediate inputs

Importing plants larger than non-importing plants

Panel

Reallocation between importers / non-importers is significant

Data: Plant-level Cross-section

		% use imports	Avg. size ratio to non-importers
Chile	average 1979-86	24.1	3.4
US (Kurz, 2006)	1992	23.8	2.3

Data: Plant-level Dynamics

Decompose changes in aggregate trade volumes

e.g., increase in aggregate imported/total inputs due to:

1. Importers increase ratio (*Within*) +
2. Importers expand, non-importers shrink (*Between*) +
3. Interaction between the two (*Cross*) +
4. Non-importers switch to importing (*Switch*) +
5. Higher proportion of new entrants are importers (*Entry*)

Baily, Hulten, Campbell (1992): productivity growth

Data: Plant-level Dynamics

Imported / Total Intermediate Inputs: Chile, 1979-1986

	TOTAL	Fraction of Total (%)				
		Within	Between	Cross	Switch	Entry
Avg of 1-year changes	-18%	**79**	**26**	**-10**	**3**	**2**
7-year change	-77%	**74**	**42**	**-30**	**5**	**10**

Model

Heterogeneous Plants

- Produce using intermediate inputs
- Importing costly, irreversible
- Trade growth through *Between* and *Entry* margins

2-country, 2-good real business cycle model

- Technology shocks: short-run changes
- Tariff reduction: long-run changes

Time and Uncertainty

Dates $t = 0, 1, 2, \ldots$

Event at date *t*: s_t. State at date *t*: $s^t = (s_0, s_1, \ldots, s_t)$.

$$\Pr(s_t \mid s^{t-1}) = \phi(s_t \mid s_{t-1})$$
$$\tilde{\phi}(s^t) = \phi(s_t \mid s_{t-1})\phi(s_{t-1} \mid s_{t-2}) \cdots \phi(s_1 \mid s_0)$$

Commodities and prices are functions $x(s^t) \to x_t$

Technology shocks $A(s^t), A^*(s^t)$

Representative Consumer

Preferences:

$$E\sum_{t=0}^{\infty}\beta^t U(C_t, 1-N_t) = \sum_{t=0}^{\infty}\sum_{s^t}\beta^t\tilde{\phi}(s^t)U(C(s^t), 1-N(s^t))$$

Budget constraint:

$$C_t + \sum_{s_{t+1}} Q(s^t, s_{t+1})B(s^t, s_{t+1}) \le w_t N_t + B(s^t) + \Pi_t + T_t$$

Consumer owns plants

Plants

Heterogeneous in inherent efficiency z.

Aggregate technology shocks A_t

Within each country, produce homogeneous output

Perfectly competitive, decreasing returns to scale technologies

Two types of decisions

1. Existing plants: static profit maximization

2. New plants: technology choice (import or not)

Plant technologies

Non-importing

$$f_d(n,d;z) = z^{1-\alpha-\theta} d^{\alpha} n^{\theta}$$

Importing

$$f_m(n,d,m;z) = z^{1-\alpha-\theta} \left(\gamma \min \left\{ \frac{d}{\omega}, \frac{m}{1-\omega} \right\} \right)^{\alpha} n^{\theta}$$

$\alpha + \theta < 1,\ \omega < 1,$

γ : efficiency gain from importing

Static profit maximization

Non-importing plant with efficiency z operating at date t

$$\pi_{dt}(z) = \max_{n,d} A_t f_d(n,d;z) - w_t n - d$$

Importing plant

$$\pi_{mt}(z) = \max_{n,d,m} A_t f_m(n,d,m;z) - w_t n - d - (1+\tau) p_t m$$

No dependence on date of entry

Plant technologies, costs

Non-importing

$$f_d(n,d;z) = z^{1-\alpha-\theta} d^{\alpha} n^{\theta}$$

Price of intermediate input: 1

Importing

$$f_m(n,d,m;z) = z^{1-\alpha-\theta} \left(\gamma \min\left\{ \frac{d}{\omega}, \frac{m}{1-\omega} \right\} \right)^{\alpha} n^{\theta}$$

Price of composite intermediate input: $\dfrac{1}{\gamma}(\omega + (1+\tau)p_t(1-\omega))$

Plant technologies, costs

Importing technology is more cost-efficient if

$$\gamma > \omega + (1+\tau)\,p_t(1-\omega)$$

Depends on equilibrium price p_t

Estimate γ from plant data

Check that inequality holds along equilibrium path

Dynamic problem: Timing

Plant pays cost κ_e to get a draw of z from distribution g

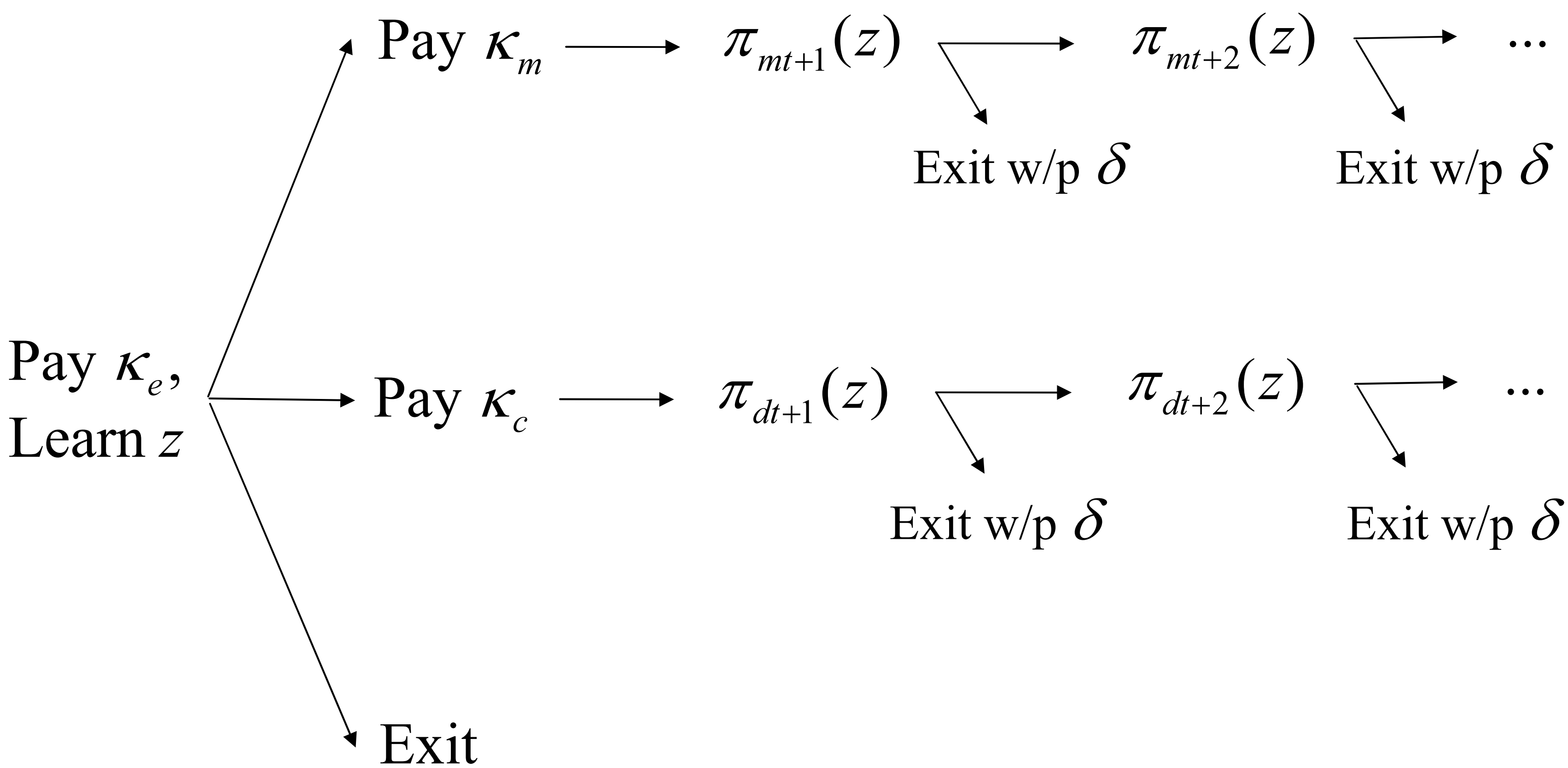
Decide whether to start producing or exit

Pay sunk investment
κ_c to use non-importing technology, or
κ_m to use importing technology
$\kappa_m > \kappa_c$

Face static profit maximization problem each period

Probability δ of exit after production each period

Timing: Plant Entering at date *t*



Dynamic Problem: Plant entering at date *t*

Present values of static profits:

$$V_{dt}(z) = E_t \sum_{k=1}^{\infty} (1-\delta)^{k-1} P_{t,t+k} \pi_{dt+k}(z)$$

$$V_{mt}(z) = E_t \sum_{k=1}^{\infty} (1-\delta)^{k-1} P_{t,t+k} \pi_{mt+k}(z)$$

with $P_{t,t+k} = \beta^k \frac{U_{Ct+k}}{U_{Ct}}$ (consumer owns plants)

Technology Choice

$$V_t(z) = \max\left\{0, -\kappa_c + V_{dt}(z), -\kappa_m + V_{mt}(z)\right\}$$

Produce using non-importing technology if

$$-\kappa_c + V_{dt}(z) > \max\left\{0, -\kappa_m + V_{mt}(z)\right\}$$

Produce using importing technology if

$$-\kappa_m + V_{mt}(z) > \max\left\{0, -\kappa_c + V_{dt}(z)\right\}$$

Otherwise exit

Technology Choice

$V_{dt}(z)$ and $V_{mt}(z) - V_{dt}(z)$ increasing in z

Cutoffs $\hat{z}_{dt}$ and $\hat{z}_{mt}$,

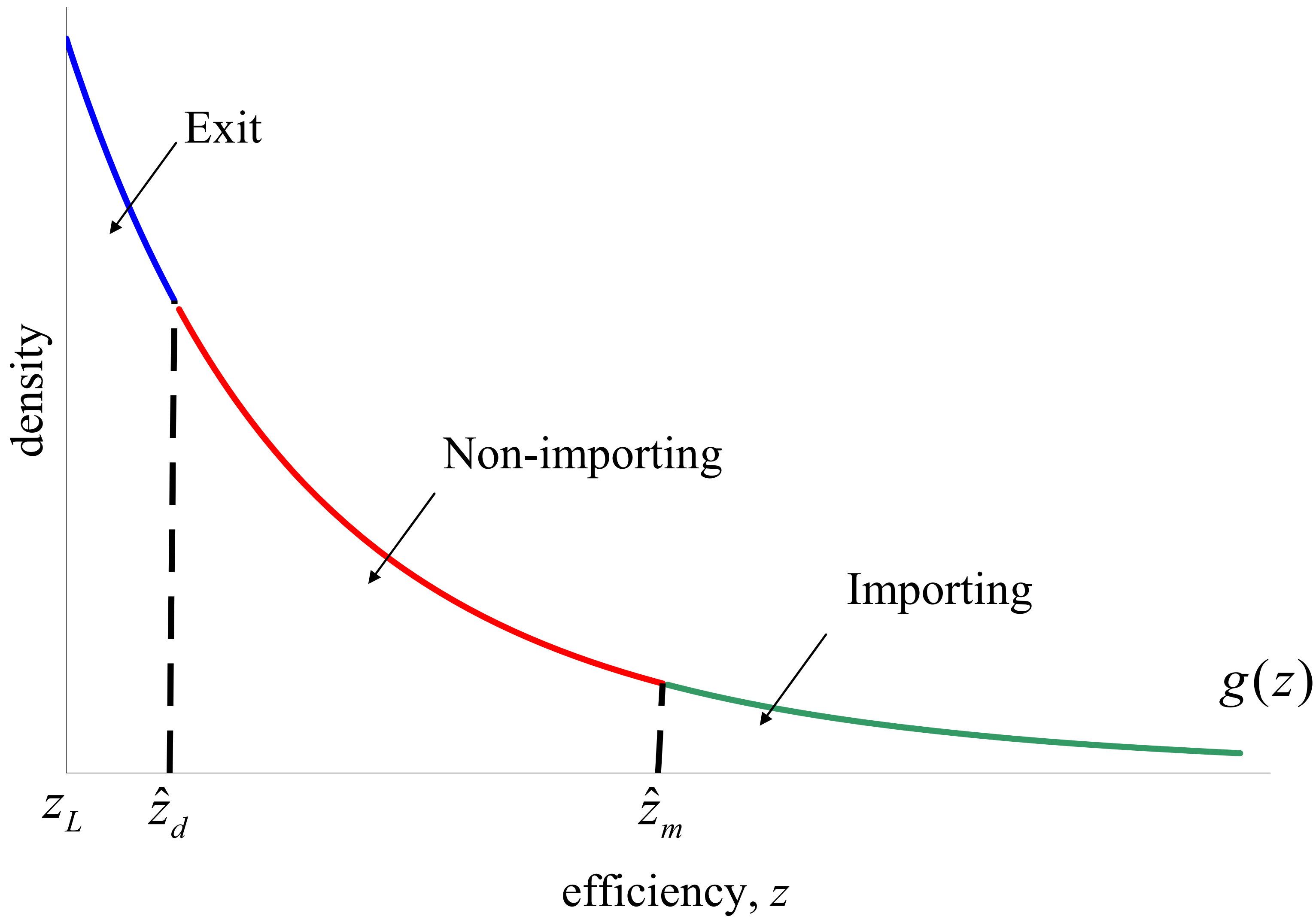
$$V_{dt}(\hat{z}_{dt}) = \kappa_c$$
$$V_{mt}(\hat{z}_{mt}) - V_{dt}(\hat{z}_{mt}) = \kappa_m$$

Use importing technology if $z \in [\hat{z}_{mt}, \infty)$

Use non-importing technology if $z \in [\hat{z}_{dt}, \hat{z}_{mt})$

Otherwise exit

Technology Choice: cutoffs



Equilibrium Conditions: Plant Dynamics

$\mu_{dt}(z)$: Mass of non-importing plants, efficiency z at date t.

X_t: Mass of entrants at date t (start producing at date $t+1$)

Dynamics of distribution:

$$\mu_{dt+1}(z) = \begin{cases} (1-\delta)\mu_{dt}(z) + X_t g(z) \text{ if } z \in [\hat{z}_{dt}, \hat{z}_{mt}] \\ (1-\delta)\mu_{dt}(z) \text{ otherwise} \end{cases}$$

Equilibrium Conditions: Plant Dynamics

$\mu_{mt}(z)$: Mass of importing plants, efficiency z at date t.

X_t: Mass of entrants at date t (start producing at date $t+1$)

Dynamics of distribution:

$$\mu_{mt+1}(z) = \begin{cases} (1-\delta)\mu_{mt}(z) + X_t g(z) \text{ if } z > \hat{z}_{mt} \\ (1-\delta)\mu_{mt}(z) \text{ otherwise} \end{cases}$$

Equilibrium Conditions: Feasibility

Goods

$$C_t + X_t\left(\kappa_e + \kappa_c \int_{\hat{z}_{dt}}^{\hat{z}_{mt}} g(z)\mathrm{d}z + \kappa_m \int_{\hat{z}_{mt}}^{\infty} g(z)\mathrm{d}z\right)$$
$$+ \int d_{dt}(z)\mu_{dt}(z)\mathrm{d}z + \int d_{mt}(z)\mu_{mt}(z)\mathrm{d}z + \int m_t^*(z)\mu_{mt}^*(z)\mathrm{d}z$$
$$= \int y_{dt}(z)\mu_{dt}(z)\mathrm{d}z + \int y_{mt}(z)\mu_{mt}(z)\mathrm{d}z$$

Labor

$$\int n_{dt}(z)\mu_{dt}(z)\mathrm{d}z + \int n_{mt}(z)\mu_{mt}(z)\mathrm{d}z = N_t$$

Equilibrium Conditions: Free Entry and Asset Market

Expected value of entry is

$$V_{et} = -\kappa_e + \int_{z_L}^{\infty} V_t(z) g(z) \mathrm{d}z$$

Free Entry:

$$V_{et} \leq 0, \quad = \text{ if } X_t > 0$$

Asset Market Clearing:

$$B(s^t) + B^*(s^t) = 0$$

Aggregation

To solve equilibrium conditions, need $\mu_{dt}(\bullet)$, $\mu_{mt}(\bullet)$

For example: $\int n_{dt}(z)\mu_{dt}(z)\mathrm{d}z$

Let $Z_{dt} = \int z\mu_{dt}(z)\mathrm{d}z$

Plants make decisions proportional to efficiency z:

$$n_{dt}(z) = \tilde{n}_{dt} \times z$$

So,

$$\int n_{dt}(z)\mu_{dt}(z)\mathrm{d}z = \tilde{n}_{dt} Z_{dt}$$

Aggregation

Replace $\mu_{dt}(\bullet)$ with Z_{dt} as state variable:

$$\mu_{dt+1}(z) = \begin{cases} (1-\delta)\mu_{dt}(z) + X_t g(z) \text{ if } z \in [\hat{z}_{dt}, \hat{z}_{mt}] \\ (1-\delta)\mu_{dt}(z) \text{ otherwise} \end{cases}$$

$$\Downarrow$$

$$Z_{dt+1} = (1-\delta)Z_{dt} + X_t \int_{\hat{z}_{dt}}^{\hat{z}_{mt}} g(z)\mathrm{d}z$$

Same with $\mu_{mt}(\bullet)$, $\mu^*_{dt}(\bullet)$, $\mu^*_{mt}(\bullet)$

Analysis of Model

1. Aggregate imported / domestic intermediate ratio – what determines substitutability?

    Static allocation across plants

    Investment decisions of new plants

2. Quantitative analysis

    Parameterization

    Business Cycle simulation – short-run elasticity

    Trade Reform – long-run elasticity; speed of trade growth

Import / domestic ratio

Plant level:

Non-importing plant: fixed, *zero*.

Importing plant: fixed, $\dfrac{m_t(z)}{d_{mt}(z)} = \dfrac{1-\omega}{\omega}$

Import / domestic ratio

Aggregate:

$$\frac{M_t}{D_{mt}+D_{dt}} = \frac{\tilde{m}_t Z_{mt}}{\tilde{d}_{mt} Z_{mt} + \tilde{d}_{dt} Z_{dt}}$$

$$= \frac{\frac{1-\omega}{\omega}\tilde{d}_{mt} Z_{mt}}{\tilde{d}_{mt} Z_{mt} + \tilde{d}_{dt} Z_{dt}}$$

Increasing in:

$\dfrac{\tilde{d}_{mt}}{\tilde{d}_{dt}}$: non-importing / importing plant with same z;

$\dfrac{Z_{mt}}{Z_{dt}}$: mass of importers / non-importers (z-weighted)

Effects of increase in relative price $(1+\tau)p_t$:

1. At date t: allocation between plants,

$$\frac{\tilde{d}_{mt}}{\tilde{d}_{dt}} = \left(\frac{\gamma}{\omega + (1+\tau)p_t(1-\omega)} \right)^{\alpha/(1-\alpha-\theta)}$$

Decreasing in $(1+\tau)p_t$

Importers less profitable; allocated less inputs in equilibrium

Effects of increase in relative price $(1+\tau)p_t$ *if persistent*:

2. At date $t+1$: new plants *entering at date t*,

$$\frac{Z_{mt+1}}{Z_{dt+1}} = \frac{(1-\delta)Z_{mt} + X_t \int_{\hat{z}_{mt}}^{\infty} g(z)\mathrm{d}z}{(1-\delta)Z_{dt} + X_t \int_{\hat{z}_{dt}}^{\hat{z}_{mt}} g(z)\mathrm{d}z}$$

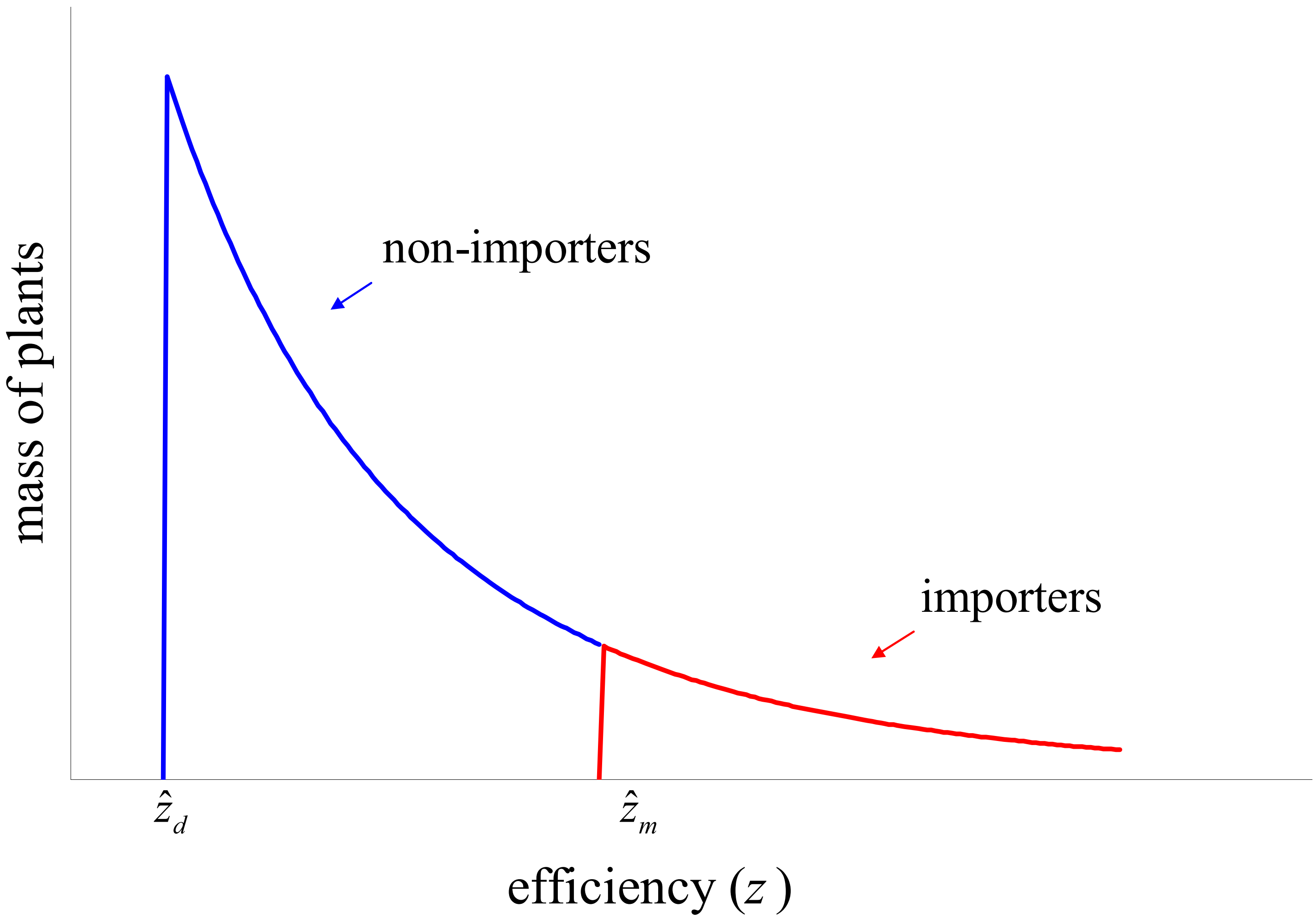
Decreasing in $(1+\tau)p_t$

Importing less profitable; fewer new plants choose importing.

$\hat{z}_{mt} \downarrow$, $\hat{z}_{dt} \uparrow$

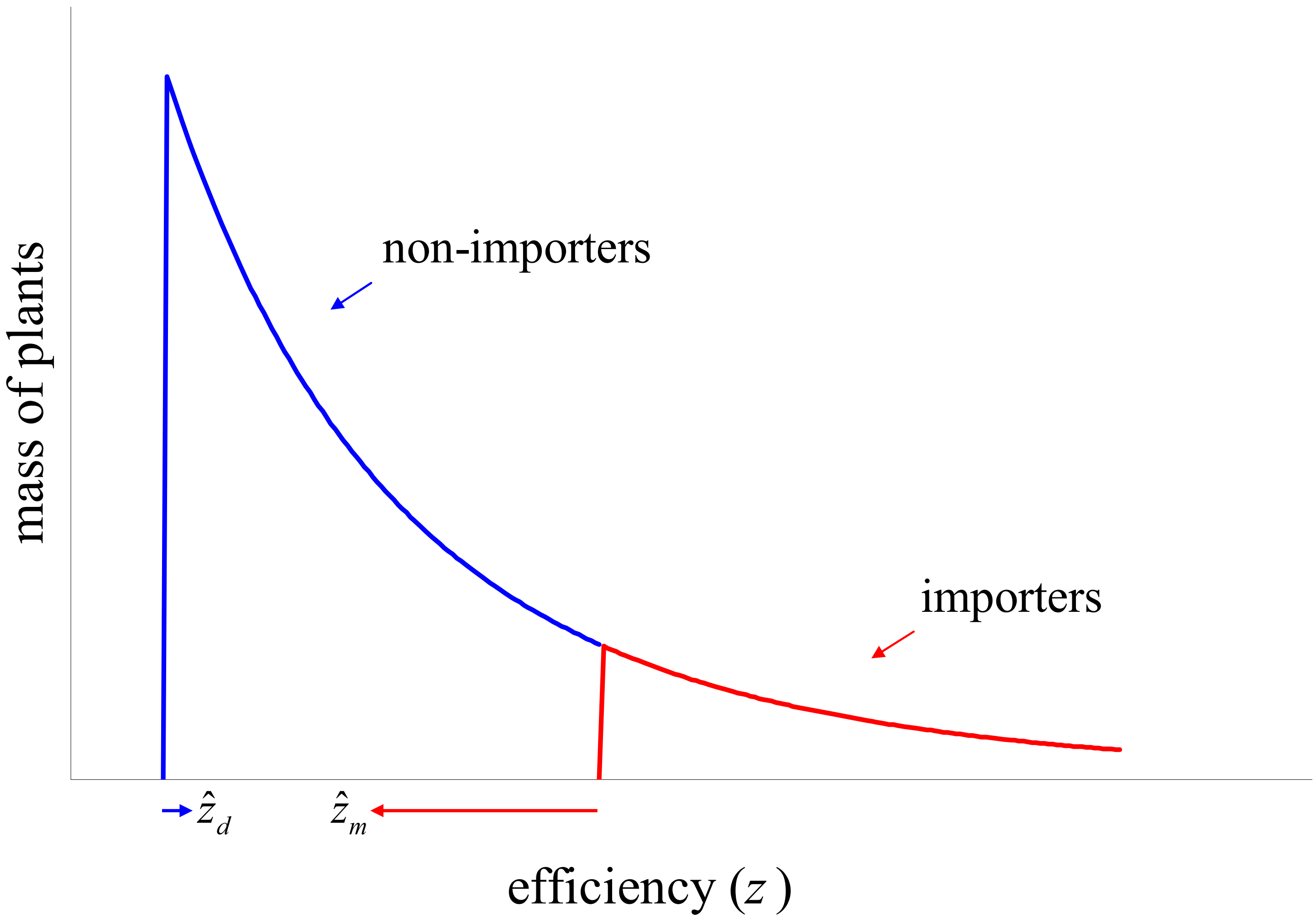
Dynamic effect of decrease in $(1+\tau)p_t$

Distribution of Plants, t



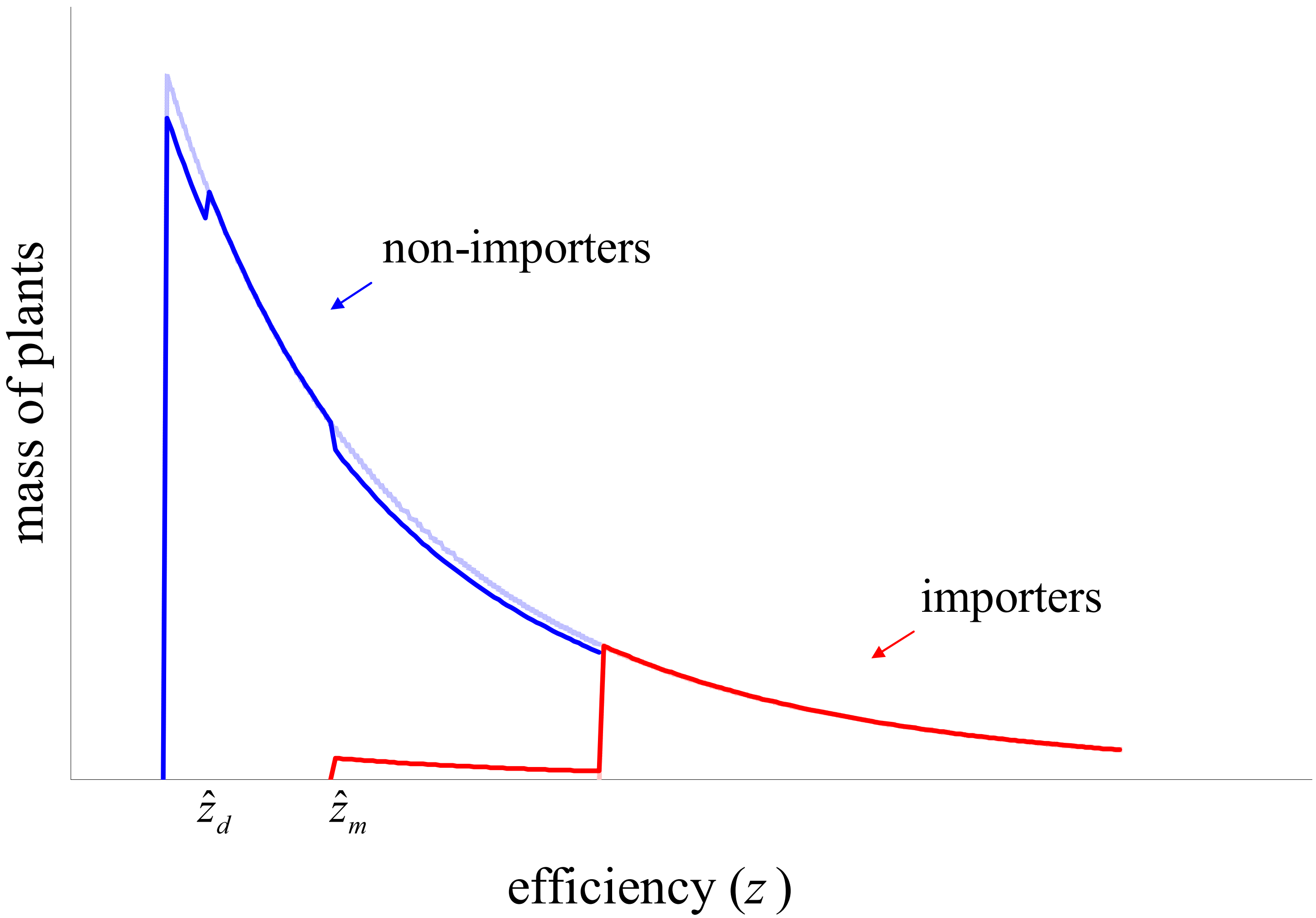
Dynamic effect of decrease in $(1+\tau)p_t$

Distribution of Plants, t



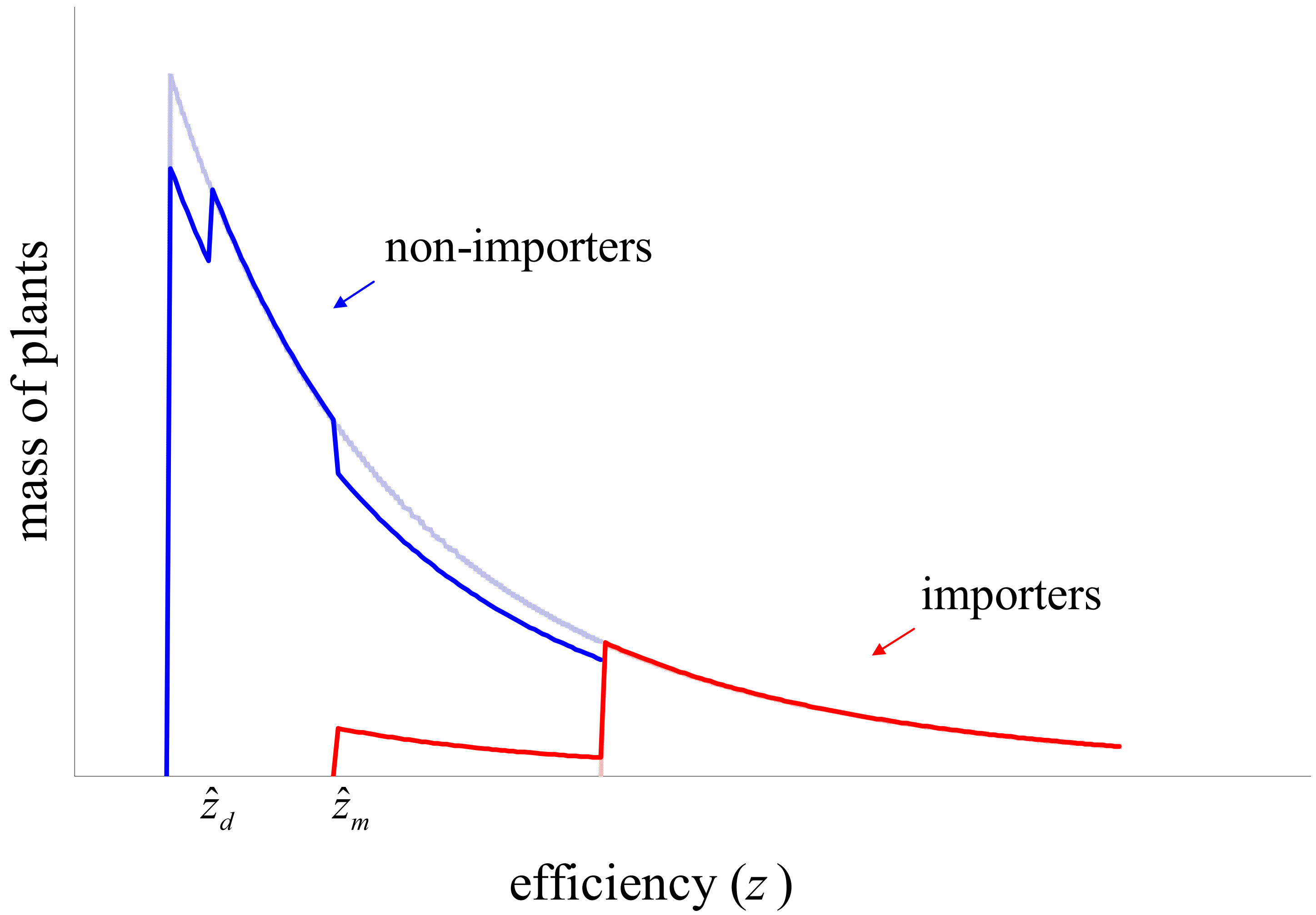
Dynamic effect of decrease in $(1+\tau)p_t$

Distribution of Plants, *t+1*



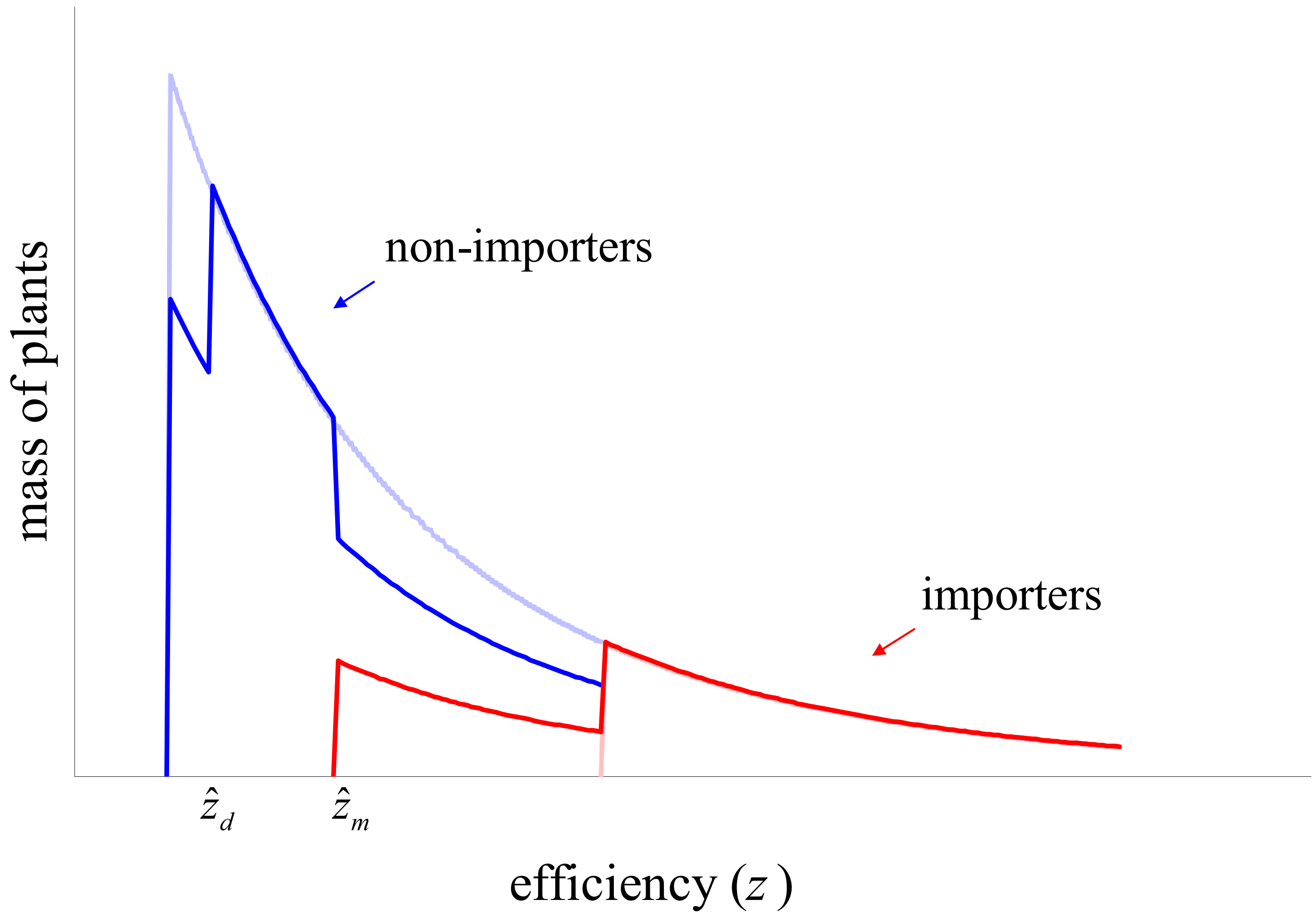
Dynamic effect of decrease in $(1+\tau)p_t$

Distribution of Plants, *t+2*



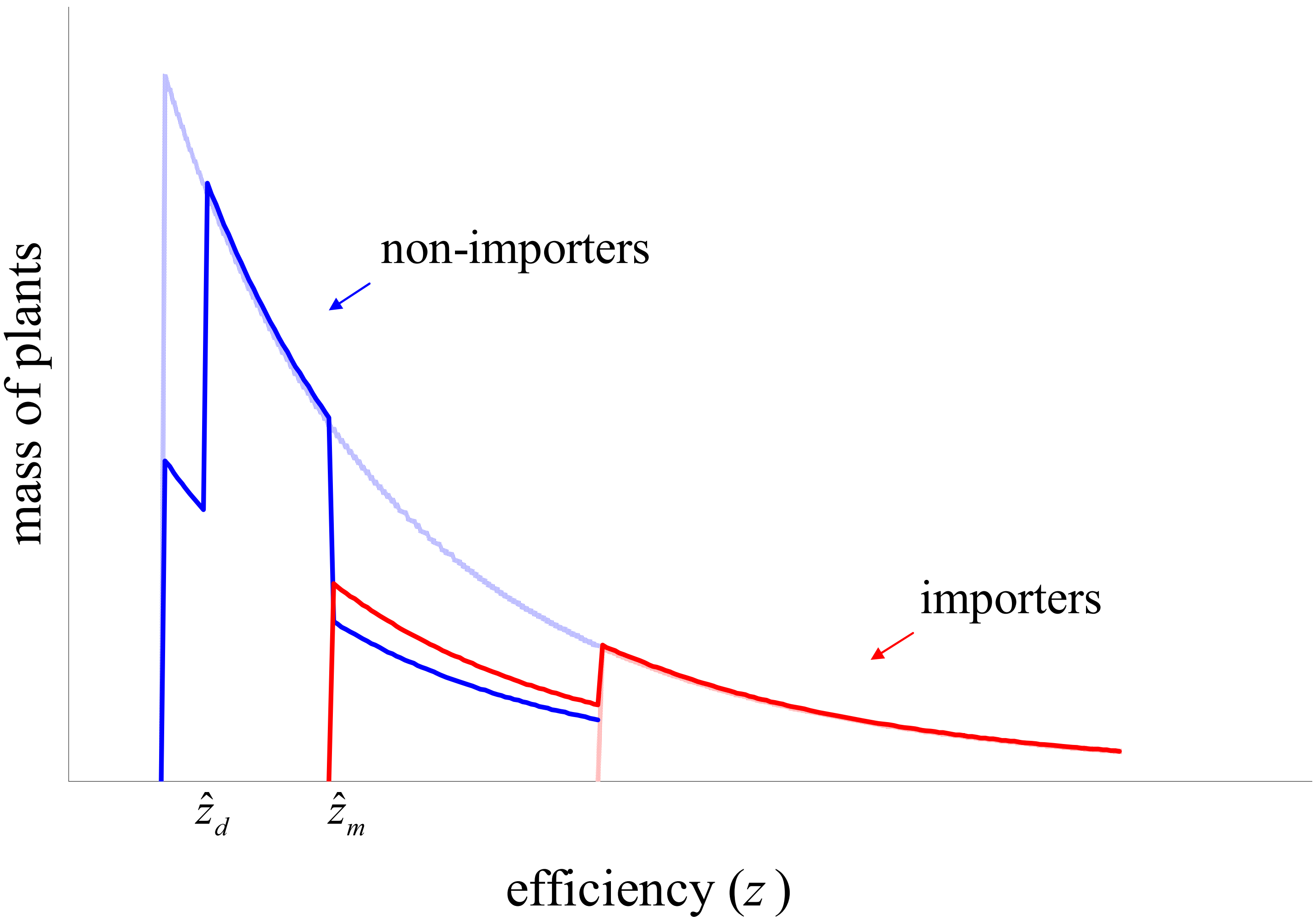
Dynamic effect of decrease in $(1+\tau)p_t$

Distribution of Plants, *t+5*



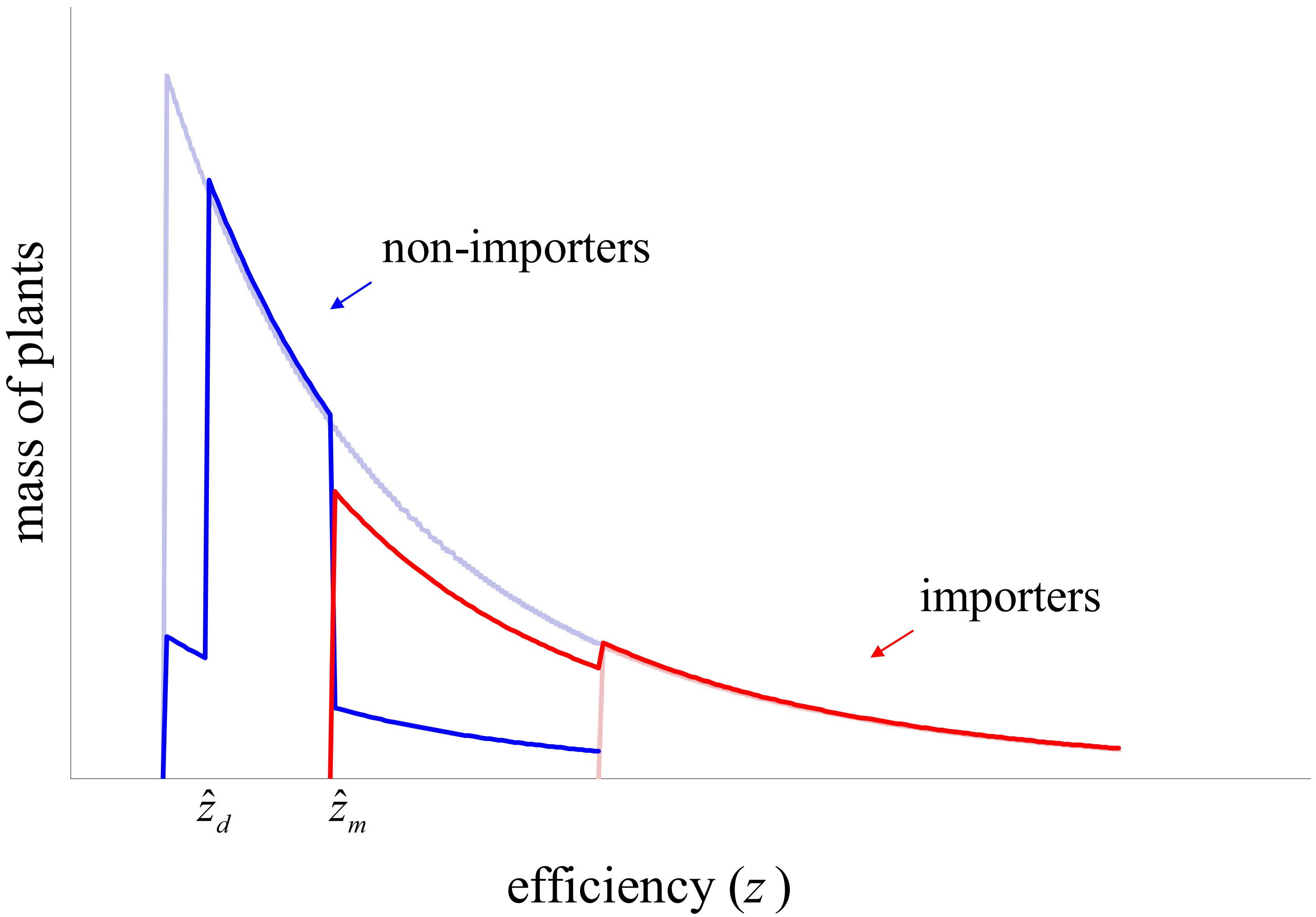
Dynamic effect of decrease in $(1+\tau)p_t$

Distribution of Plants, *t+10*



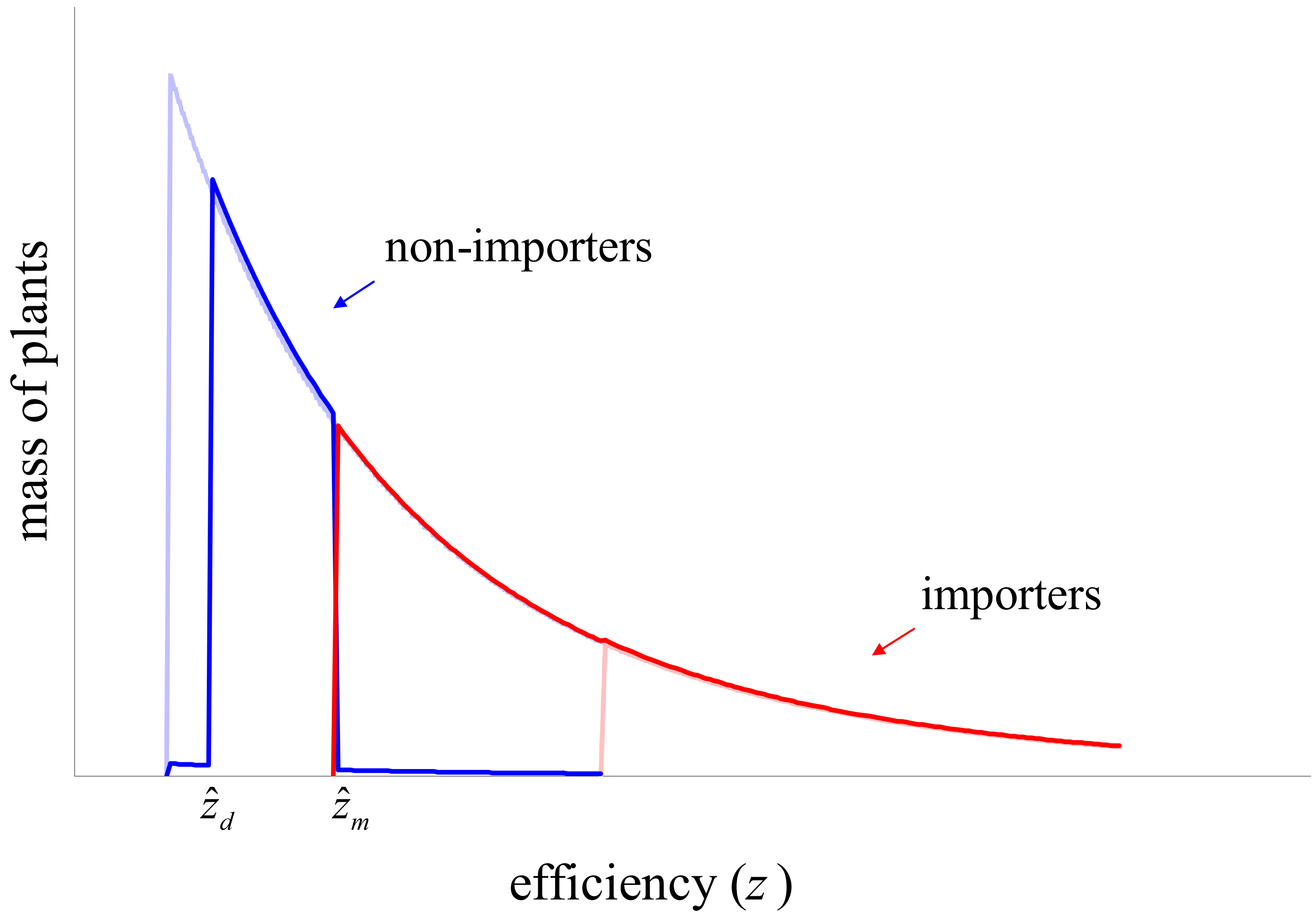
Dynamic effect of decrease in $(1+\tau)p_t$

Distribution of Plants, *t+20*



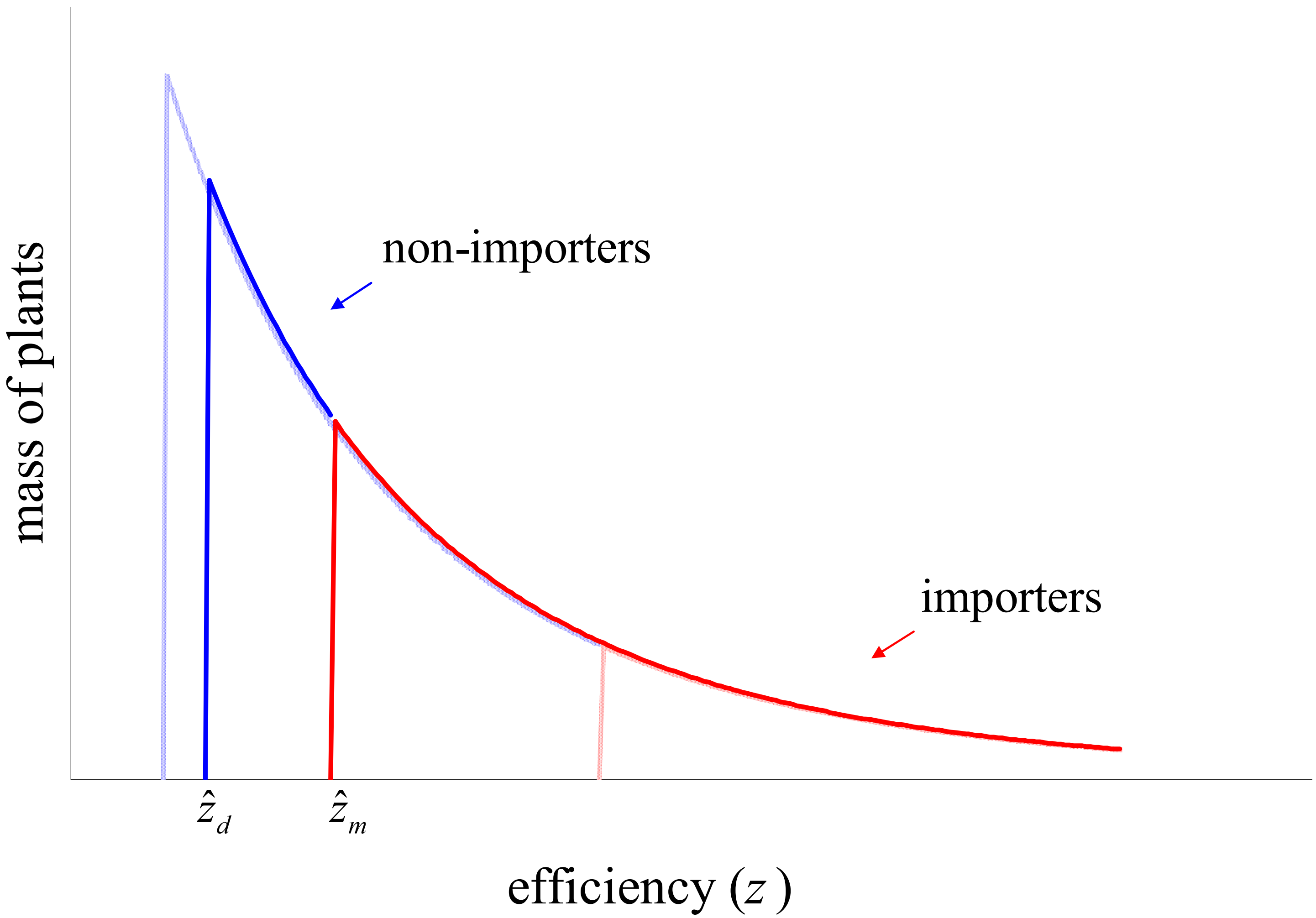
Dynamic effect of decrease in $(1+\tau)p_t$

Distribution of Plants, *t+50*



Dynamic effect of decrease in $(1+\tau)p_t$

Distribution of Plants, $t+\infty$



1. Cyclical fluctuations: static reallocation dominant

   Low aggregate elasticity of substitution (~ 1.3)

2. Trade liberalization: gradual change in ratio of plants

   High aggregate elasticity of substitution (~ 7)

   Gradual increase in trade

Conclusions

Heterogeneity and irreversibility in importing at producer level

Slow-moving dynamics at aggregate level

Significant implications for welfare gains from trade reform

6. Models with uniform fixed cost across firms with heterogeneous productivity have implications that are sharply at odds with micro data. A model with increasing costs of accessing a fraction of a market has many of features of models with fixed costs without these undesirable properties.

C. Arkolakis, "Market Access Costs and the New Consumers Margin in International Trade," University of Minnesota, 2006. http://www.econ.umn.edu/~tkehoe/papers/Arkolakis.pdf.

Two Key Observations in Trade Data

Key Observation 1: Who exports and how much

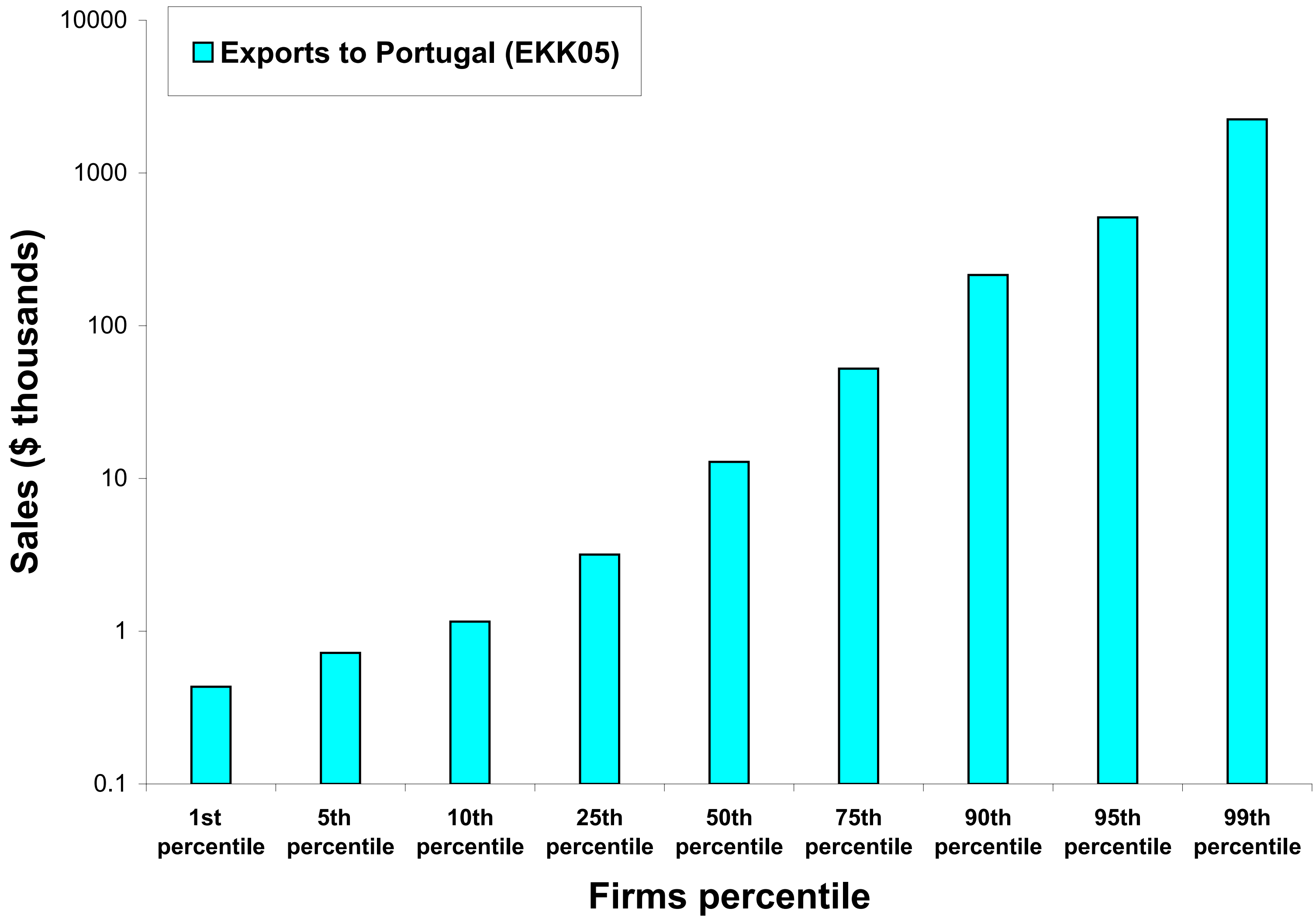
(Eaton Kortum and Kramarz '05)

- Most firms do not export **and**
- Large fraction of firms exporting to each country sell tiny amounts there

Example

- Only 1.9% of French firms export to Portugal **and**
- More than 25% of French firms exporting to Portugal $<$ 10K there

Example: 1.9% of French firms export to Portugal, mostly tiny amounts



Two Key Observations in Trade Data

Key Observation 1: Who exports and how much

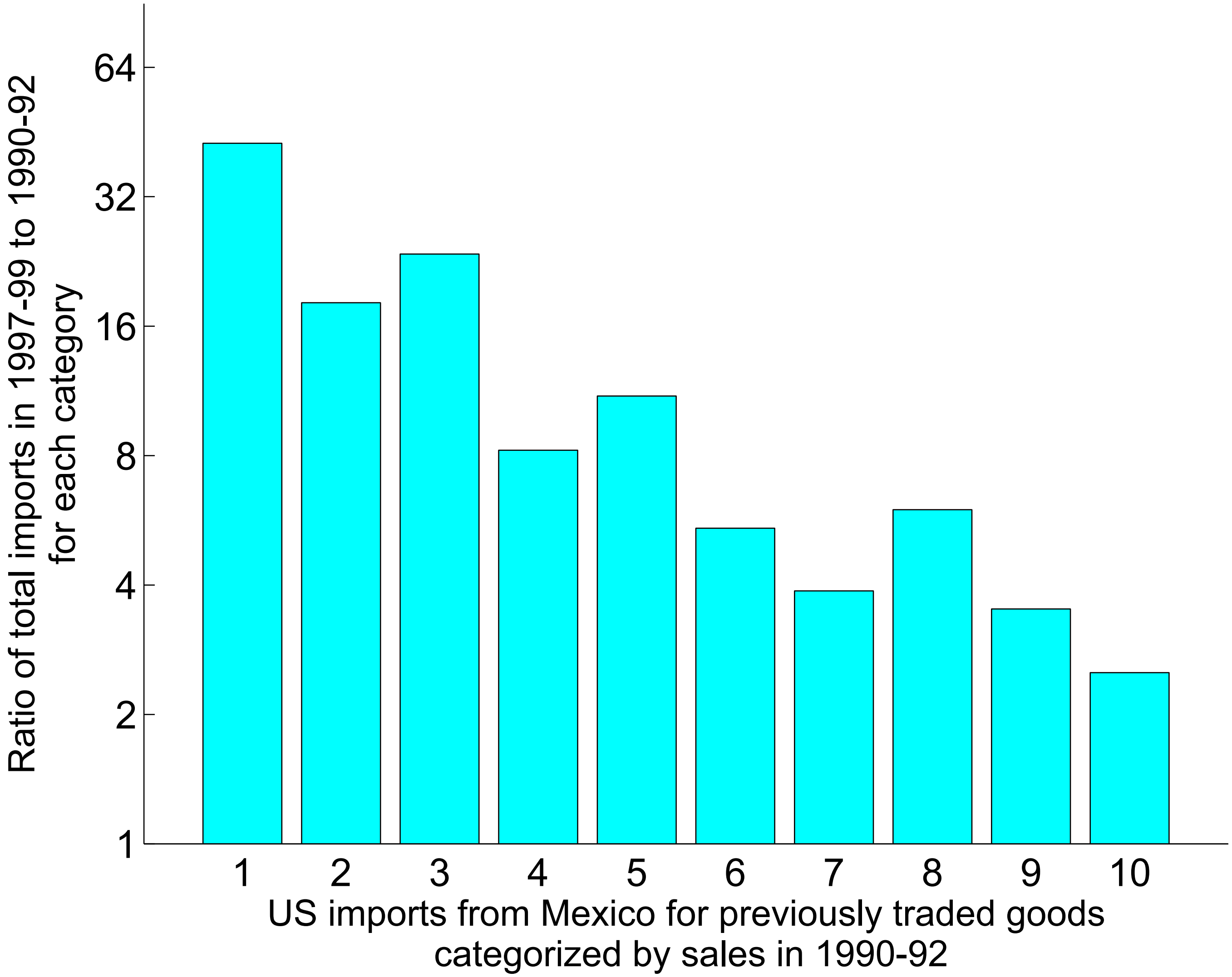
- Most firms do not export **and**
- Large fraction of firms exporting to each country sell tiny amounts there

Key Observation 2: Trading decisions after a trade liberalization

(Kehoe '05, Kehoe & Ruhl '03)

- Large increases in trade for goods with positive but little trade

Example: Large increases in goods with positive but little trade prior NAFTA



Existing Firm-Level Models of Trade

- Models such as those of Melitz '03 and Chaney '06 assume
  - Differentiated products
  - Heterogeneous productivity firms
  - Fixed market access cost of exporting

- Yield 2 puzzles related to 2 key observations

Two Puzzles for Theory with Fixed Costs

- **Puzzle 1: Fixed Cost model needs**
  - Large fixed cost for most firms not to export
  - Small fixed cost for small exporters

- **Puzzle 2: Fixed Cost model relies solely on Dixit-Stiglitz demand**
  - Predicts symmetric changes for all previously positively traded goods

- This paper points out the shortcomings of the Fixed Cost model
  - Proposes **a theory of marketing** that can resolve them

A Theory of Marketing: The Basic Idea

Example: TV channel, each ad randomly reaches 50% of consumers

	1st ad	2nd ad	3rd ad
fraction reached	50%		
cost per consumer	2		

A Theory of Marketing: The Basic Idea

Example: TV channel, each ad randomly reaches 50% of consumers

	1st ad	**2nd ad**	**3rd ad**
fraction reached	50%	+25%	
cost per consumer	2	4	

A Theory of Marketing: The Basic Idea

Example: TV channel, each ad randomly reaches 50% of consumers

	1st ad	**2nd ad**	**3rd ad**
fraction reached	50%	+25%	+12.5%
cost per consumer	2	4	8

A Theory of Marketing: The Basic Idea

Example: TV channel, each ad randomly reaches 50% of consumers

	1st ad	**2nd ad**	**3rd ad**
fraction reached	50%	+25%	+12.5%
cost per consumer	2	4	8

Properties of marketing cost per consumer

a) Costly to reach first consumer

b) Increasing marketing cost per consumer to reach additional consumers

A Theory of Marketing: The Basic Idea

Example: TV channel, each ad randomly reaches 50% of consumers

	1st ad	**2nd ad**	**3rd ad**
fraction reached	50%	+25%	+12.5%
cost per consumer	2	4	8

Properties of marketing cost per consumer

a) Costly to reach first consumer

b) Increasing marketing cost per consumer to reach additional consumers

Model with a)+b) can account for observation 1, namely,

- Most firms do not export **and**
- Large fraction of firms exporting to each country sell tiny amounts there

A Theory of Marketing: The Basic Idea

Example: TV channel, each ad randomly reaches 50% of consumers

	1st ad	**2nd ad**	**3rd ad**
fraction reached	50%	+25%	+12.5%
cost per consumer	2	4	8

Properties of marketing cost per consumer

a) Costly to reach first consumer

b) Increasing marketing cost per consumer to reach additional consumers

c) More ads bring fewer new consumers (saturation)

A Theory of Marketing: The Basic Idea

Example: TV channel, each ad randomly reaches 50% of consumers

	1st ad	**2nd ad**	**3rd ad**
fraction reached	50%	+25%	+12.5%
cost per consumer	2	4	8

Properties of marketing cost per consumer

a) Costly to reach first consumer

b) Increasing marketing cost per consumer to reach additional consumers

c) More ads bring fewer new consumers (saturation)

Model with c) can account for observation 2, namely,

- Large increases in trade for goods with positive but little trade

Model Environment

Builds on Melitz '03 and Chaney '06

- **Countries**
  - Index by i when exporting, j when importing, $i, j = 1, ..., N$
  - L_j consumers
  - Firms sell locally and/or export

Model Environment

Builds on Melitz '03 and Chaney '06

- **Representative Consumers**
  - Sell unit of labor, own shares of domestic firms
  - Symmetric CES Dixit-Stiglitz preferences over continuum of goods
  - Buy the goods they have access to
- **Firms**
  - Indexed by productivity ϕ (drawn from same distribution), nationality i
  - Each sells 1 good
  - Determine probability a consumer in a market has access to their good

Demand Faced by a Type ϕ Firm from Country i

- $n_{ij}(\phi)$: probability a type ϕ firm from i reaches a repres. consumer in j

- Large number of consumers
  - thus firm **reaches** fraction $n_{ij}(\phi)$ of them

- Effective demand for firm ϕ:

$$\underbrace{n_{ij}(\phi) L_j}_{\text{consumers that firm reaches}} \underbrace{\frac{p_{ij}(\phi)^{-\sigma}}{P_j^{1-\sigma}} y_j}_{\text{D-S demand per consumer}}$$

$p_{ij}(\phi)$: price that type ϕ firm from i charges in j, y_j: output (income) per capita

P_j : D-S price aggregator, σ : elasticity of substitution ($\sigma > 1$, demand is elastic)

Firm's Problem

Type ϕ firm from country i solves for each country $j = 1, ..., N$

$$\pi_{ij} = \max_{n_{ij}, p_{ij}, q_{ij}} \; p_{ij} q_{ij} - w_i \frac{\tau_{ij} q_{ij}}{\phi} - w_i f(n_{ij}, L_j)$$

$$s.t. \qquad q_{ij} = n_{ij} L_j \frac{p_{ij}^{-\sigma}}{P_j^{1-\sigma}} y_j, \quad n_{ij} \in [0,1]$$

- Uses production function $q_{ij} = \phi l_{ij}$ to produce good
- τ_{ij} : iceberg cost to ship a unit of good from i to j (in terms of labor)
- $f(n_{ij}, L_j)$: marketing to reach fraction n_{ij} of a population with size L_j

Firm's Problem

- **Result:** Price is the usual markup over unit production cost,

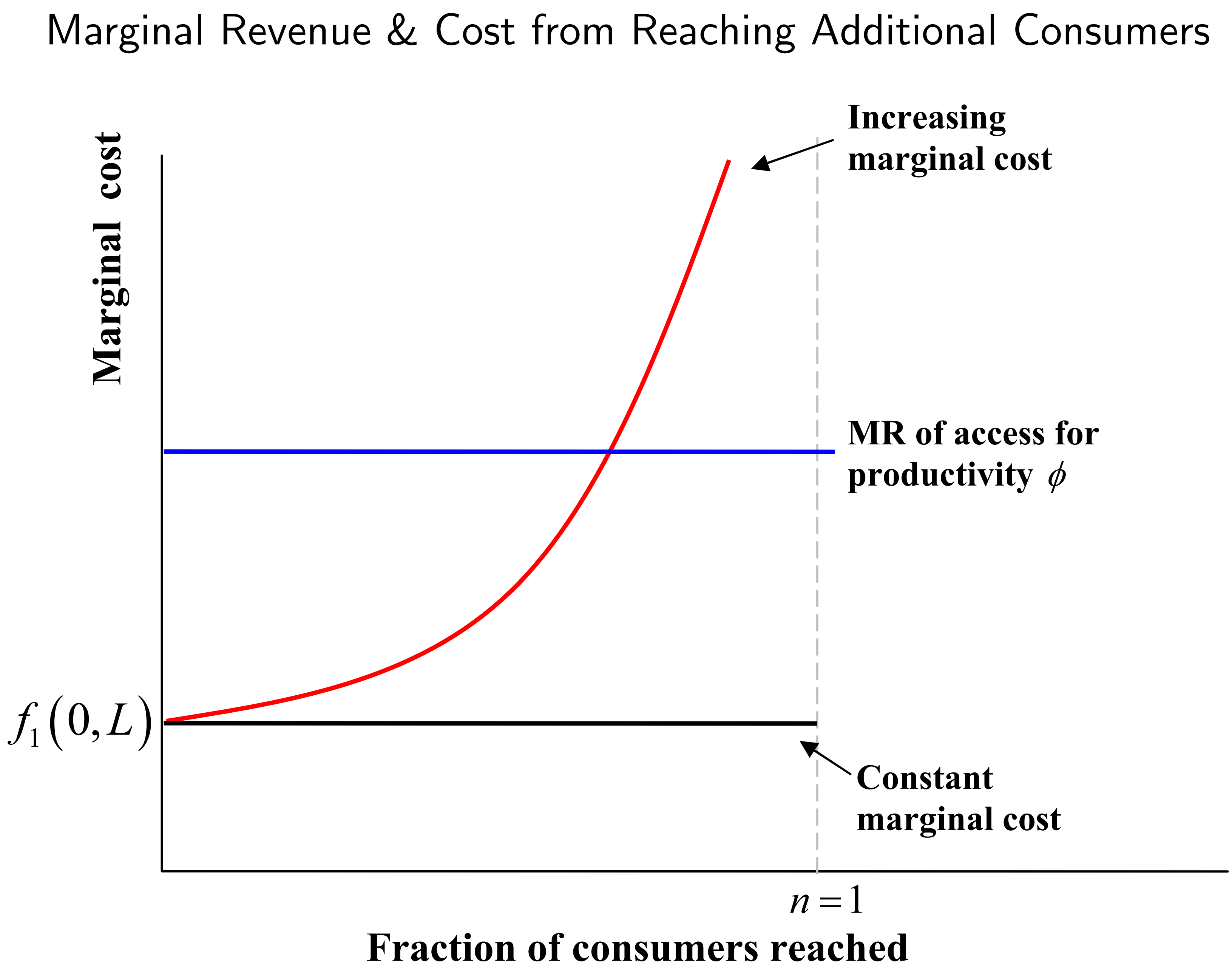
$$p_{ij}(\phi) = \tilde{\sigma}\frac{\tau_{ij}w_j}{\phi},\ \tilde{\sigma} = \frac{\sigma}{\sigma-1}$$

- Given price markup rule firm solves:

$$\pi_{ij} = \max_{n_{ij}} n_{ij}\, L_j\, \underbrace{\phi^{\sigma-1}\frac{(\tau_{ij}w_j\tilde{\sigma})^{1-\sigma}}{P_j^{1-\sigma}}\frac{y_j}{\sigma}}_{\substack{\text{Revenue per consumer} \\ \text{(net of labor production cost)}}} - w_j f(n_{ij}, L_j)$$

$$\text{s.t} \qquad n_{ij} \in [0,1]$$

- Look at marginal decision of reaching additional fractions of consumers



Marginal Revenue & Cost from Reaching Additional Consumers
Marginal cost
Increasing marginal cost
MR of access for productivity ϕ
$f_1(0, L)$
Constant marginal cost
$n = 1$
Fraction of consumers reached

The Market Access Cost Function

- Solve the differential equation

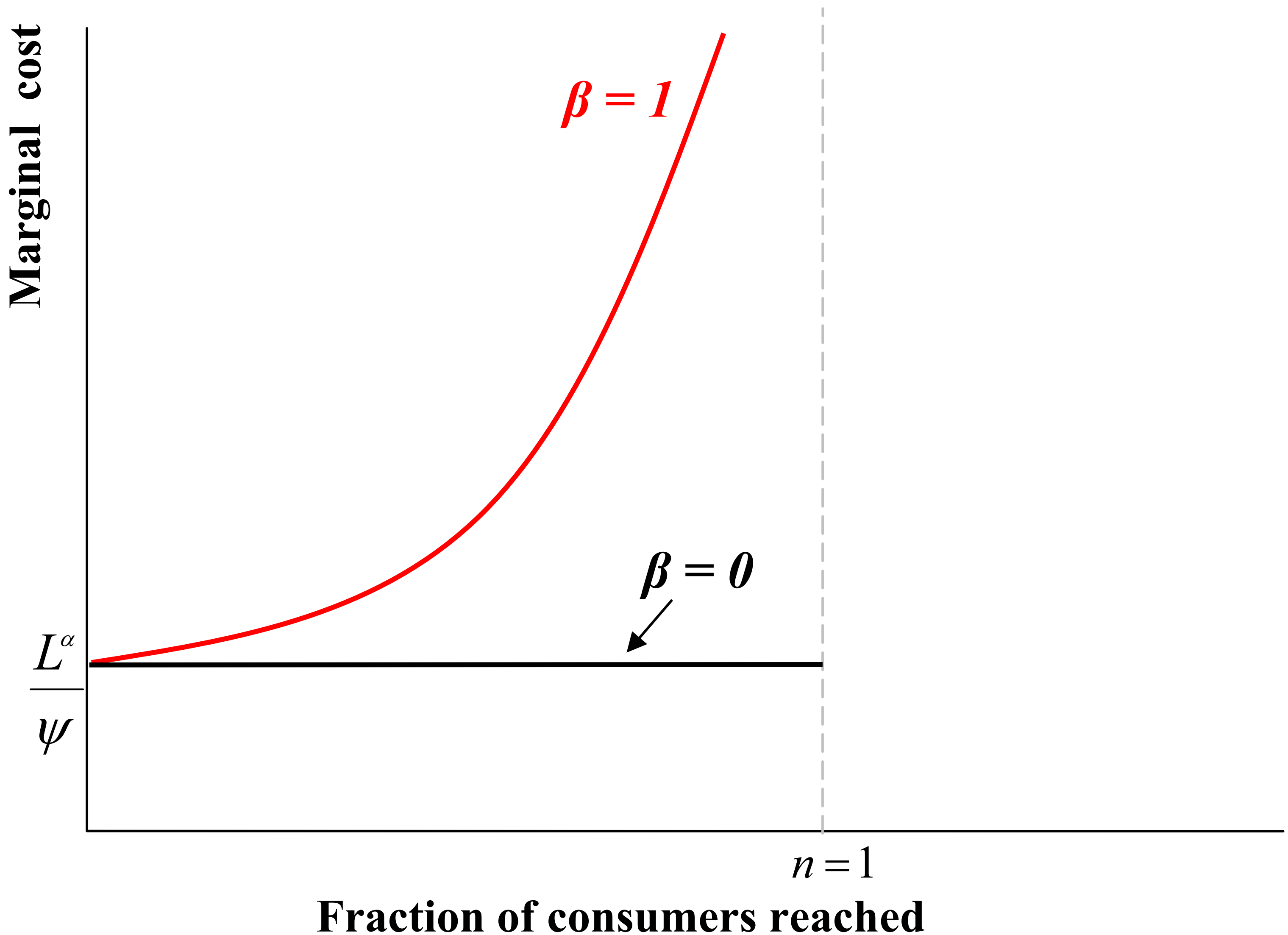
$$n'(S) = [1 - n(S)]^{\beta} L^{1-\alpha} \frac{1}{L}, \quad \text{s.t. } n(0) = 0$$

- Obtain Market Access Cost function
  - Assuming that $\frac{1}{\psi}$ is the labor required for each ad

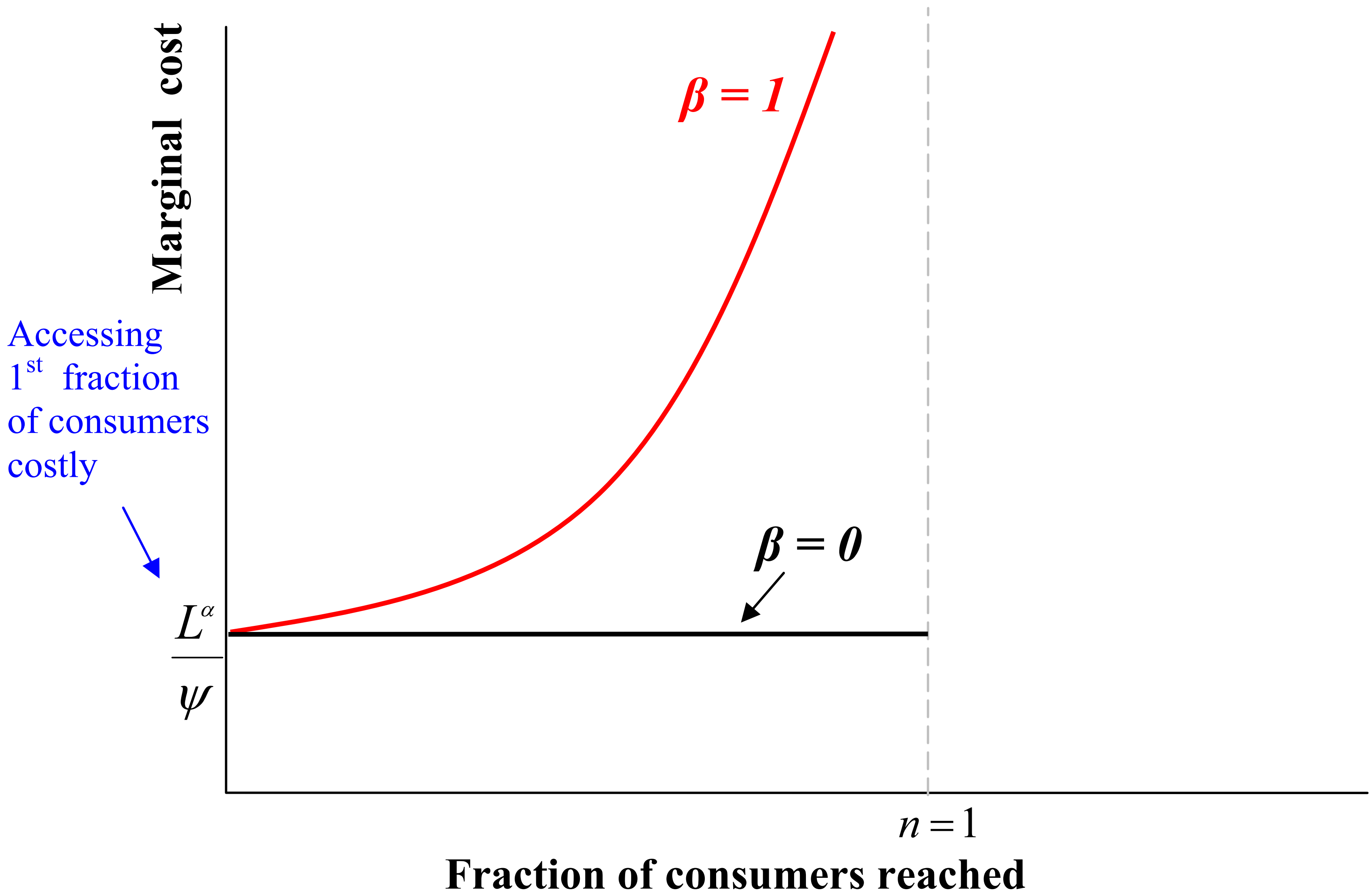
$$f(n, L) = \begin{cases} \frac{L^{\alpha}}{\psi} \frac{1-(1-n)^{-\beta+1}}{-\beta+1} & \text{if } \beta \in [0,1) \cup (1, +\infty) \\ \\ -\frac{L^{\alpha}}{\psi} log(1-n) & \text{if } \beta = 1 \end{cases}$$

$$\text{where } \alpha \in [0,1]$$

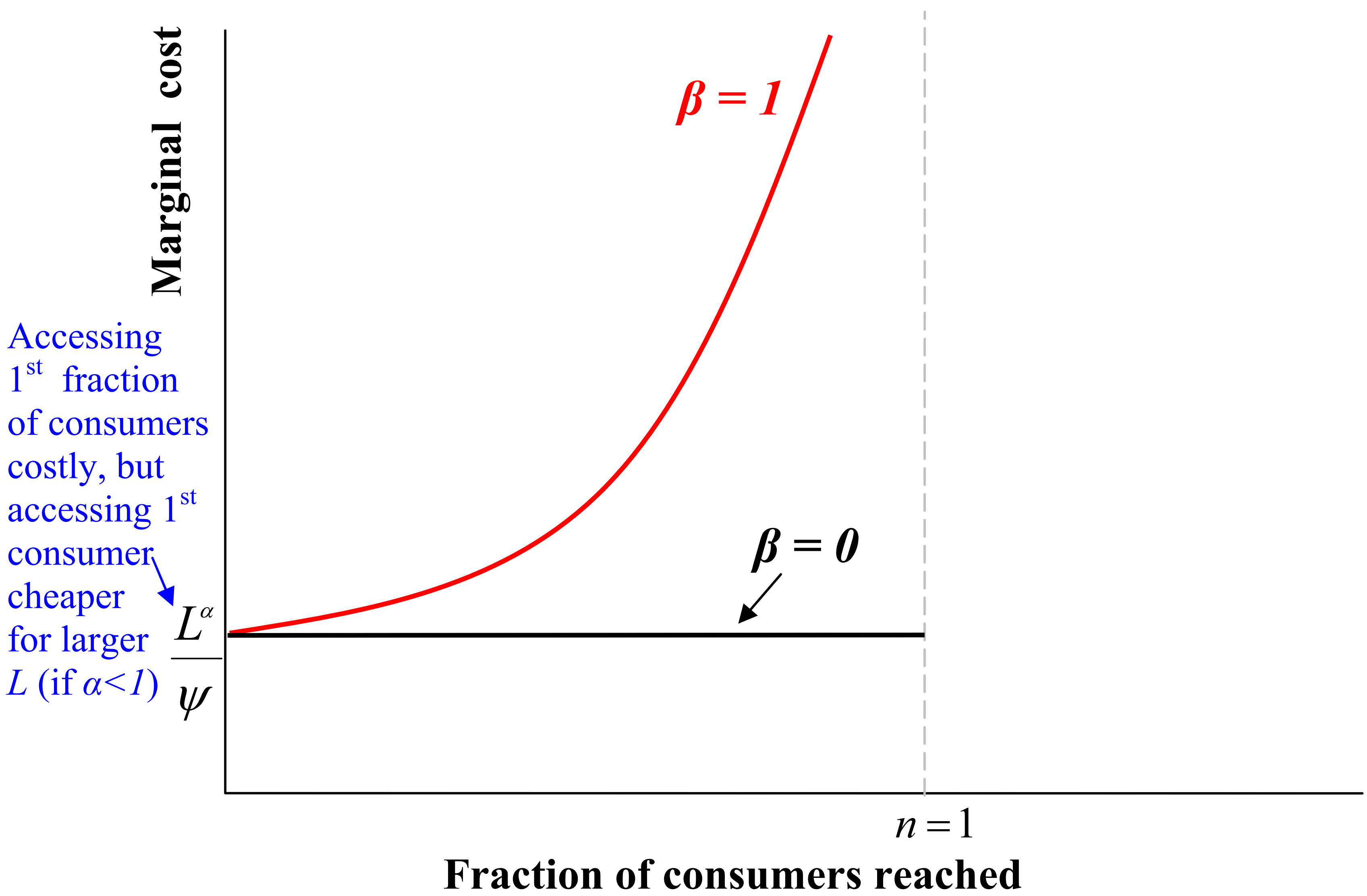
The properties of the Market Access Cost function



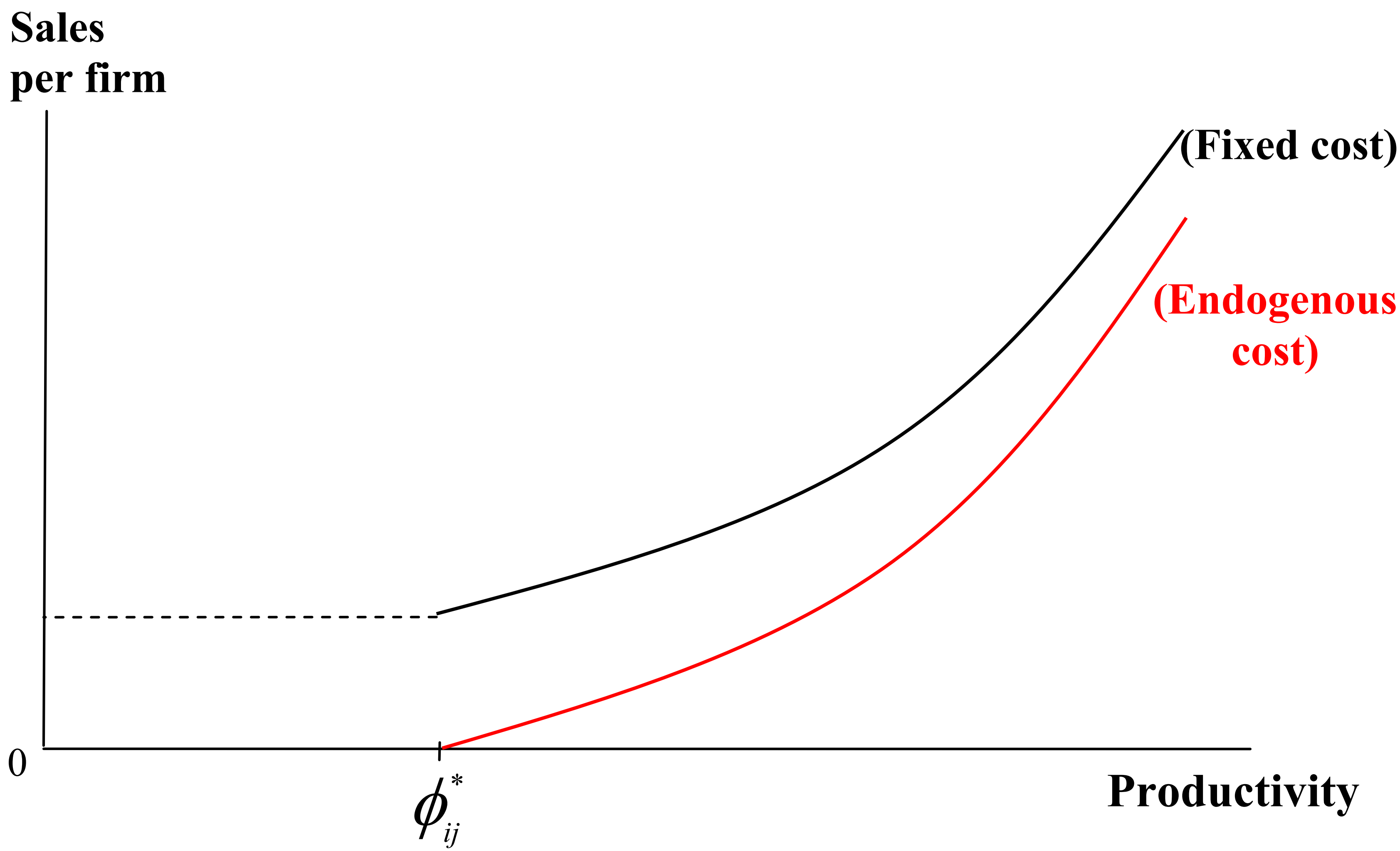
The properties of the Market Access Cost function



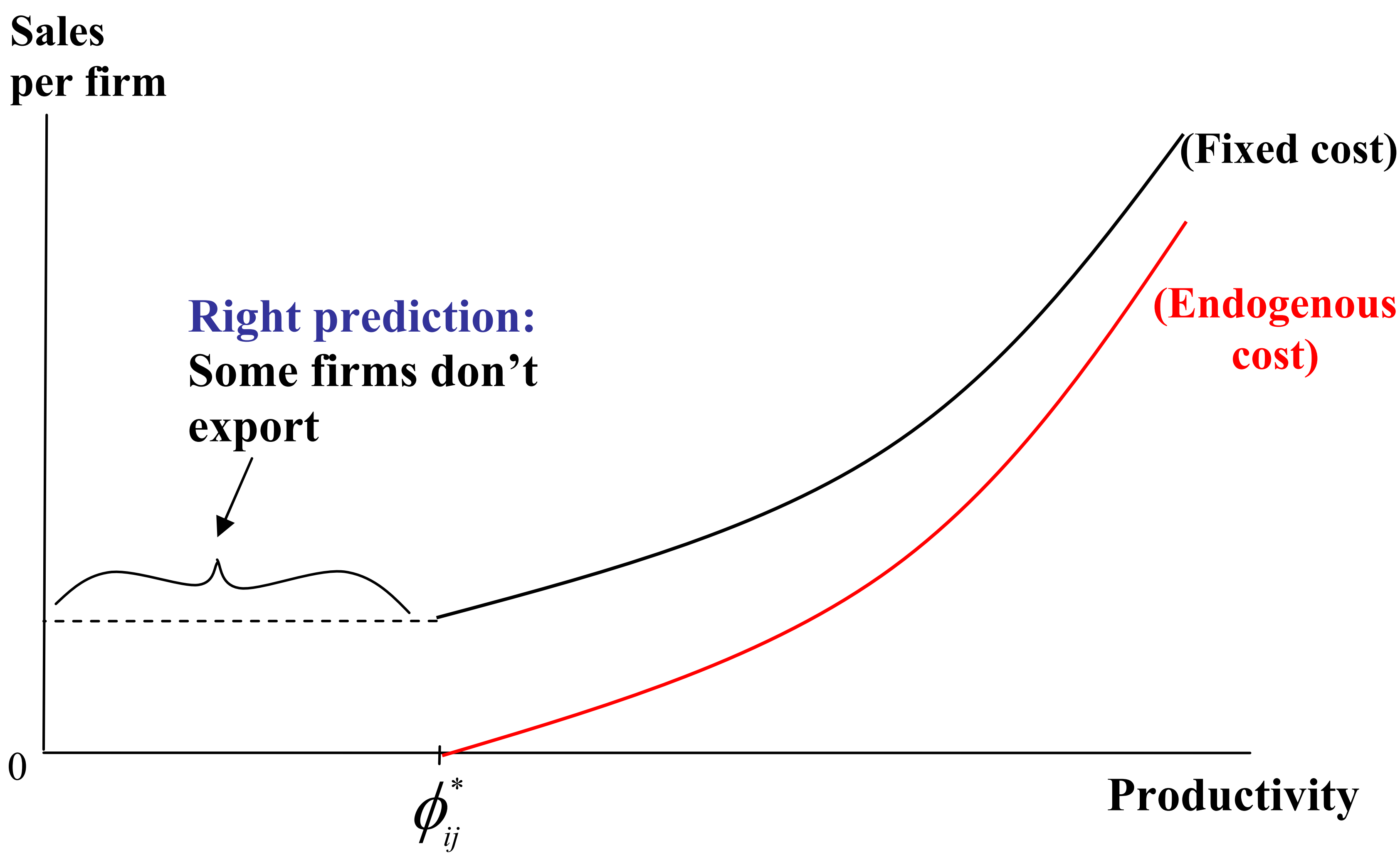
The properties of the Market Access Cost function



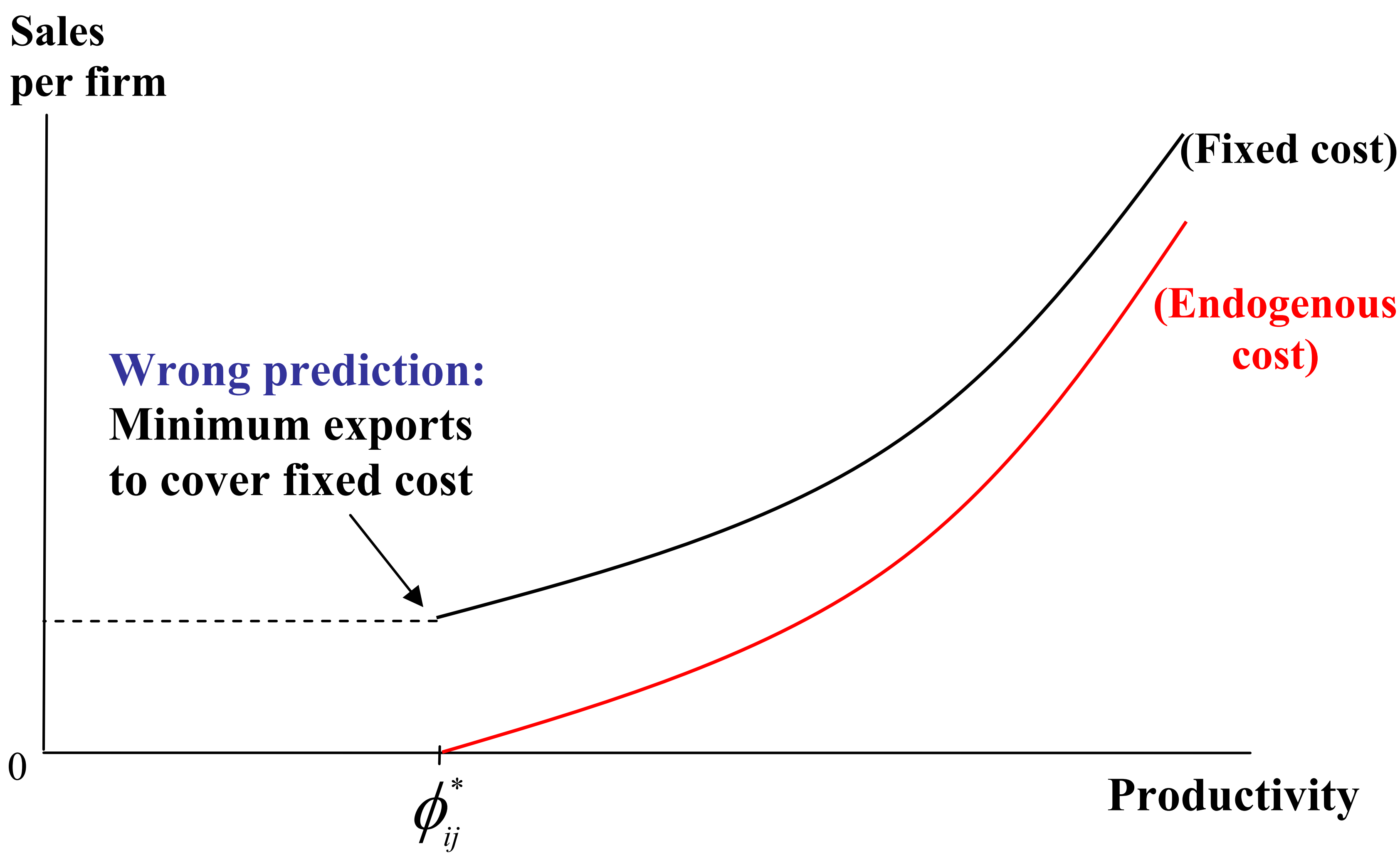
The product of the two margins: total sales per firm



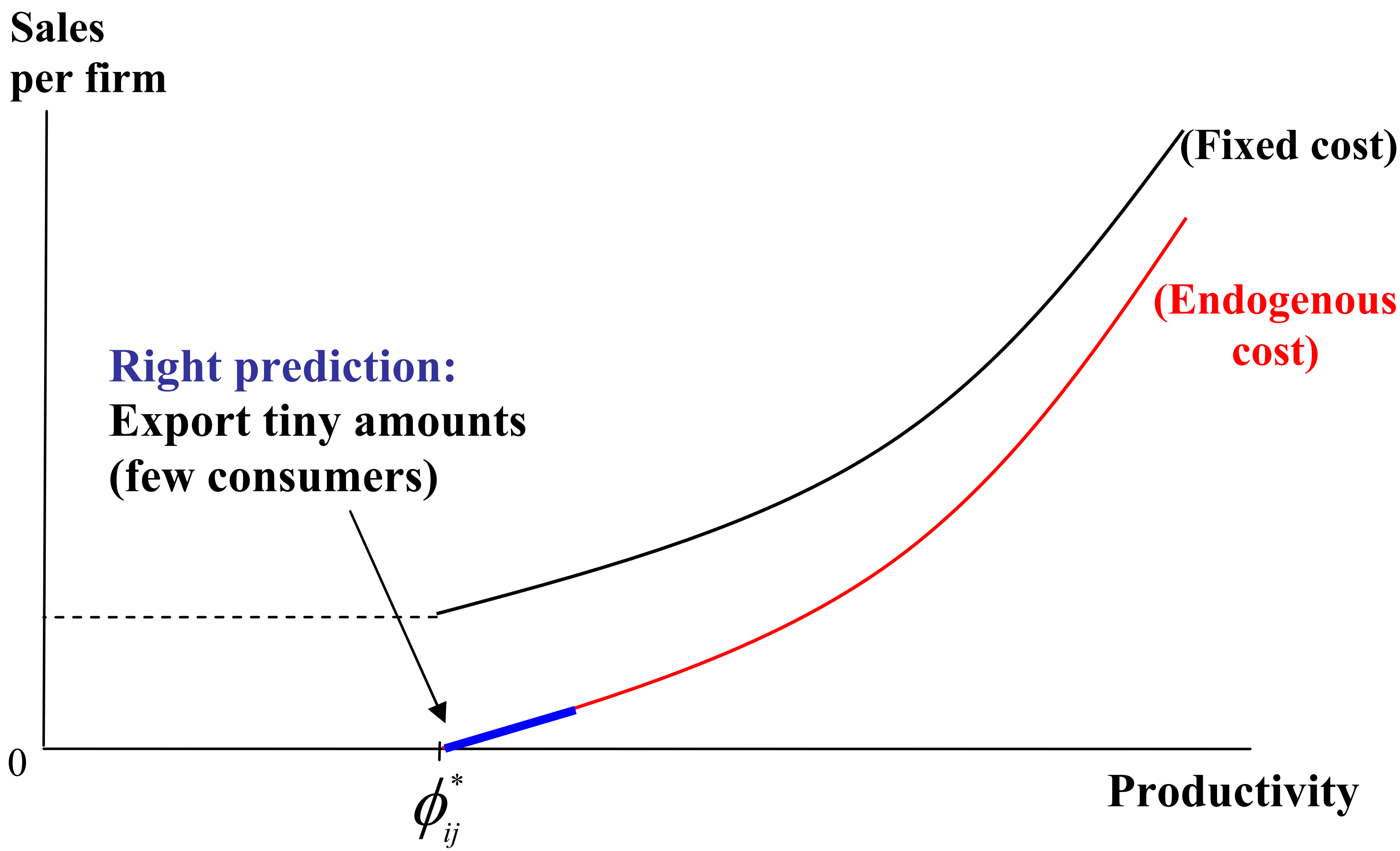
Models' predictions on which firms export



Models' predictions on how much firms export



Models' predictions on how much firms export



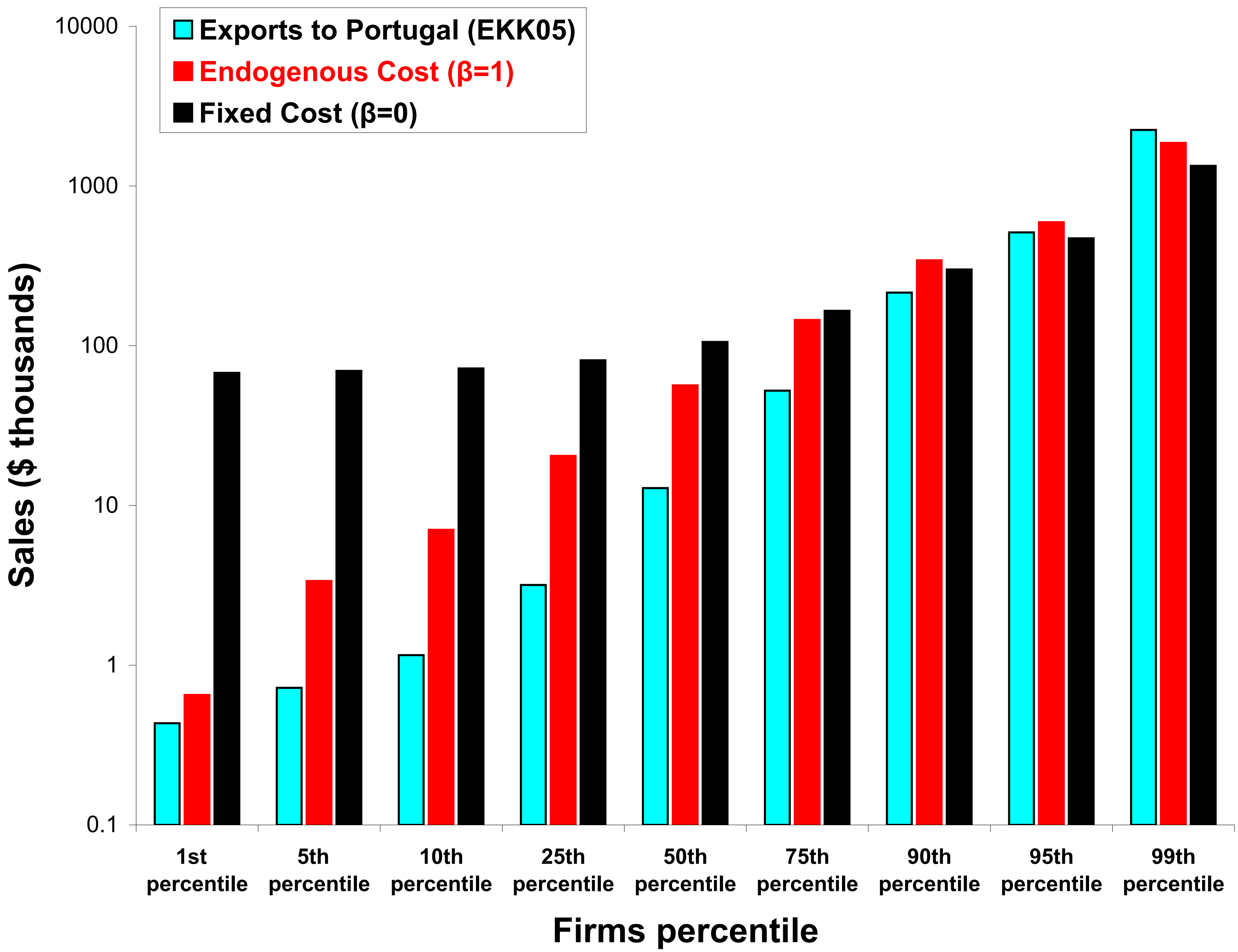
Comparing the Calibrated Model to French Data

- Look at the sales distribution for the model with $\beta = 0, 1$

- Remember: $\beta = 1$ calibrated to match higher sales in France of French firms exporting to more countries

- $\frac{1}{\psi}, \alpha$ calibrated to match number of French exporters to each country

Calibrated Endogenous Cost model accounts for large fraction of small exporters



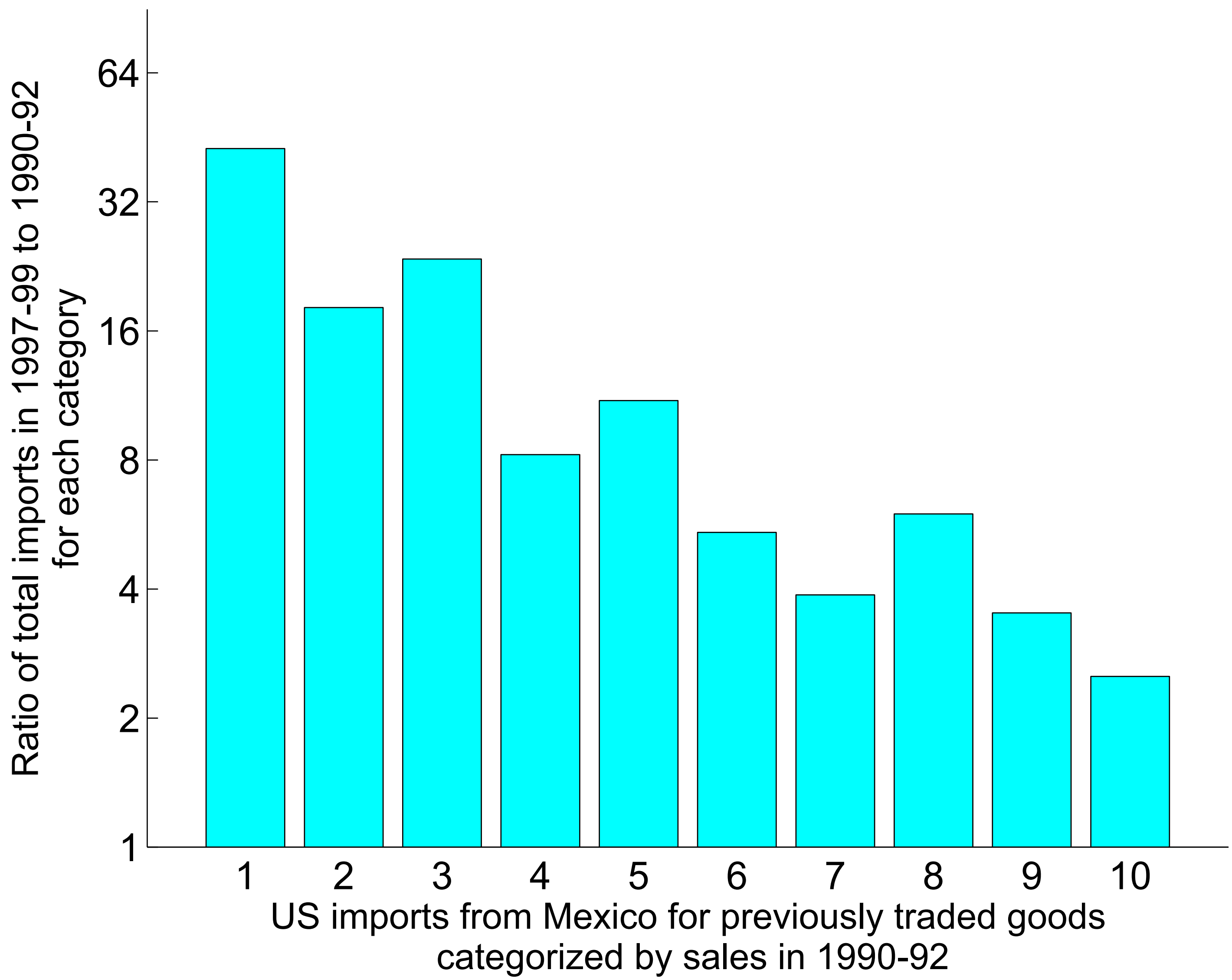
Observation 2: Trading Decisions After Trade Liberalization

- **Data:** Large increases in trade in least traded goods, Kehoe & Ruhl '03

- Look at US-Mexico trade liberalization; extend Kehoe-Ruhl analysis

- **Compute growth of positively traded goods prior to NAFTA**
  1. Data: US imports from Mexico '90-'99, 6-digit HS, $\approx$ 5400 goods
  2. Keep goods traded throughout '90-'92, $\approx$ 2900 goods
  3. Rank goods in terms of sales '90-'92
  4. Categorize **traded** goods in 10 bins

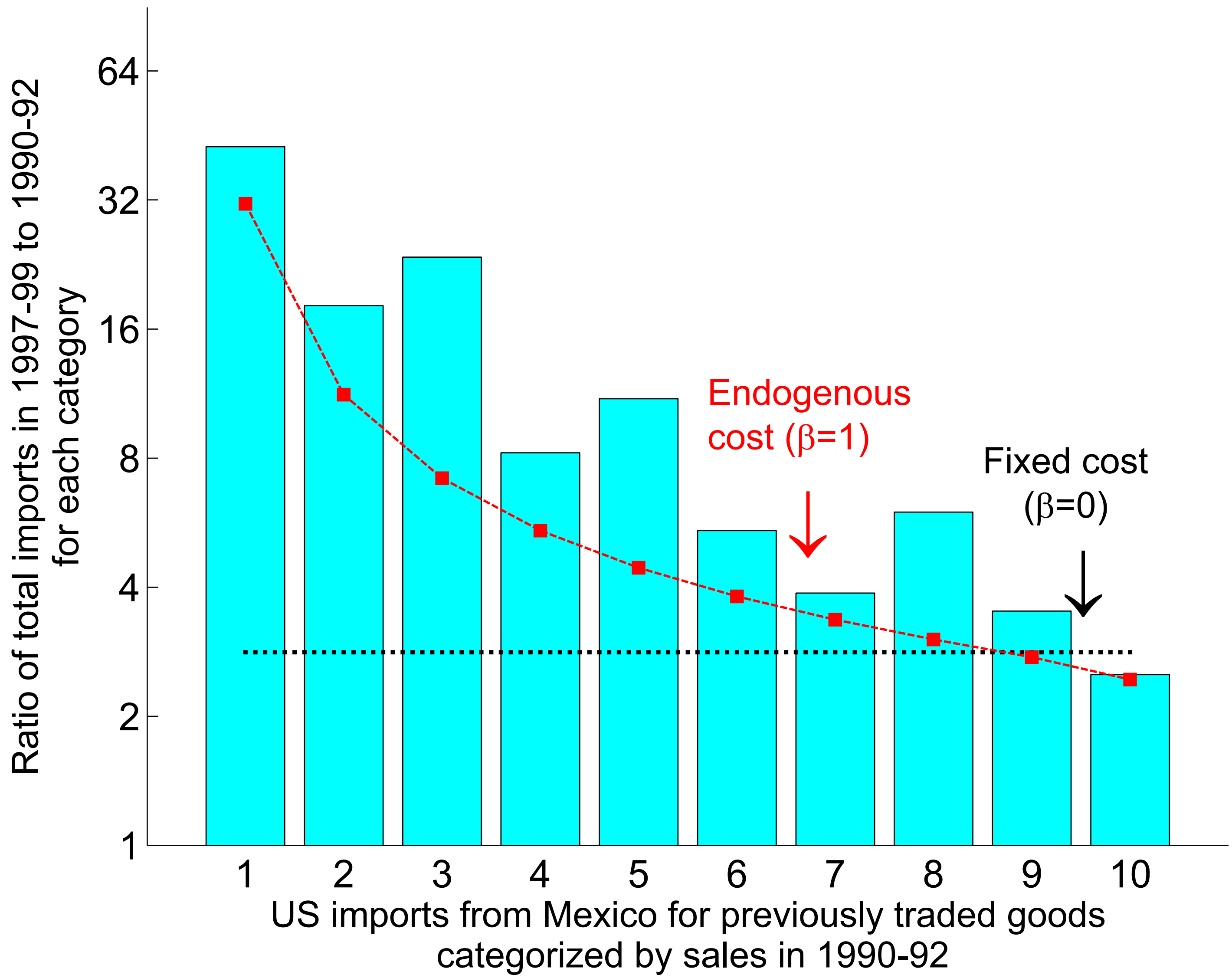
Large increases in trade for least traded goods



Comparing Calibrated Model to Data from NAFTA Episode

- Look at growth of trade for previously traded goods for $\beta = 0, 1$
- Use calibrated parameters, consider a firm as a good
- Change variable trade costs symmetrically across goods
  - Match increase in trade in previously traded goods
    - Fixed Cost model: 12.5% decrease in variable trade costs
    - My model: 9.5% decrease in variable trade costs (e.g. $\tau'_{ij} = 0.905\tau_{ij}$)

Calibrated Endogenous Cost model predicts increases in trade for least traded goods

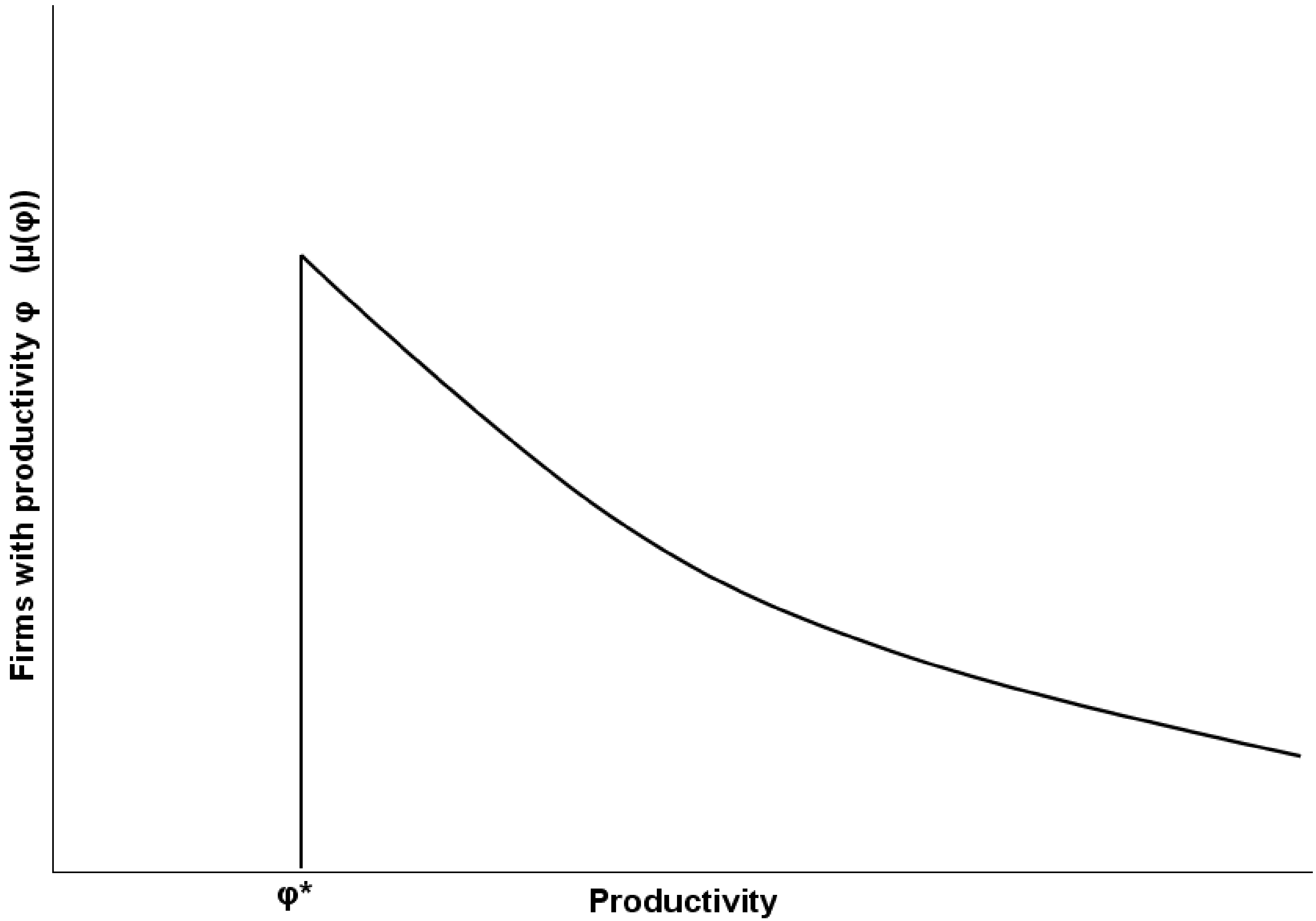


New Consumers Margin and New Trade

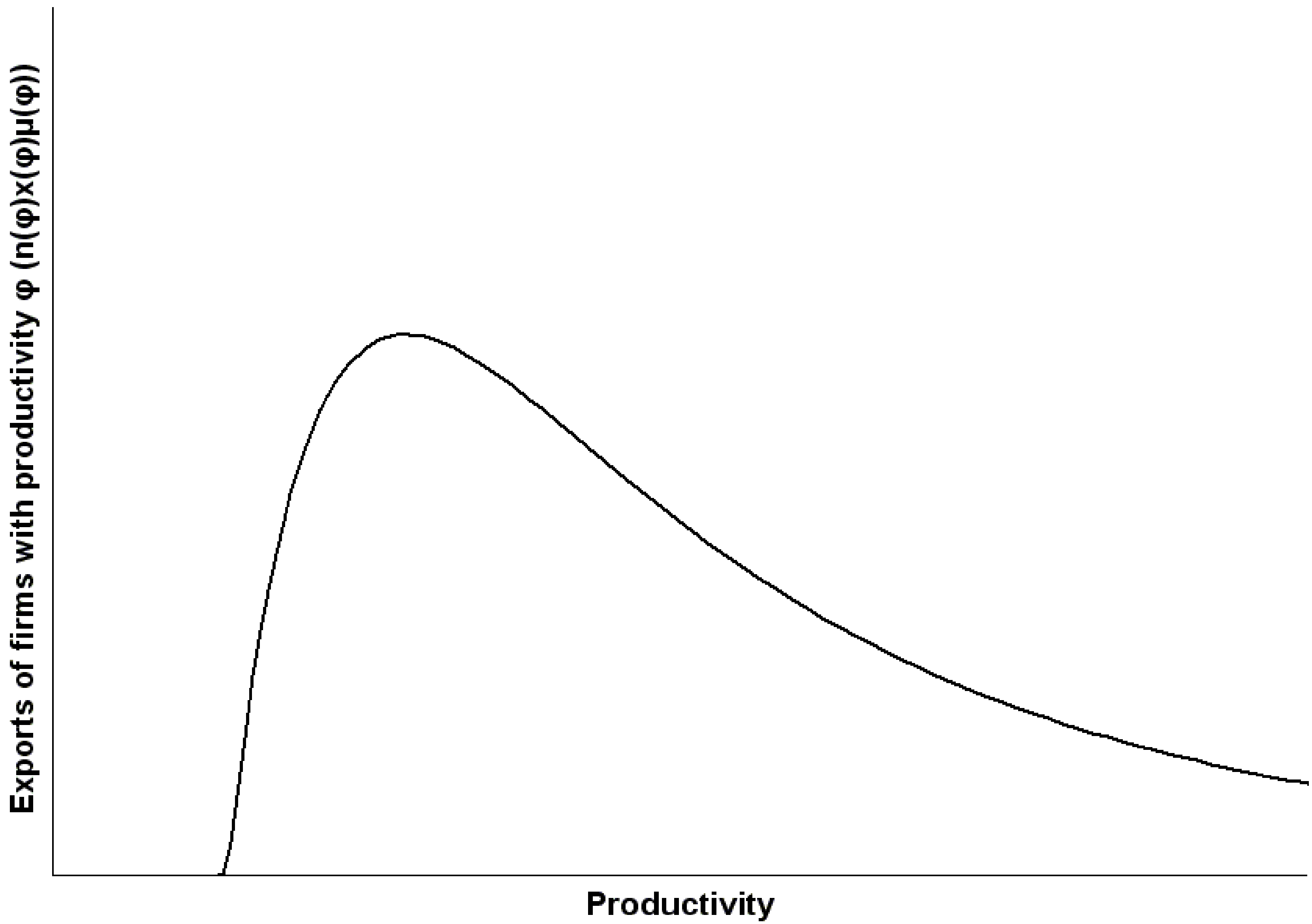
- Recent theory emphasizes increase in trade due to **many** new firms (EK02, Chaney '06 à la Melitz '03)

- **Decompose contribution of the <u>3</u> margins to total trade**
  - Intensive margin growth (total growth in sales per consumer)
  - New consumers margin (total growth in extensive margin of consumers)
  - New firms margin (total growth in extensive margin of firms)

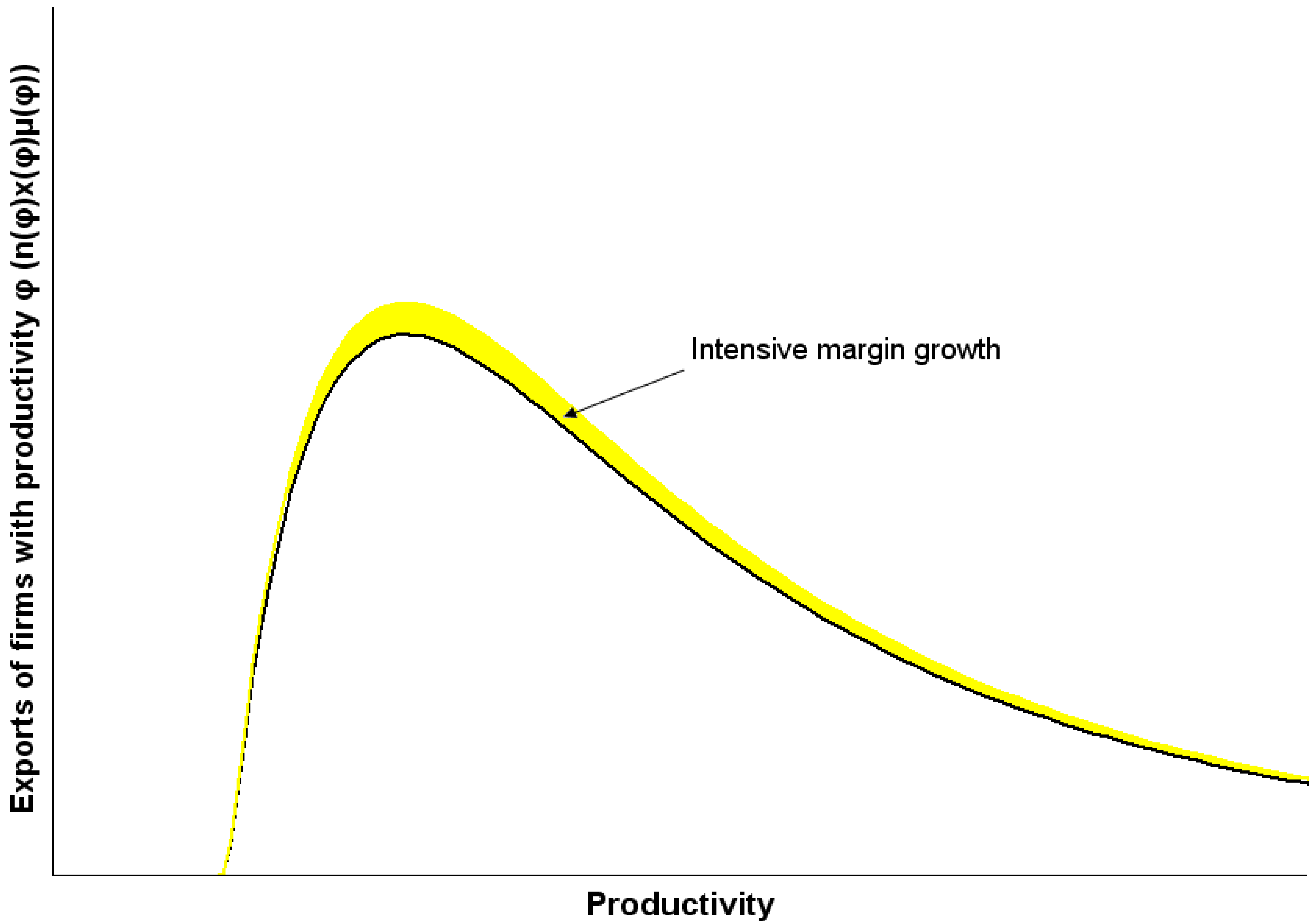
Pareto Density and Number of Firms with Productivity ϕ



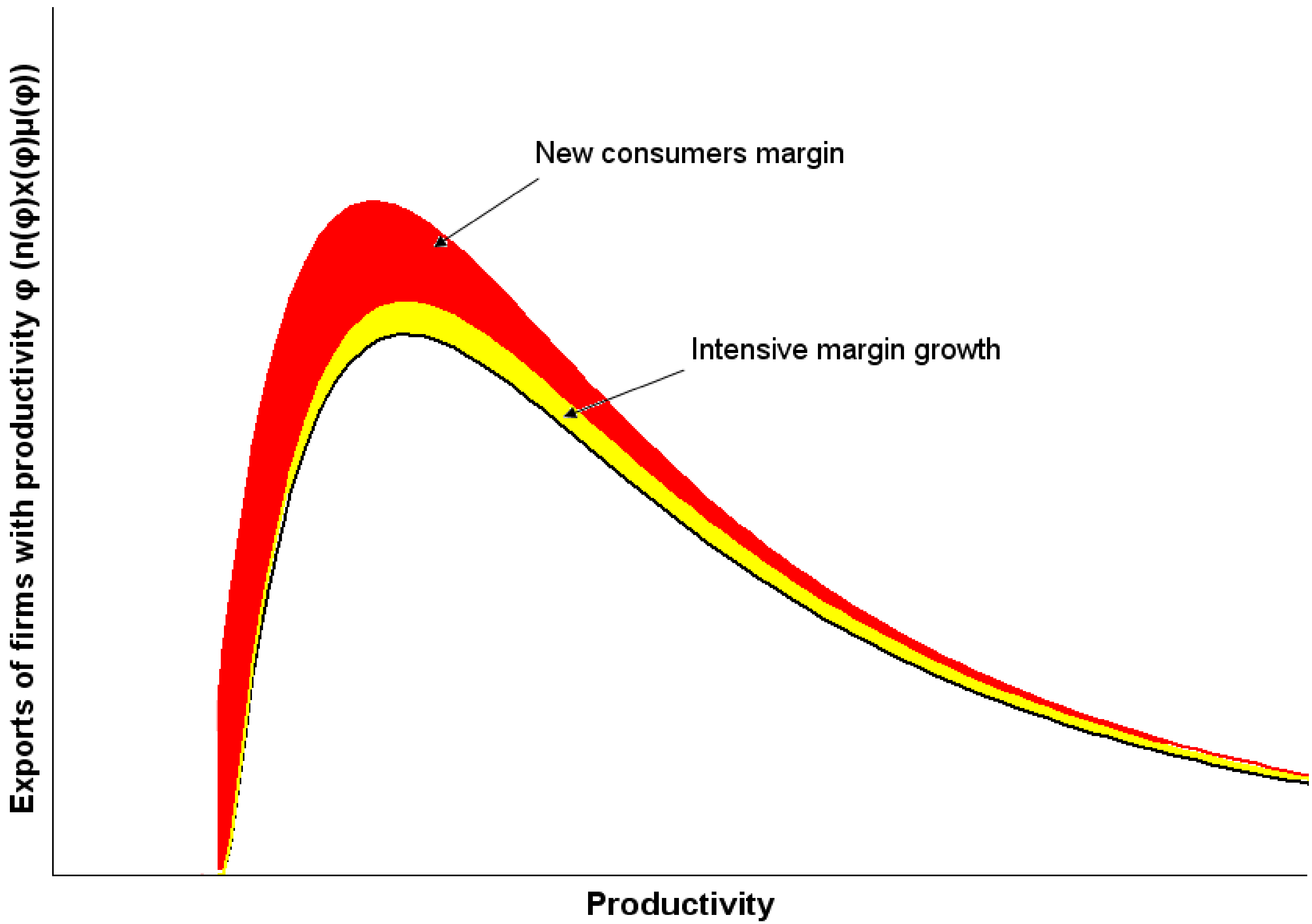
Density of exports



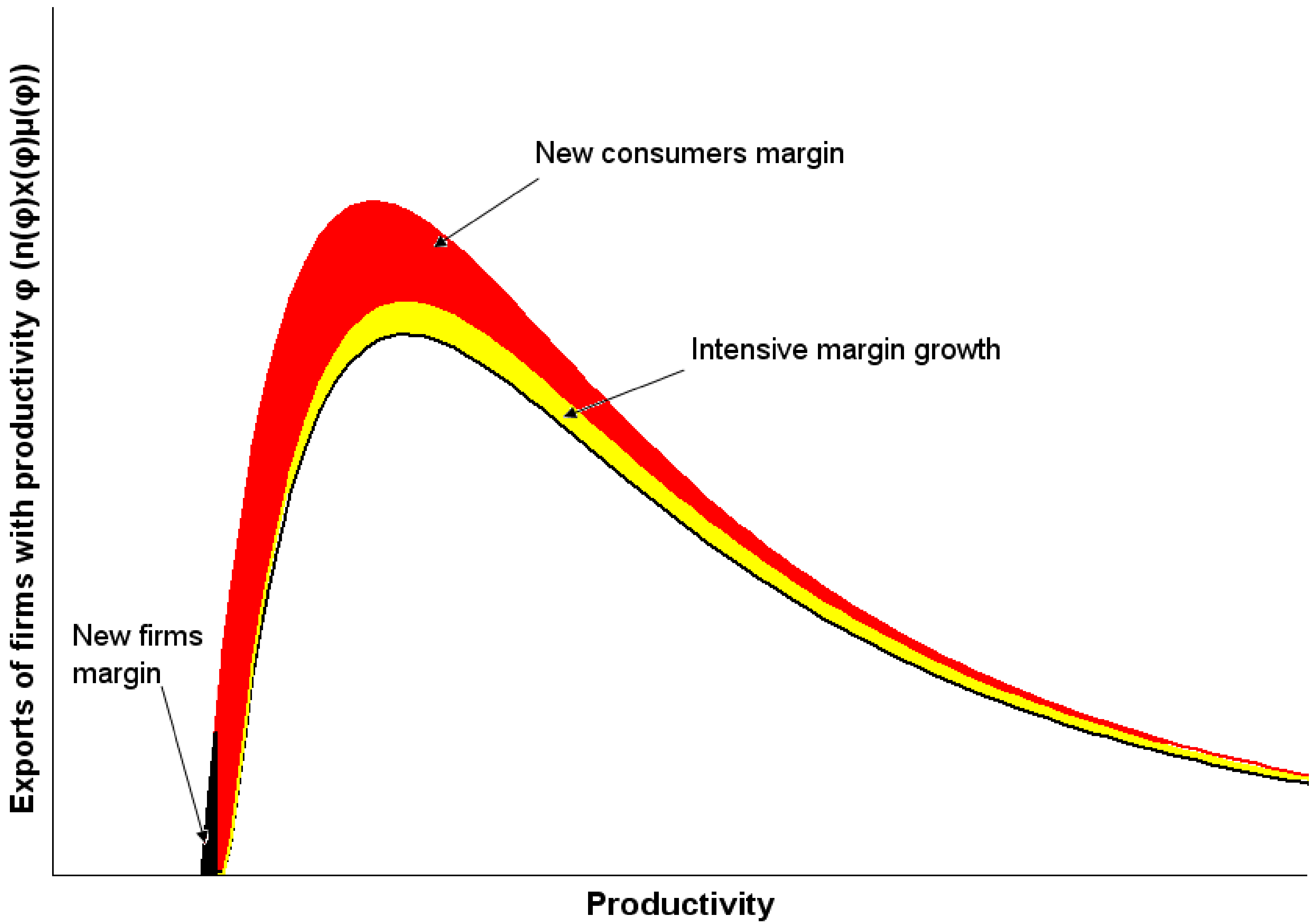
New Consumers Margin and new trade



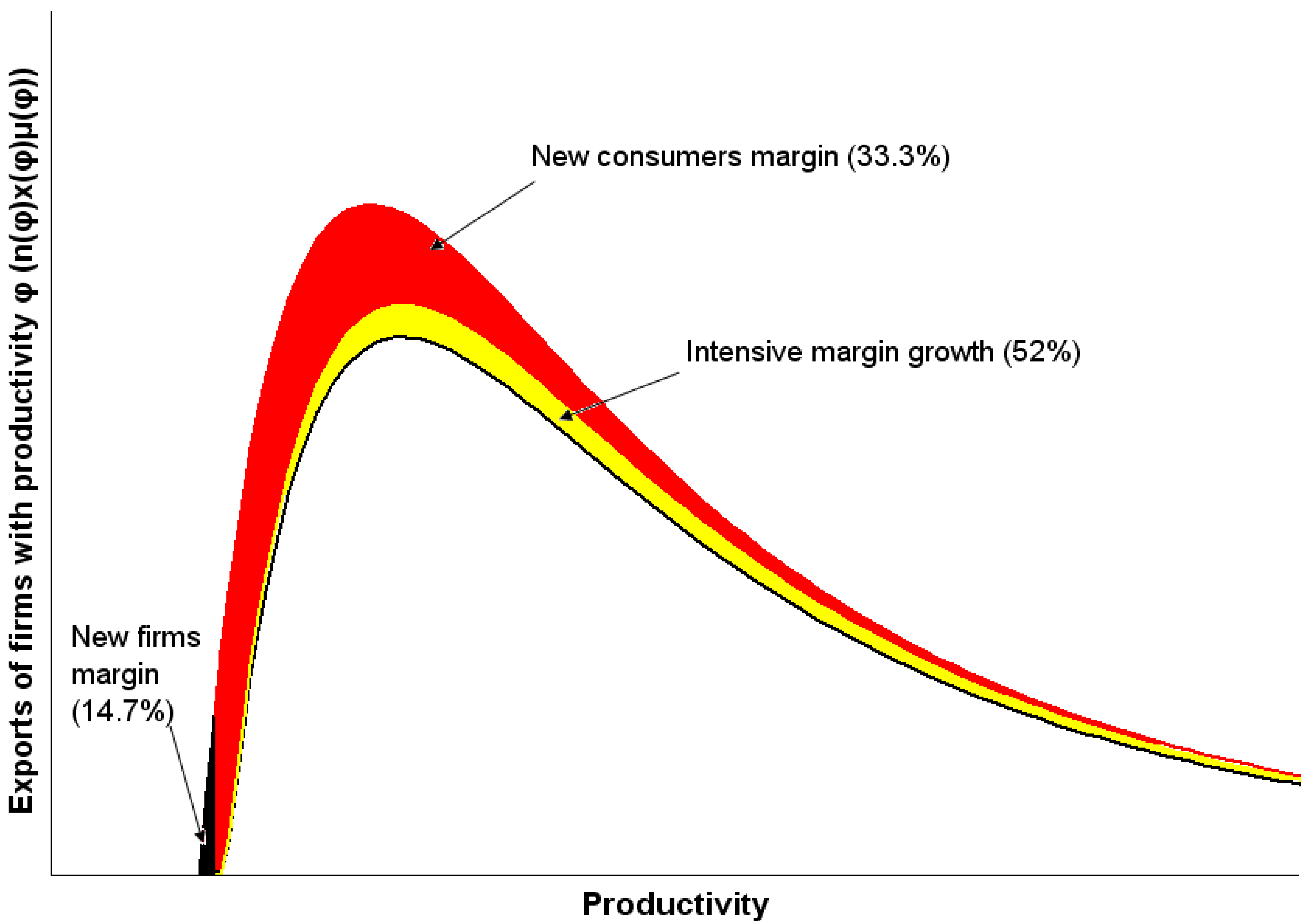
New Consumers Margin and new trade



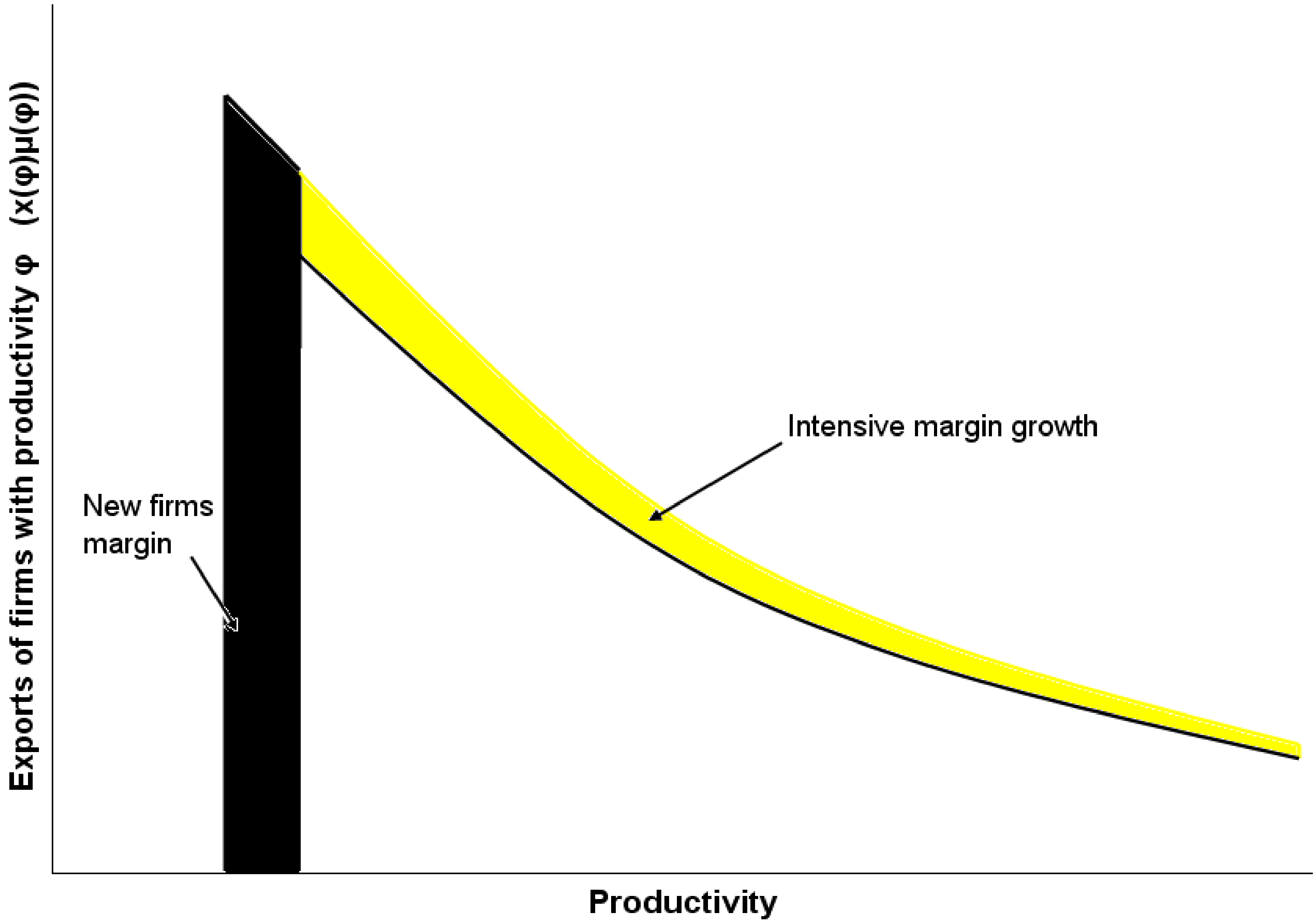
New Consumers Margin and new trade



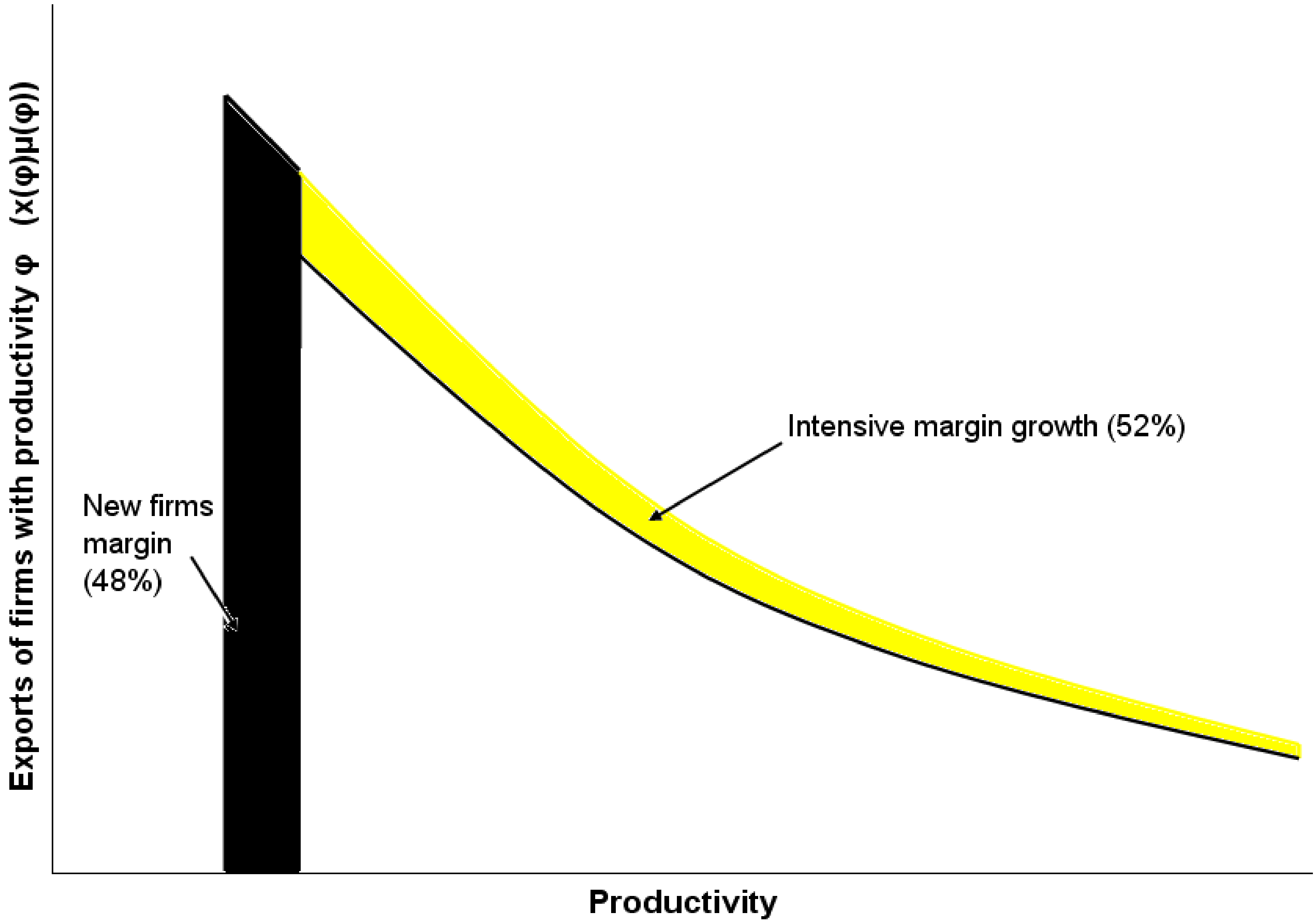
New Consumers Margin and new trade



New Firms Margin and the Fixed Cost model ($\beta = 0$)



New Firms Margin and new trade ($\beta = 0$)



7. Growth theory needs to be reconsidered in the light of trade theory. In particular, a growth model that includes trade can have the opposite convergence properties from a model of closed economies.

C. Bajona and T. J. Kehoe, “Trade, Growth, and Convergence in a Dynamic Heckscher-Ohlin Model,” Federal Reserve Bank of Minneapolis, 2006.

Trade and Growth

In 2004 Mexico has income per capita of 6500 U.S. dollars. In 1935 the United Stated had income per capita of about 6600 U.S. dollars (real 2004 U.S. dollars).

To study what will happened in Mexico over the next 70 years, should we study what happened to the United States since 1935?

…or should we take into account that the United States was the country with the highest income in the world in 1935, while Mexico has a very large trade relation with the United States — a country with a level of income per capita approximately 6 times larger in 2004?

We study this question using the Heckscher-Ohlin model of international trade: Countries differ in their initial endowments of capital per worker.

The General Dynamic Heckscher-Ohlin Model

n countries

countries differ in initial capital-labor ratios $\bar{k}_0^i$

and in size of population L^i.

two traded goods — a capital intensive good and a labor intensive good

$$y_j = \phi_j(k_j, \ell_j)$$

$$\frac{\phi_{1L}(k/\ell,1)}{\phi_{1K}(k/\ell,1)} < \frac{\phi_{2L}(k/\ell,1)}{\phi_{2K}(k/\ell,1)}$$

nontraded investment good

$$x = f(x_1, x_2)$$

Feasibility:

$$\sum_{i=1}^{n} L^i (c^i_{jt} + x^i_{jt}) = \sum_{i=1}^{n} L^i y^i_{jt} = \sum_{i=1}^{n} L^i \phi_j (k^i_{jt}, \ell^i_{jt}).$$

$$k^i_{1t} + k^i_{2t} = k^i_t$$

$$\ell^i_{1t} + \ell^i_{2t} = 1$$

$$k^i_{t+1} - (1-\delta) k^i_t = x^i_t = f(x^i_{1t}, x^i_{2t})$$

Infinitely-Lived Consumers

consumer in country i, $i = 1,...,n$:

$$\max \sum_{t=0}^{\infty} \beta^t u(c_{1t}^i, c_{2t}^i)$$

$$\text{s.t. } p_{1t}c_{1t}^i + p_{2t}c_{2t}^t + q_t^i x_t^i + b_{t+1}^i = w_t^i + (1 + r_t^{bi})b_t^i + r_t^i k_t^i$$

$$k_{t+1}^i - (1-\delta)k_t^i = x_t^i$$

$$c_{jt}^i \geq 0,\ x_t^i \geq 0,\ b_t^i \geq -B$$

$$k_0^i = \overline{k}_0^i,\ b_0^i = 0.$$

Notice that since p_{1t} and p_{2t} are equalized across countries by trade, we can set

$$q_t^i = q_t = 1.$$

The factor prices w_t^i and r_t^i are potentially different across countries. International borrowing and lending:

$$\sum_{i=1}^{n} L^i b_t^i = 0,$$

No international borrowing and lending:

$$b_t^i = 0.$$

International borrowing and lending implies that $r_t^{bi} = r_t^b$, $t = 1, 2, \ldots.$ No arbitrage implies that $r_t^i = r_t = r_t^b + \delta$.

Integrated Equilibrium Approach

Characterization and computation of equilibrium is relatively easy when we can solve for equilibrium of an artificial world economy in which we ignore restrictions on factor mobility and then disaggregate the consumption, production, and investment decisions.

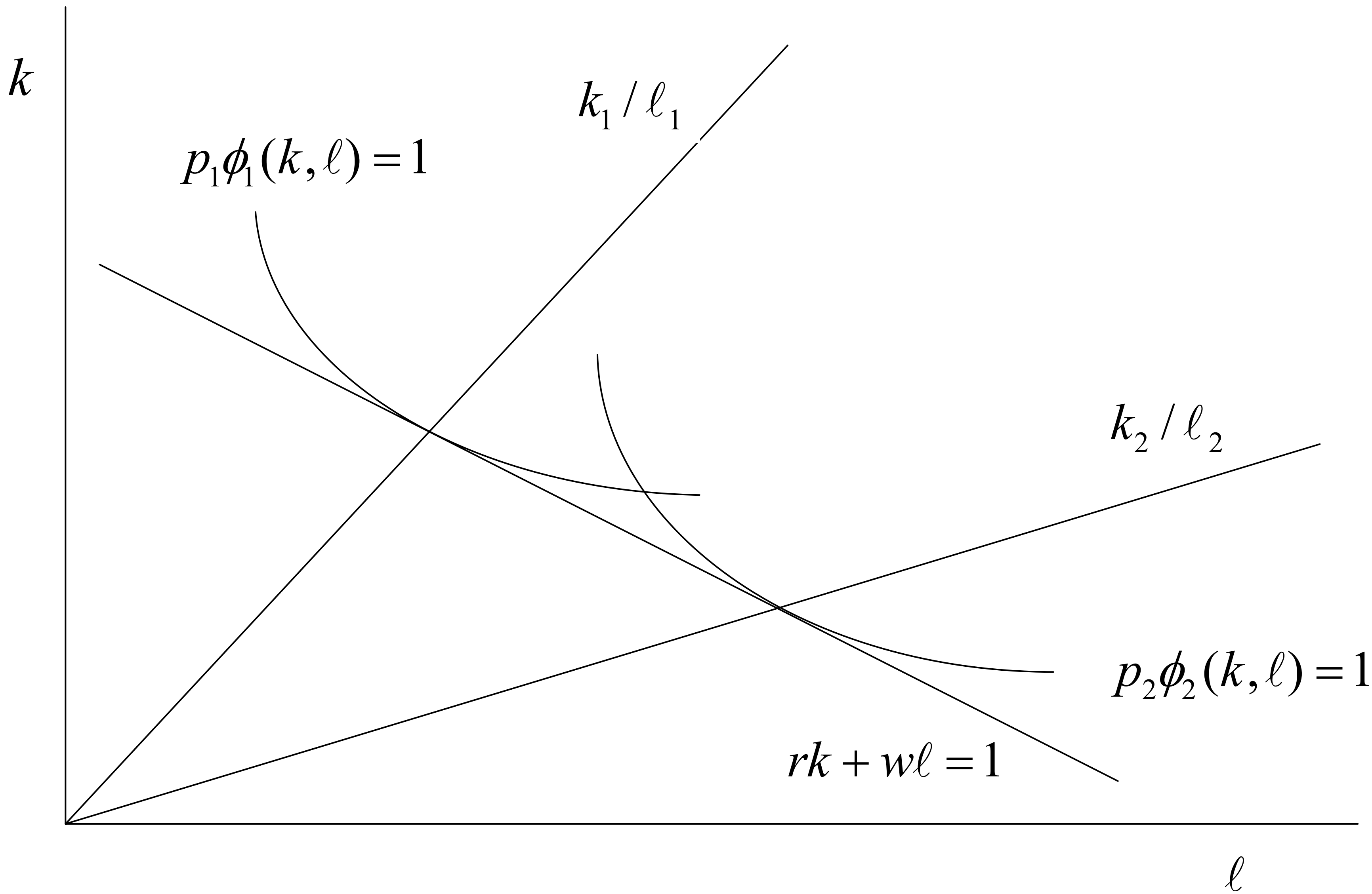
This is a guess-and-verify approach: We first solve for the integrated equilibrium of the world economy and then we see if we can disaggregate the consumption, production, and investment decisions.

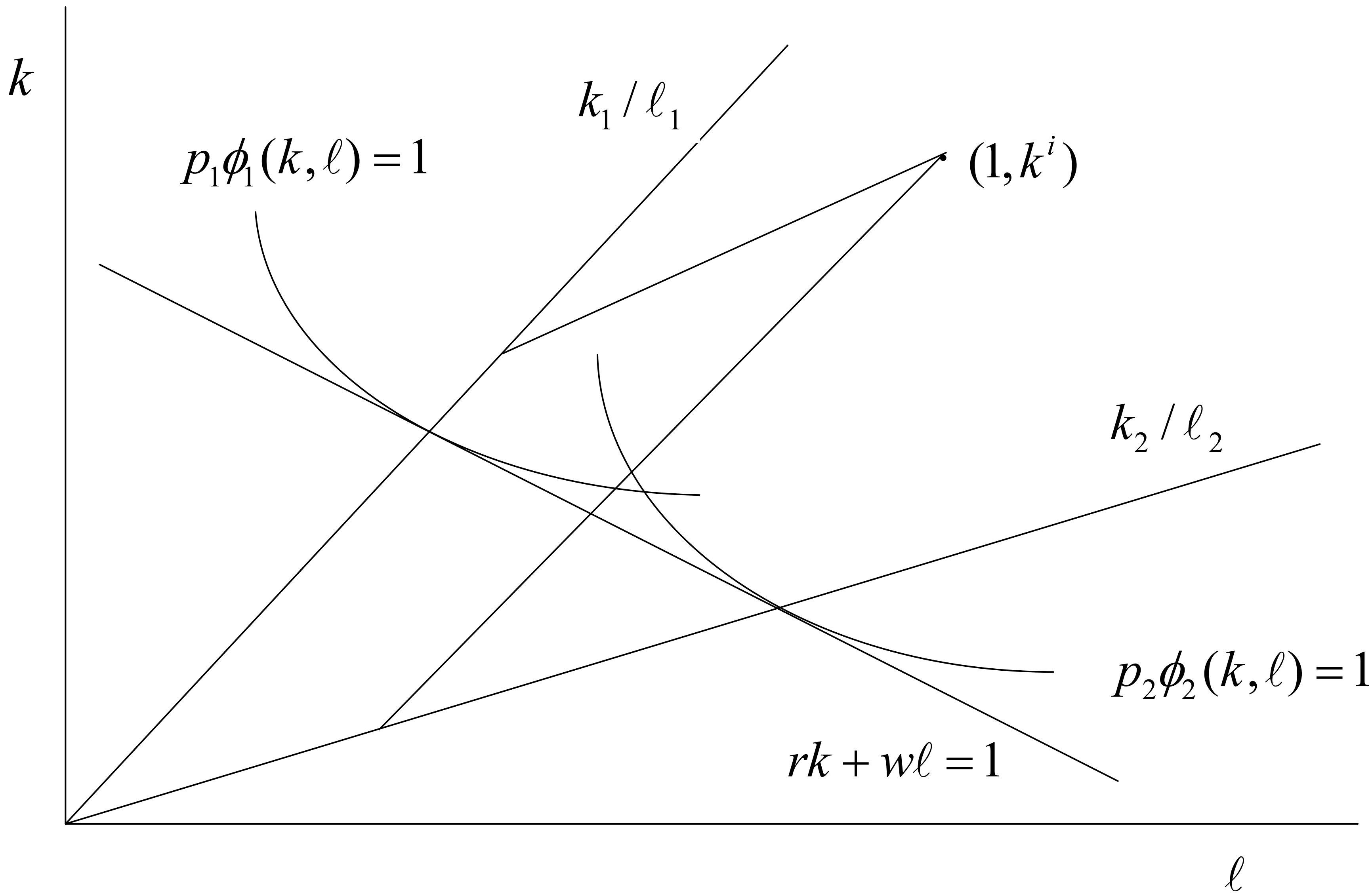
Potential problem: We cannot assign each country nonnegative production plans for each of the two goods while maintaining factor prices equal to those in the world equilibrium.

Another potential problem: We cannot assign each country nonnegative investment.

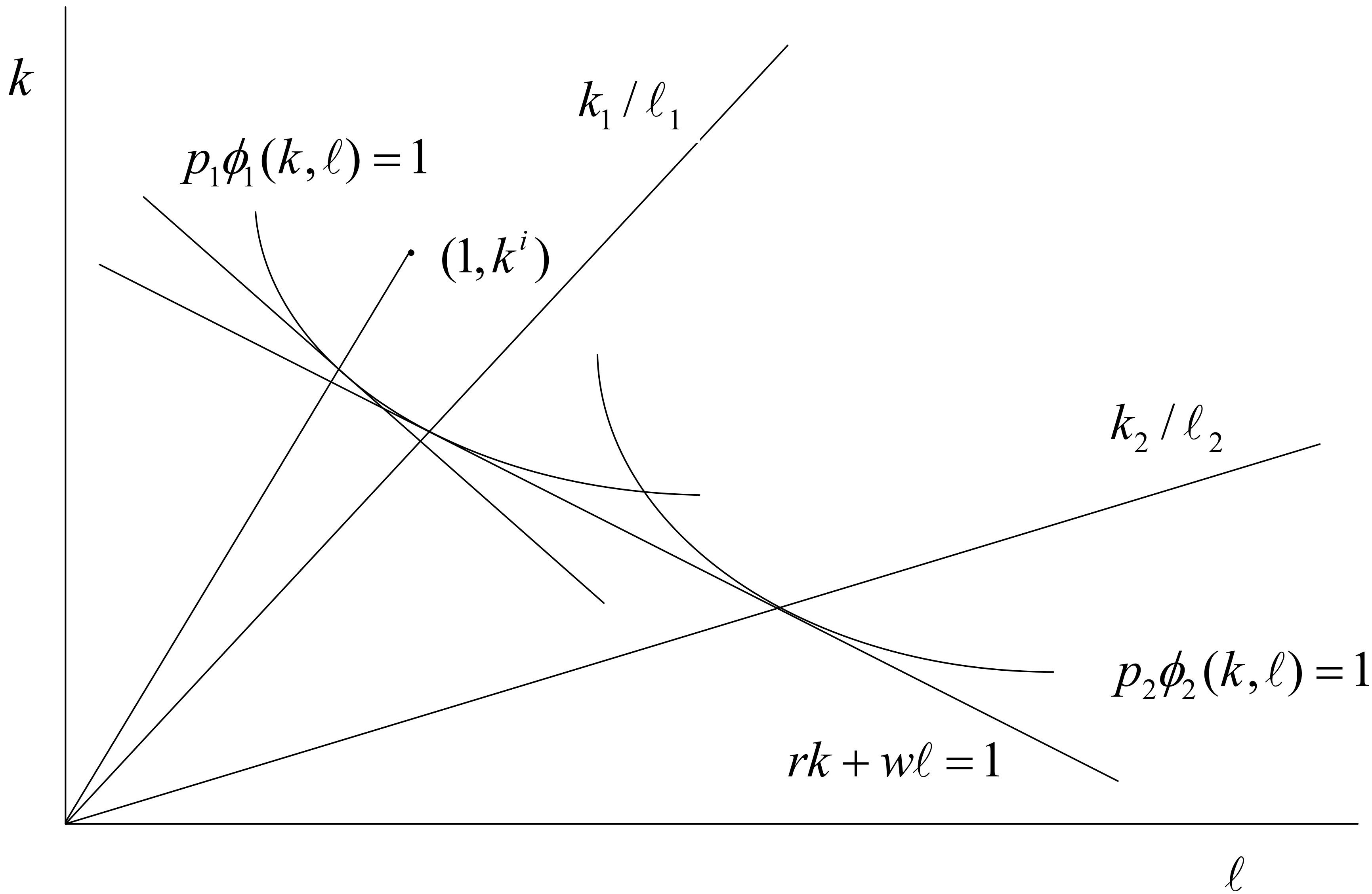
If the integrated equilibrium approach does not work, it could be very difficult to calculate an equilibrium.

We would have to determine the pattern of specialization over an infinite time horizon.


k
k_1 / ℓ_1
$p_1\phi_1(k,\ell) = 1$
k_2 / ℓ_2
$p_2\phi_2(k,\ell) = 1$
$rk + w\ell = 1$
ℓ



k
k_1 / ℓ_1
$p_1\phi_1(k,\ell)=1$
$(1,k^i)$
k_2 / ℓ_2
$p_2\phi_2(k,\ell)=1$
$rk + w\ell = 1$
ℓ



k
k_1 / ℓ_1
$p_1\phi_1(k,\ell) = 1$
$(1, k^i)$
k_2 / ℓ_2
$p_2\phi_2(k,\ell) = 1$
$rk + w\ell = 1$
ℓ

Results for General Model

International borrowing and lending implies factor price equalization in period $t = 1, 2, \ldots$ Production plans and international trade patterns are indeterminate.

Any steady state or sustained growth path has factor price equalization.

If there exists a steady state in which the total capital stock is positive or a sustained growth path, then there exists a continuum of such steady states or sustained growth paths, indexed by the distribution of world capital $\hat{k}^1/\hat{k}, \ldots, \hat{k}^n/\hat{k}$.

International trade occurs in every steady state or sustained growth path of the model in which $\hat{k}^i/\hat{k} \neq 1$ for some i.

We focus on models with no international borrowing and lending.

For analysis of general model with infinitely lived consumers and comparison with model with overlapping generations, see

C. Bajona and T. J. Kehoe (2006), “Demographics in Dynamic Heckscher-Ohlin Models: Overlapping Generations versus Infinitely Lived Consumers.”

Ventura Model

$$u(c_1,c_2)=v\left(f(c_1,c_2)\right)=\log\left(f(c_1,c_2)\right)$$

$$\phi_1(k_1,\ell_1)=k_1$$

$$\phi_2(k_2,\ell_2)=\ell_2$$

$$f(x_1,x_2)=\begin{cases} d\left(a_1x_1^b+a_2x_2^b\right)^{1/b} & \text{if } b\neq 0 \\ dx_1^{a_1}x_2^{a_2} & \text{if } b=0 \end{cases}.$$

Ventura (1997) examines the continuous-time version of this model.

In the Ventura model, we can solve for the equilibrium of the world economy by solving a one-sector growth model in which $c_t = f(c_{1t}, c_{2t})$:

$$
\begin{gathered}
\max \sum_{t=0}^{\infty} \beta^t \log c_t \\
\text{s.t. } c_t + x_t = f(k_t, 1) \\
k_{t+1} - (1-\delta)k_t = x_t \\
c_t \geq 0,\ k_t \geq 0 \\
k_0 = \bar{k}_0 .
\end{gathered}
$$

If $b < 0$ and $1/\beta - 1 + \delta > d a_1^{1/b}$, the equilibrium converges to $\hat{k} = 0$.

If $b > 0$ and $1/\beta - 1 + \delta < d a_1^{1/b}$, the economy grows without bound, and the equilibrium converges to a sustained growth path.

In every other case, the equilibrium converges to a steady state in which $f_K(\hat{k}, 1) = 1/\beta - 1 + \delta$.

The 2 sectors matter a lot for disaggregating the integrated equilibrium!

In particular, we cannot solve for the equilibrium values of the variables for one of the countries by solving an optimal growth problem for that country in isolation.

Instead, the equilibrium path for k_t^i and the steady state value of $\hat{k}^i$ depends on $\overline{k}_0^i$ as well as on the path for k_t and the steady state value of $\hat{k}$.

Proposition: Let $y_t^i = p_{1t}y_{1t}^i + p_{2t}y_{2t}^i = r_t k_t^i + w_t$. Suppose that $x_t^i > 0$ for all i and all t. Then

$$\frac{y_{t+1}^i - y_{t+1}}{y_{t+1}} = \frac{r_{t+1}c_t / y_{t+1}}{r_t c_{t-1} / y_t}\left(\frac{y_t^i - y_t}{y_t}\right)$$

If $\delta = 1$,

$$\frac{y_{t+1}^i - y_{t+1}}{y_{t+1}} = \frac{s_{t+1}}{s_t}\left(\frac{y_t^i - y_t}{y_t}\right)$$

where $s_t = c_t / y_t$.

Proof: The first-order conditions from the consumers' problems are

$$\frac{c_t^i}{c_{t-1}^i} = \frac{c_t}{c_{t-1}} = \beta(1+r_t-\delta).$$

The demand functions are

$$c_t^i = (1-\beta)\left[\sum_{s=t}^{\infty}\left(\prod_{\tau=t+1}^{s}\frac{1}{1+r_\tau-\delta}\right)w_s + (1+r_t-\delta)k_t^i\right]$$

$$c_t^i - c_t = (1-\beta)(1+r_t-\delta)(k_t^i-k_t).$$

The budget constraint implies that

$$c_t^i - c_t + k_{t+1}^i - k_{t+1} = (1+r_t-\delta)(k_t^i-k_t).$$

Combining these conditions, we obtain

$$k_{t+1}^i - k_{t+1} = \frac{c_t}{c_{t-1}}(k_t^i-k_t).$$

The difference between a country's income per worker and the world's income per worker can be written as

$$y^i_{t+1} - y_{t+1} = r_{t+1}(k^i_{t+1} - k_{t+1}).$$

Using the expression for $k^i_{t+1} - k_{t+1}$ found above and operating, we obtain:

$$\frac{y^i_{t+1} - y_{t+1}}{y_{t+1}} = \frac{r_{t+1}c_t / y_{t+1}}{r_t c_{t-1} / y_t}\left(\frac{y^i_t - y_t}{y_t}\right).$$

In the case $\delta = 1$ this becomes (using $c_{t+1} / c_t = \beta r_{t+1}$),

$$\frac{y^i_{t+1} - y_{t+1}}{y_{t+1}} = \frac{s_{t+1}}{s_t}\left(\frac{y^i_t - y_t}{y_t}\right),$$

where $s_t = c_t / y_t$. ■

$$\frac{y_t^i - y_t}{y_t} = \frac{s_t}{s_0}\left(\frac{y_0^i - y_0}{y_0}\right)$$

Proposition. Suppose that $\delta = 1$, that $0 < k_0 < \hat{k}$, and that $x_t^i > 0$ for all i and all t. Then

if $b > 0$, differences in relative income levels decrease over time;

if $b = 0$, differences in relative income levels stay constant over time; and

if $b < 0$, differences in relative income levels increase over time.

$$\frac{y_t^i - y_t}{y_t} = \frac{s_t}{s_0}\left(\frac{y_0^i - y_0}{y_0}\right)$$

Proposition. Suppose that $\delta = 1$, that $0 < k_0 < \hat{k}$, and that $x_t^i > 0$ for all i and all t. Then

if $b > 0$, differences in relative income levels decrease over time;

if $b = 0$, differences in relative income levels stay constant over time; and

if $b < 0$, differences in relative income levels increase over time.

Notice contrast with convergence results for world of closed economies!

What about corner solutions in investment?

If $x_t^i > 0$ for all i and all t, then

$$\frac{k_{t+1}^i - k_{t+1}}{k_{t+1}} = \frac{c_t / k_{t+1}}{c_{t-1} / k_t} \left(\frac{k_t^i - k_t}{k_t} \right) = \frac{z_{t+1}}{z_t} \left(\frac{k_t^i - k_t}{k_t} \right)$$

where $z_t = c_{t-1} / k_t$ and $z_0 = c_0 / \left(\beta r_0 k_0 \right)$.

The sequence z_t has the same monotonicity properties as the sequence $s_t = c_t / y_t$.

Proposition: Suppose that the sequence $s_t = c_t / y_t$ in the equilibrium of the integrated economy is constant or strictly decreasing. There exists an equilibrium where $x_t^i > 0$ for all i and all t.

Proposition: Suppose that the sequence $s_t = c_t / y_t$ in the equilibrium of the integrated economy is strictly increasing. Let

$$\hat{z} = \lim_{t\to\infty} \frac{c_{t-1}}{k_t},$$

and let $\overline{k}_0^{i_{min}} \leq \overline{k}_0^{i}$, $i = 1,\dots,n$. If

$$\frac{\hat{z}}{z_0}\left(\frac{\overline{k}_0^{i_{min}} - \overline{k}_0}{\overline{k}_0}\right) \geq -1,$$

then there exists an equilibrium where $x_t^i > 0$ for all i and all t. Otherwise, there is no equilibrium where $x_t^i > 0$ for all i and all t. When there exists an equilibrium with no corner solutions in investment, it is the unique such equilibrium.

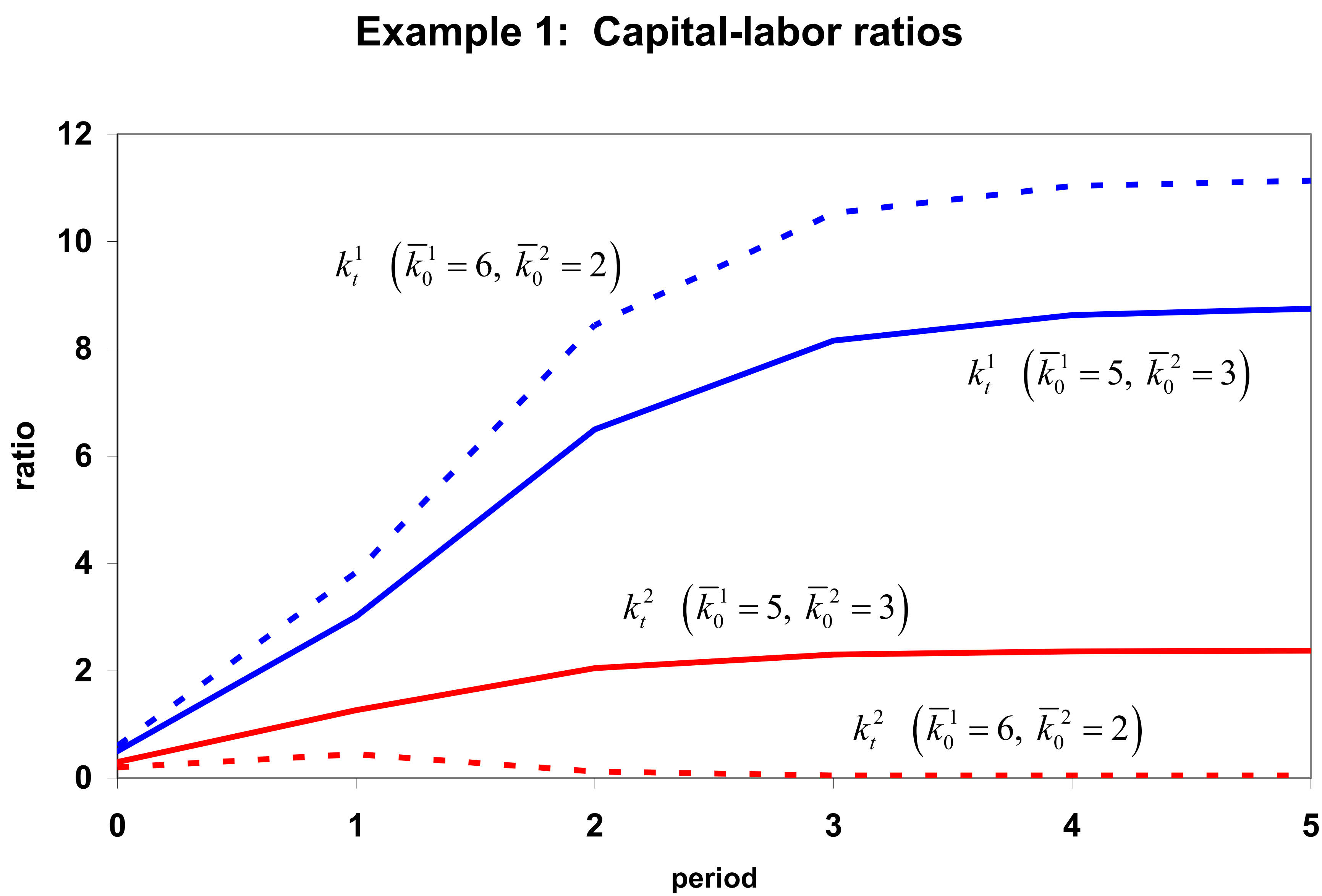
Numerical example 1: Two countries. $\beta = 0.95$, $\delta = 1$, and $L^1 = L^2 = 10$.

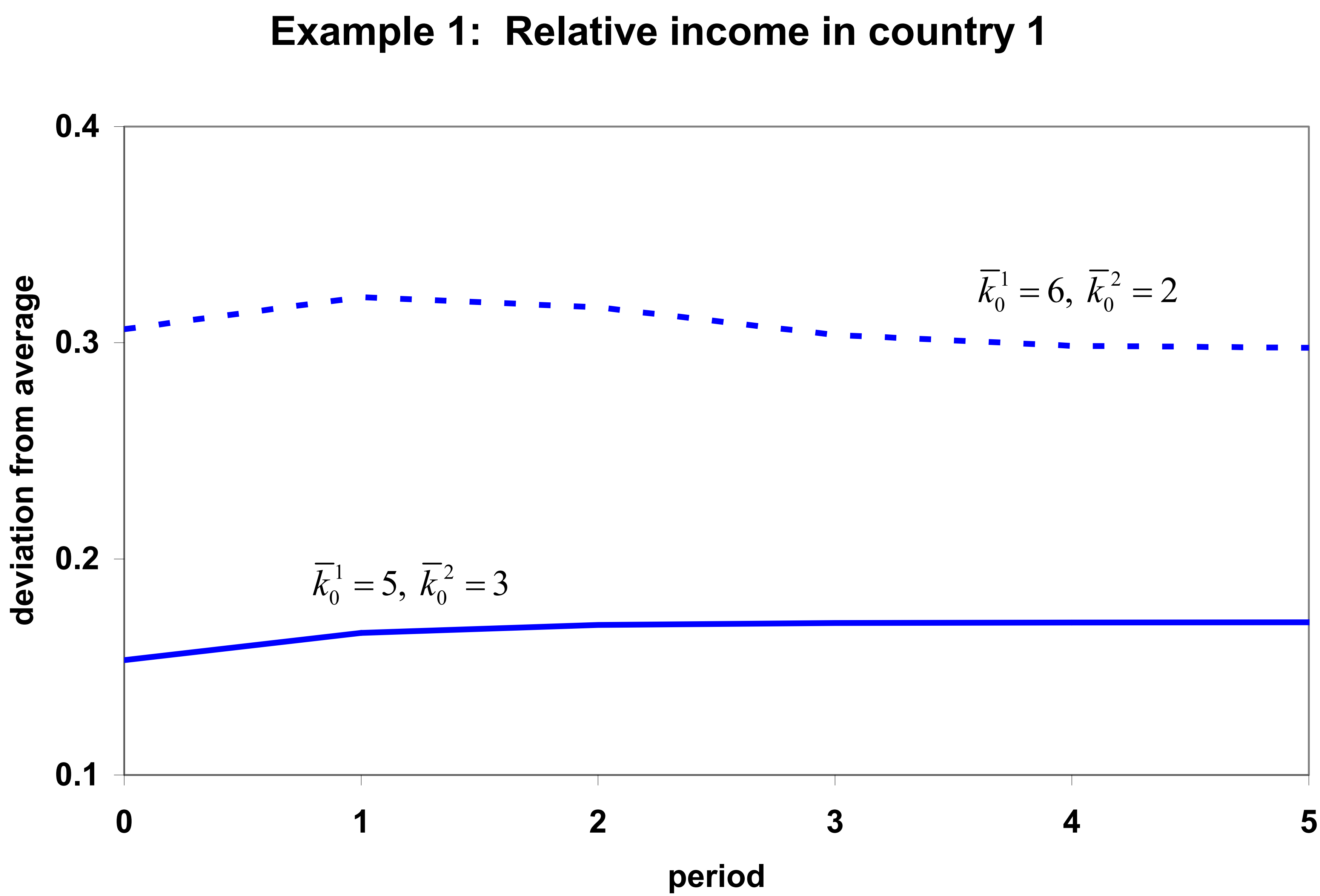
$$f(x_1, x_2) = 10\left(0.5x_1^{-0.5} + 0.5x_2^{-0.5}\right)^{-2}.$$

We contrast two different worlds:

In the first world, $\overline{k}_0^1 = 5$ and $\overline{k}_0^2 = 3$. Here there is an equilibrium with no corner solutions for investment.

In the second world, $\overline{k}_0^1 = 6$ and $\overline{k}_0^2 = 2$. Country 2 has $x_t^i = k_t^i = 0$ starting in period 3.


Example 1: Capital-labor ratios
12
10
8
6
4
2
0
ratio
0
1
2
3
4
5
period
$k_t^1 \quad \left(\bar{k}_0^1 = 6,\ \bar{k}_0^2 = 2\right)$
$k_t^1 \quad \left(\bar{k}_0^1 = 5,\ \bar{k}_0^2 = 3\right)$
$k_t^2 \quad \left(\bar{k}_0^1 = 5,\ \bar{k}_0^2 = 3\right)$
$k_t^2 \quad \left(\bar{k}_0^1 = 6,\ \bar{k}_0^2 = 2\right)$


Example 1: Relative income in country 1
0.4
0.3
0.2
0.1
deviation from average
$\overline{k}_0^1 = 6, \ \overline{k}_0^2 = 2$
$\overline{k}_0^1 = 5, \ \overline{k}_0^2 = 3$
0
1
2
3
4
5
period

Generalized Ventura Model

$u(c_1, c_2) = v\big(f(c_1, c_2)\big) = \log\big(f(c_1, c_2)\big)$, and f, ϕ_1, and ϕ_2 are general constant-elasticity-of-substitution functions

Define

$$F(k, \ell) = \max \; f(y_1, y_2)$$

$$\text{s.t. } y_1 = \phi_1(k_1, \ell_1)$$

$$y_2 = \phi_2(k_2, \ell_2)$$

$$k_1 + k_2 = k$$

$$\ell_1 + \ell_2 = \ell$$

$$k_j \geq 0, \; \ell_j \geq 0.$$

In Ventura model $F(k, \ell) = f(k, \ell)$.

C. E. S. Model

$$y_1 = \phi_1(k_1, \ell_1) = \theta_1\left(\alpha_1 k_1^b + (1-\alpha_1)\ell_1^b\right)^{1/b}$$

$$y_2 = \phi_2(k_2, \ell_2) = \theta_2\left(\alpha_2 k_2^b + (1-\alpha_2)\ell_2^b\right)^{1/b}$$

$$f(y_1, y_2) = d\left(a_1 y_1^b + a_2 y_1^b\right)^{1/b}$$

(All elasticities of substitution are equal.)

In this case,

$$F(k,\ell) = D\left(A_1 k^b + A_2 \ell^b\right)^{1/b}$$

where

$$A_1 = \frac{\left[\left(a_1\alpha_1\theta_1^b\right)^{\frac{1}{1-b}} + \left(a_2\alpha_2\theta_2^b\right)^{\frac{1}{1-b}}\right]^{1-b}}{\left[\left(a_1\alpha_1\theta_1^b\right)^{\frac{1}{1-b}} + \left(a_2\alpha_2\theta_2^b\right)^{\frac{1}{1-b}}\right]^{1-b} + \left[\left(a_1(1-\alpha_1)\theta_1^b\right)^{\frac{1}{1-b}} + \left(a_2(1-\alpha_2)\theta_2^b\right)^{\frac{1}{1-b}}\right]^{1-b}}$$

$$A_2 = 1 - A_1$$

$$D = d\left\{\left[\left(a_1\alpha_1\theta_1^b\right)^{\frac{1}{1-b}} + \left(a_2\alpha_2\theta_2^b\right)^{\frac{1}{1-b}}\right]^{1-b} + \left[\left(a_1(1-\alpha_1)\theta_1^b\right)^{\frac{1}{1-b}} + \left(a_2(1-\alpha_2)\theta_2^b\right)^{\frac{1}{1-b}}\right]^{1-b}\right\}^{\frac{1}{b}}.$$

The cone of diversification for the integrated economy has the form $\bar{\kappa}_1 k_t \geq k_t^i \geq \bar{\kappa}_2 k_t$.

$$\bar{\kappa}_i = \left(\frac{\alpha_i}{1-\alpha_i}\right)^{\frac{1}{1-b}} \frac{\left(a_1(1-\alpha_1)\theta_1^b\right)^{\frac{1}{1-b}} + \left(a_2(1-\alpha_2)\theta_2^b\right)^{\frac{1}{1-b}}}{\left(a_1\alpha_1\theta_1^b\right)^{\frac{1}{1-b}} + \left(a_2\alpha_2\theta_2^b\right)^{\frac{1}{1-b}}}.$$

The cone of diversification for the integrated economy has the form $\bar{\kappa}_1 k_t \geq k_t^i \geq \bar{\kappa}_2 k_t$.

$$\bar{\kappa}_i = \left(\frac{\alpha_i}{1-\alpha_i}\right)^{\frac{1}{1-b}} \frac{\left(a_1(1-\alpha_1)\theta_1^b\right)^{\frac{1}{1-b}} + \left(a_2(1-\alpha_2)\theta_2^b\right)^{\frac{1}{1-b}}}{\left(a_1\alpha_1\theta_1^b\right)^{\frac{1}{1-b}} + \left(a_2\alpha_2\theta_2^b\right)^{\frac{1}{1-b}}}.$$

This is not the cone of diversification when factor prices are not equalized.

$$\kappa_1(p_2/p_1) = \left(\frac{\alpha_1}{1-\alpha_1}\right)^{\frac{1}{1-b}} \left[\frac{(1-\alpha_2)^{\frac{1}{1-b}}(\theta_2 p_2/p_1)^{\frac{b}{1-b}} - (1-\alpha_1)^{\frac{1}{1-b}}\theta_1^{\frac{b}{1-b}}}{\alpha_1^{\frac{1}{1-b}}\theta_1^{\frac{b}{1-b}} - \alpha_2^{\frac{1}{1-b}}(\theta_2 p_2/p_1)^{\frac{b}{1-b}}}\right]^{\frac{1}{b}}$$

$$\kappa_1(p_2/p_1) = \left[\left(\frac{\alpha_2}{1-\alpha_2}\right)\left(\frac{1-\alpha_1}{\alpha_1}\right)\right]^{\frac{1}{1-b}} \kappa_2(p_2/p_1).$$

Cobb-Douglas Model

$$y_1 = \phi_1(k_1, \ell_1) = \theta_1 k_1^{\alpha_1} \ell_1^{1-\alpha_1}$$

$$y_2 = \phi_2(k_2, l_2) = \theta_2 k_2^{\alpha_2} \ell_2^{1-\alpha_2}$$

$$f(y_1, y_2) = d y_1^{a_1} y_2^{a_2}$$

(This is the special case of the C.E.S. model where $b = 0$.)

In this case

$$F(k,\ell) = Dk^{A_1}\ell^{A_2}$$

where

$$A_1 = a_1\alpha_1 + a_2\alpha_2$$

$$A_2 = 1 - A_1$$

$$D = \frac{d\left[\theta_1 a_1 \alpha_1^{\alpha_1}(1-\alpha_1)^{1-\alpha_1}\right]^{a_1}\left[\theta_2 a_2 \alpha_2^{\alpha_2}(1-\alpha_2)^{1-\alpha_2}\right]^{a_2}}{A_1^{A_1} A_2^{A_2}}$$

$$\bar{\kappa}_i = \left(\frac{\alpha_i}{1-\alpha_i}\right)\frac{A_2}{A_1}.$$

Proposition: In the Cobb-Douglas model with $\delta = 1$, suppose that factor price equalization occurs at period T. Then factor price equalization occurs at all $t \geq T$. Furthermore, the equilibrium capital stocks can be solved for as

$$k_t^i = \gamma^i k_t$$

where $\gamma^i = k_T^i / k_T$ and $k_{t+1} = \beta A_1 D k_t^{A_1}$ for $t \geq T$.

Proposition: In the C.E.S. model with $\delta = 1$, suppose that the sequence $s_t = c_t / y_t$ in the equilibrium of the integrated economy is weakly decreasing. Suppose that factor price equalization occurs in period T. Then there exists an equilibrium in which factor price equalization occurs at all $t \geq T$. Furthermore, this equilibrium is the only such equilibrium.

Proposition: In the C.E.S. model with $\delta = 1$, suppose that the sequence $s_t = c_t / y_t$ in the equilibrium of the integrated economy is strictly increasing. Again let $z_t = c_{t-1} / k_t$, $z_0 = c_0 /(\beta r_0 k_0)$, and $\hat{z} = \lim_{t\to\infty} c_{t-1} / k_t$. Let $\bar{k}_0^{i_{min}} \leq \bar{k}_0^i \leq \bar{k}_0^{i_{max}}$, $i = 1,\ldots,n$. If

$$\frac{\hat{z}}{z_0}\left(\frac{\bar{k}_0^{i_{min}} - \bar{k}_0}{\bar{k}_0}\right) \geq \kappa_2 - 1, \quad \frac{\hat{z}}{z_0}\left(\frac{\bar{k}_0^{i_{max}} - \bar{k}_0}{\bar{k}_0}\right) \leq \kappa_1 - 1,$$

then there exists an equilibrium with factor price equalization in every period. If, however, either of these conditions is violated, there is no equilibrium with factor price equalization in every period. When there exists an equilibrium with factor price equalization in every period, it is the unique such equilibrium.

Numerical example 2: Two countries. $\beta = 0.95$, $\delta = 1$, and $L^1 = L^2 = 10$.

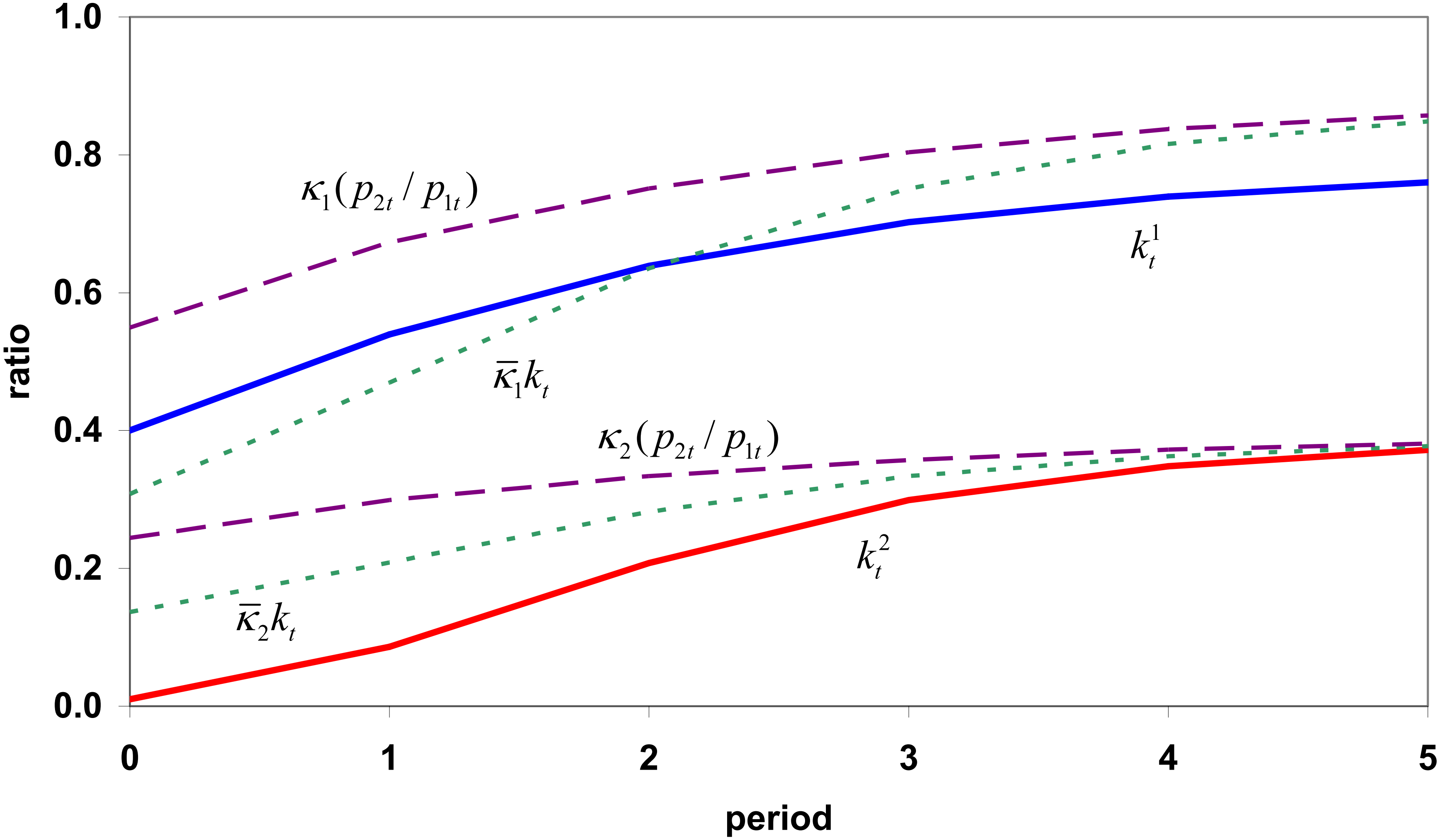
$$\phi_1(k, \ell) = 10k^{0.6}\ell^{0.4}$$

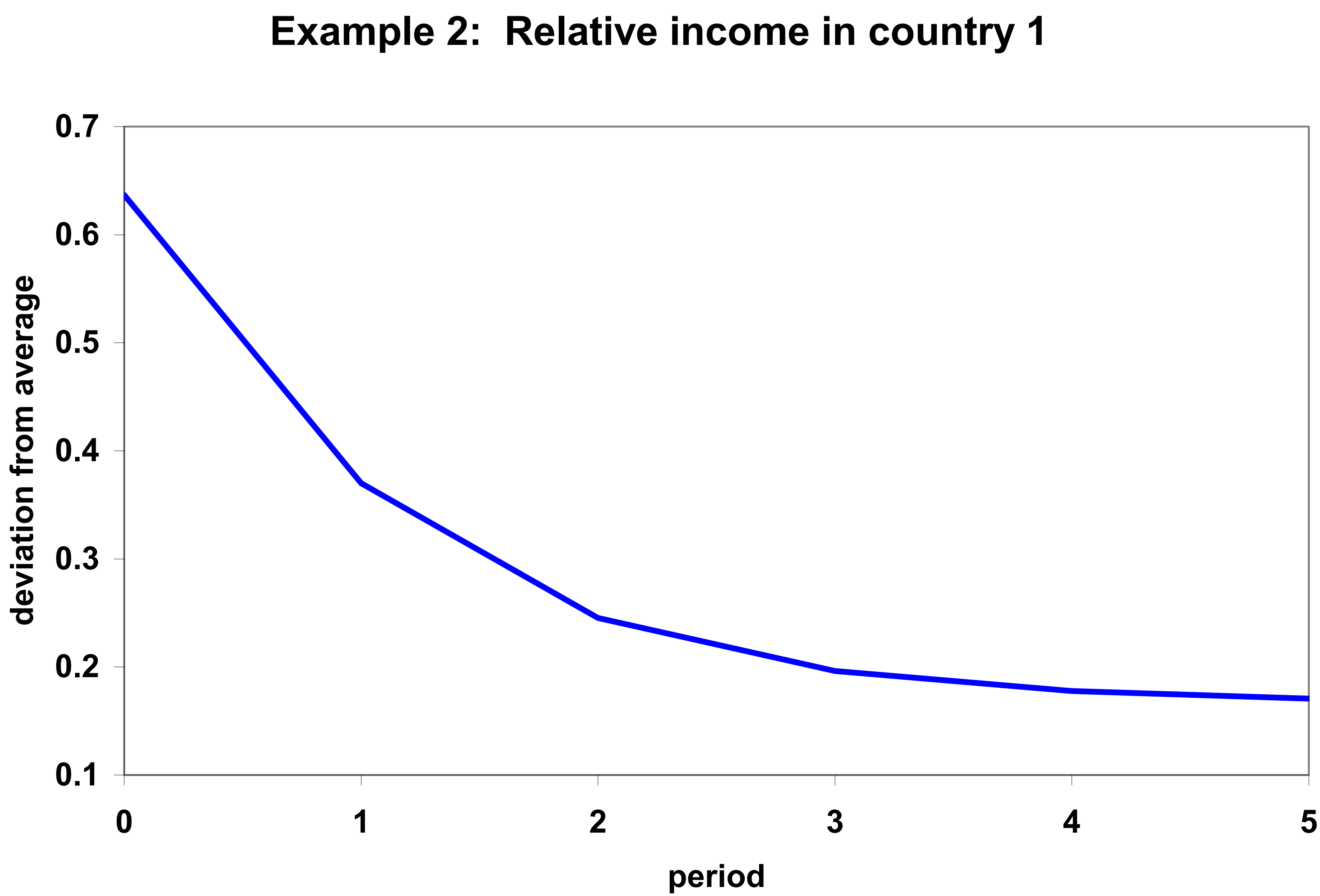
$$\phi_2(k, \ell) = 10k^{0.4}\ell^{0.6}$$

$$f(x_1, x_2) = x_1^{0.5}x_2^{0.5}$$

$\overline{k}_0^1 = 4$, $\overline{k}_0^2 = 0.1$.

Example 2: Capital-labor ratios




Example 2: Relative income in country 1
deviation from average
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
period

Numerical example 3: Two countries. $\beta = 0.95$, $\delta = 1$, and $L^1 = L^2 = 10$.

$$\phi_1(k,\ell) = 10\left(0.8k^{-0.5} + 0.2\ell^{-0.5}\right)^{-2}$$

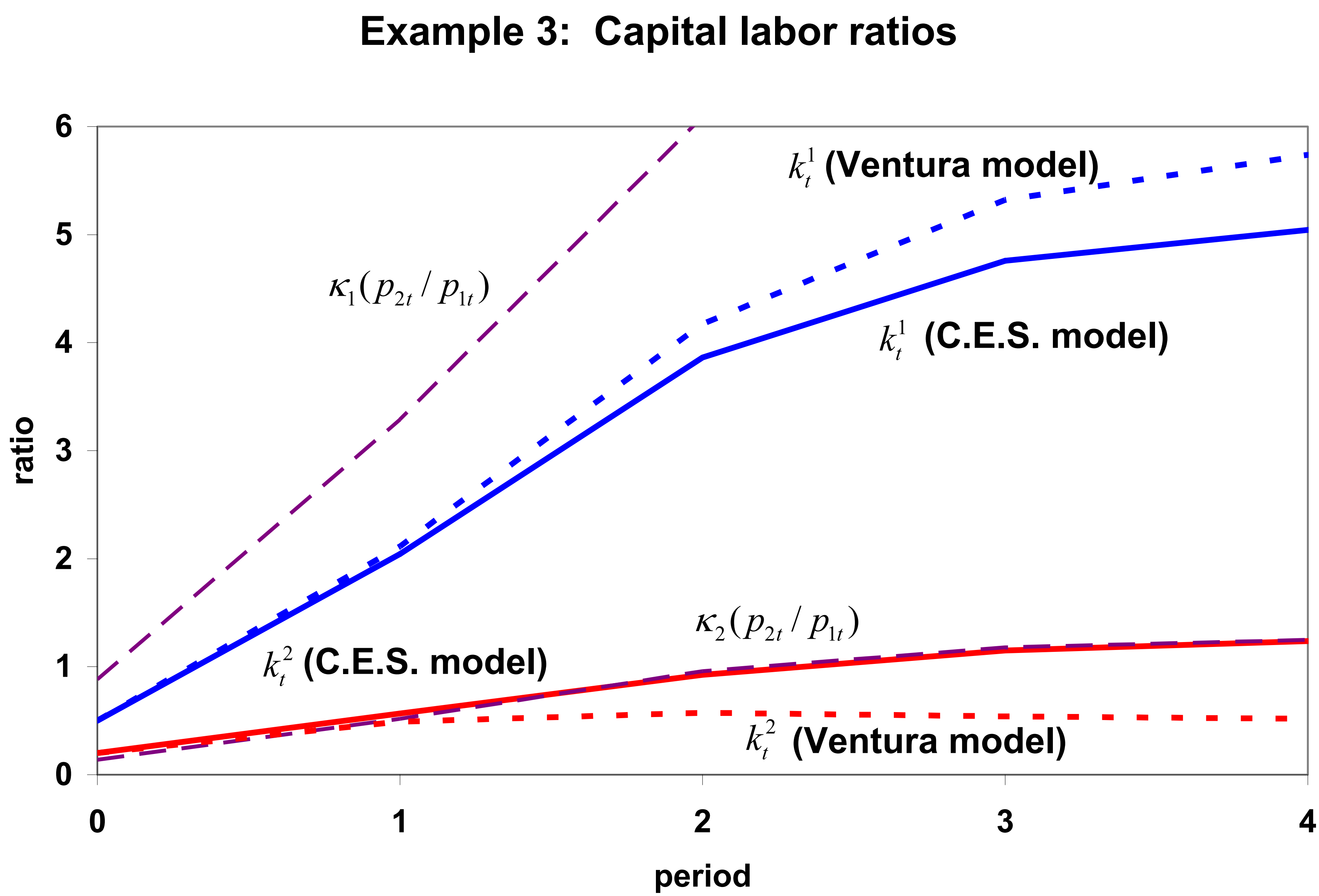
$$\phi_2(k,\ell) = 10\left(0.2k^{-0.5} + 0.8\ell^{-0.5}\right)^{-2}$$

$$f(x_1,x_2) = \left(0.5x_1^{-0.5} + 0.5x_2^{-0.5}\right)^{-2}$$

$$\overline{k}_0^1 = 5\ ,\overline{k}_0^2 = 2.$$

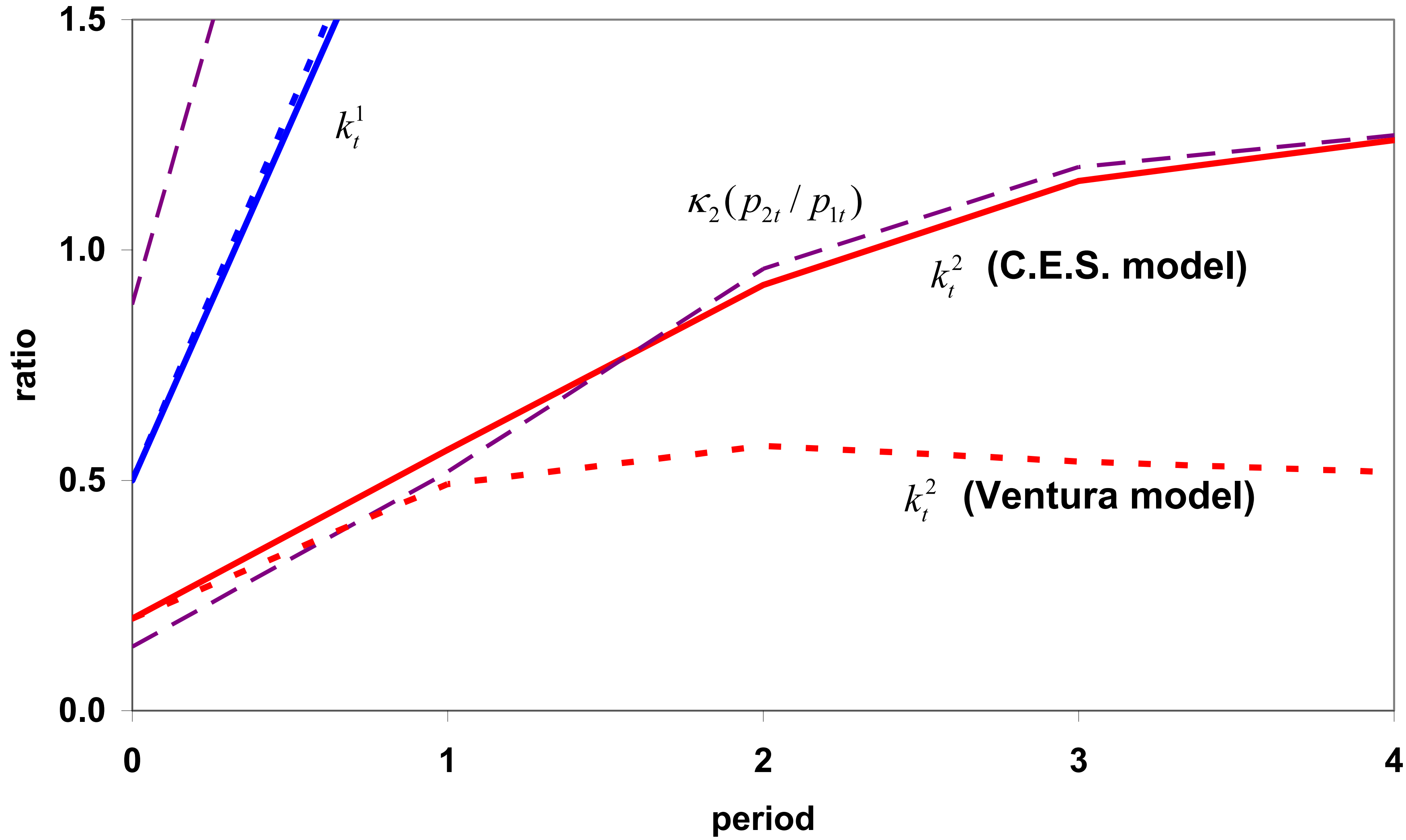
Contrast with the Ventura model with the same integrated equilibrium:

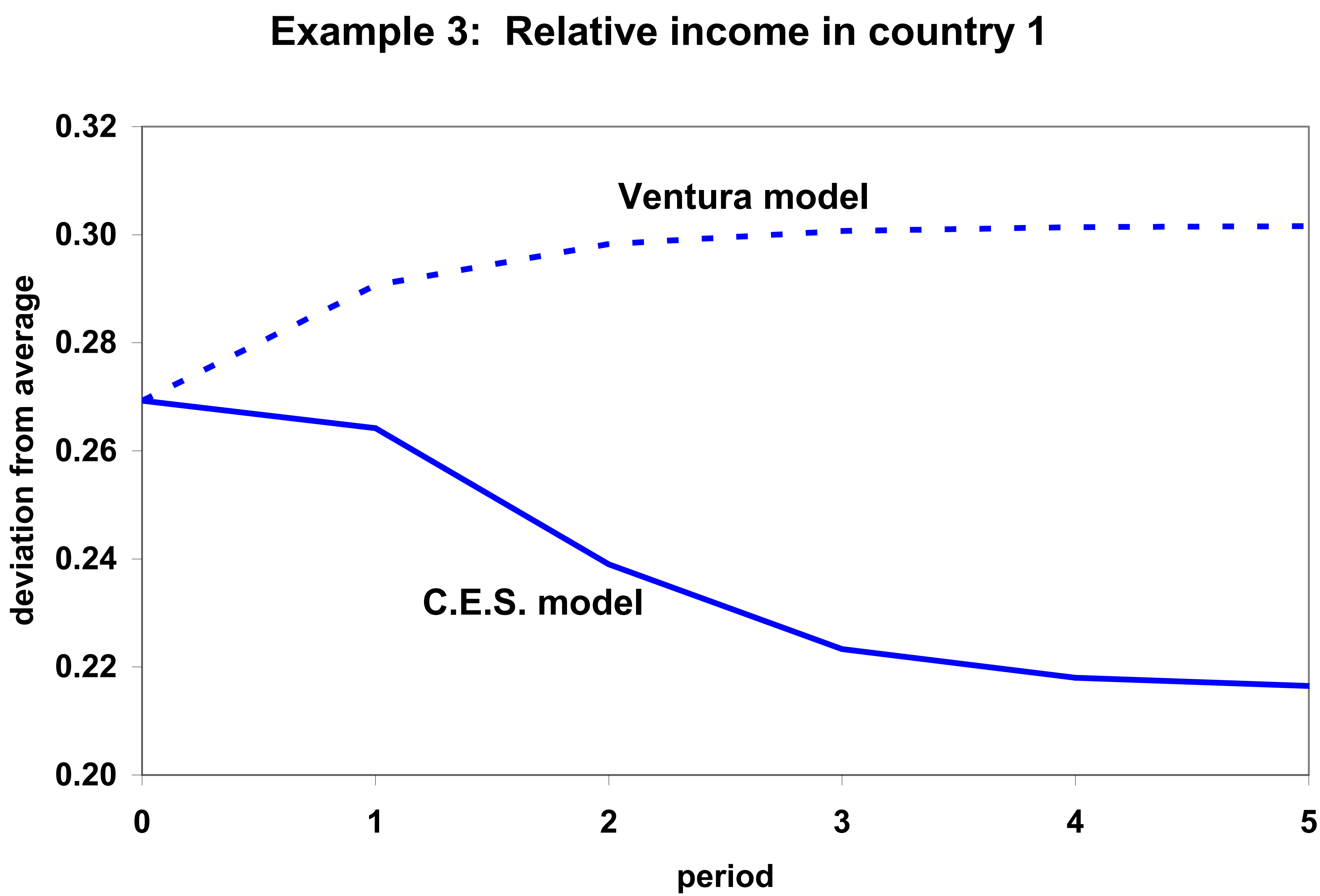
$$f(x_1,x_2) = 5.7328\left(0.5x_1^{-0.5} + 0.5x_2^{-0.5}\right)^{-2}.$$



Example 3: Capital labor ratios
ratio
period
0
1
2
3
4
5
6
k_t^1 (Ventura model)
$\kappa_1(p_{2t}/p_{1t})$
k_t^1 (C.E.S. model)
$\kappa_2(p_{2t}/p_{1t})$
k_t^2 (C.E.S. model)
k_t^2 (Ventura model)

Example 3: Capital labor ratios (detail)




Example 3: Relative income in country 1
Ventura model
C.E.S. model
deviation from average
0.32
0.30
0.28
0.26
0.24
0.22
0.20
0
1
2
3
4
5
period

8. Favorable changes in the terms of trade and/or reductions in tariffs make it easier to import intermediate goods. Although this is often interpreted as an increase in productivity, it does not show up as such in productivity measures that use real GDP as a measure of output.

T. J. Kehoe and K. J. Ruhl, "Are Shocks to the Terms of Trade Shocks to Productivity?" Federal Reserve Bank of Minneapolis, 2007.

A deterioration in the terms of trade makes it expensive for an economy to import intermediate goods.

We can think of international trade as part of the production technology. Exports are inputs, imports are outputs. A deterioration in the terms of trade corresponds to a negative technology shock.

Can this negative "technology shock" account for the drop in TFP during the crisis?

A deterioration in the terms of trade makes it expensive for an economy to import intermediate goods.

We can think of international trade as part of the production technology. Exports are inputs, imports are outputs. A deterioration in the terms of trade corresponds to a negative technology shock.

Can this negative "technology shock" account for the drop in TFP during the crisis?

No!

Standard national income accounting (SNA, NIPA) implies that terms of trade shocks have no first-order effects on real output (GDP, GNP)

A simple model with intermediate goods

Labor

$$\ell_t = \bar{\ell}$$

Final good

$$y_t = f(\bar{\ell}, m_t)$$

Intermediate good

$$m_t = \frac{x_t}{a_t}$$

Feasibility

$$c_t + x_t = y_t$$

Real GDP

$$c_t = y_t - x_t = f(\bar{\ell}, m_t) - a_t m_t$$

Competitive economy solves

$$\max_{m_t} f(\bar{\ell}, m_t) - a m_t$$

$$f_m(\bar{\ell}, m(a_t)) \equiv a_t$$

$$f_{mm}(\bar{\ell}, m(a_t)) m'(a_t) = 1$$

$$m'(a_t) = \frac{1}{f_{mm}(\bar{\ell}, m(a_t))} < 0$$

How does real GDP change with an increase in a — a negative shock to the intermediate goods producing technology?

$$Y(a_t) \equiv f(\bar{\ell}, m(a_t)) - a_t m(a_t)$$

$$Y'(a_t) = f_m(\bar{\ell}, m(a_t)) m'(a_t) - a_t m'(a_t) - m(a_t) = -m(a_t) < 0$$

A model with international trade

Suppose now that

m is imported intermediate inputs,

x is exports,

$p = a$ is terms of trade (real exchange rate)

Balanced trade

$$p_t m_t = x_t$$

Real GDP

$$c_t + x_t - p_0 m_t = y_t - p_0 m_t = f(\overline{\ell}, m_t) - p_0 m_t$$

where p_0 is price of imports in the base year.

Competitive economy continues to solve

$$\max_{m_t} f(\bar{\ell}, m_t) - p_t m_t$$

$$f_m(\bar{\ell}, m(p_t)) \equiv p_t$$

$$m'(p_t) = \frac{1}{f_{mm}(\bar{\ell}, m(p_t))} < 0$$

How does real GDP change with an increase in p_t — a deterioration in the terms of trade (depreciation in the real exchange rate)?

$$Y(p_t) \equiv f(\bar{\ell}, m(p_t)) - p_0 m(p_t)$$

$$Y'(p_t) = f_m(\bar{\ell}, m(p_t))m'(p_t) - p_0 m'(p_t) = (p_t - p_0)m'(p_t)$$

$$p_0 \approx p_t \;\Rightarrow\; Y'(p_t) \approx 0$$

Alternative accounting concepts

- Diewert and Morrison (1974, 1986)
- Kohli (1983, 1996)
- U.S. Bureau of Economic Analysis (Command Basis GDP)
- United Nations Statistics Division (Gross National Income)
- GNP, GDP (SNA, NIPA) do not.

Alternative accounting concepts

- Diewert and Morrison (1974, 1986)
- Kohli (1983, 1996)
- U.S. Bureau of Economic Analysis (Command Basis GDP)
- United Nations Statistics Division (Gross National Income)
- GNP, GDP (SNA, NIPA) do not.

Terms of trade shocks are worse than you think!

Extensions

Chain weighted price indices

Changes in tariffs

Endogenous labor

9. In models with heterogeneous firms (for example, Melitz, Chaney), trade liberalization can cause resources to shift from less productive firms to more productive firms. Although this is often interpreted as an increase in productivity, it does not show up as such in productivity measures that use real GDP as a measure of output.

M. J. Gibson, "Trade Liberalization, Reallocation, and Productivity," University of Minnesota, 2006. http://www.econ.umn.edu/~tkehoe/papers/Gibson.pdf.

Some countries experience aggregate productivity increases following trade liberalization

What is the economic mechanism through which this occurs?

Does trade liberalization increase aggregate productivity through reallocation toward more productive firms or through productivity increases at individual firms?

Reallocation mechanism

Technology of each firm is fixed

Trade liberalization results in a reallocation of resources:

- The least efficient firms exit
- Resources are moved toward more efficient firms, particularly exporters

Main findings

Reallocation following trade liberalization has no first-order effect on productivity, but it matters for welfare

Productivity gains must primarily come from firm-level productivity increases

Gibson studies a technology adoption mechanism in which firms can upgrade to a better technology, but it is costly to do so. Trade liberalization encourages technology adoption.

Model

I symmetric countries, each with an *ad valorem* tariff on imports

Monopolistically competitive firms that are heterogeneous in technological efficiency

Sunk cost of entering export markets — only the most efficient firms export

Fixed cost of production — not all firms choose to operate

No aggregate uncertainty

Consumer's problem

$$\max \sum_{t=0}^{\infty} \beta^t \log\left(\int_{z \in Z_t} c_t(z)^\rho \, dz \right)^{1/\rho}$$

$$\text{s.t.} \quad \int_{z \in Z_t^d} p_t(z) c_t(z) \, dz + (1+\tau_t) \int_{z \in Z_t^x} p_t(z) c_t(z) \, dz = \bar{N} + \Pi_t + \mathrm{T}_t$$

Aggregation

Ideal real income index:

$$C_t = \left(\int_{z \in Z_t} c_t(z)^{\rho} \, dz \right)^{1/\rho}$$

Ideal price index:

$$P_t = \left(\int_{z \in Z_t^d} p_t(z)^{\frac{-\rho}{1-\rho}} \, dz + (1+\tau_t)^{\frac{-\rho}{1-\rho}} \int_{z \in Z_t^x} p_t(z)^{\frac{-\rho}{1-\rho}} \, dz \right)^{\frac{-(1-\rho)}{\rho}}$$

Budget constraint again:

$$P_t C_t = \bar{N} + \Pi_t + \mathrm{T}_t$$

Demand functions

Firms take the consumer's demand functions as given

Demand for domestically produced goods:

$$\tilde{c}_t^d(p) = \left(\frac{P_t}{p}\right)^{\frac{1}{1-\rho}} C_t$$

Demand for imported goods:

$$\tilde{c}_t^x(p) = \left(\frac{P_t}{(1+\tau_t)p}\right)^{\frac{1}{1-\rho}} C_t$$

Firms: Timing within a period

Entrants learn their efficiencies

Each firm decides whether to operate or exit — producing requires paying a fixed cost of f^p units of labor

Non-exporters decide whether to pay the sunk cost of entering export markets, f^x units of labor

After producing, each firm faces exogenous probability of death δ

Technologies

A firm of type a has the increasing-returns technology

$$y(n;a) = \max\left[a\left(n - f^p\right), 0\right]$$

$a \in [1,\infty)$ is the firm's technology draw from Pareto distribution
$F(a) = 1 - a^{-\eta}$

f^p is the fixed cost, in units of labor, of producing

Firm's static problem: Maximize period profits

Non-exporters:

$$\pi_t^d(a) = \max_{p,n} p\tilde{c}_t^d(p) - n$$
$$\text{s.t. } a\left(n - f^p\right) = \tilde{c}_t^d(p)$$

Exporters:

$$\pi_t^x(a) = \max_{p,n} p\left(\tilde{c}_t^d(p) + (I-1)\tilde{c}_t^x(p)\right) - n$$
$$\text{s.t. } a\left(n - f^p\right) = \tilde{c}_t^d(p) + (I-1)\tilde{c}_t^x(p)$$

Prices

The profit-maximizing price is a constant markup over marginal cost:

$$p(a) = \frac{1}{\rho a}$$

The price of a good is inversely related to the efficiency with which it is produced

Exporter's dynamic problem

$$v_t^x(a) = \max\left[0,\ \pi_t^x(a) + \frac{1-\delta}{1+r_{t+1}} v_{t+1}^x(a)\right]$$

Non-exporter's dynamic problem

$$v_t^d(a) = \max\left[0,\ \pi_t^d(a) + \frac{1-\delta}{1+r_{t+1}} \max\left[v_{t+1}^d(a), v_{t+1}^x(a) - \frac{1+r_{t+1}}{1-\delta} f^x\right]\right]$$

Outer maximization: Whether to operate

Inner maximization: Whether to devote f^x units of labor to enter export markets

Firm entry

There is free entry of firms, and firms enter as non-exporters

The cost of a technology draw from probability distribution F is f^e units of labor

The measure of draws taken, e_t, is determined endogenously through a free-entry condition:

$$\frac{1}{1+r_{t+1}} \int v_{t+1}^d(a) F(da) - f^e \leq 0, \quad = 0 \text{ if } e_t > 0$$

The inequality reflects the constraint that $e_t \geq 0$

Distributions of firms by efficiency

Suppose that at the beginning of period t the distribution of non-exporters is m_t^d and the distribution of exporters is m_t^x

To obtain the distributions of firms that choose to operate, apply the decision rules:

$$\mu_t^x(a) = \int_1^a \chi_t^x(\alpha) m_t^x(d\alpha)$$

$$\mu_t^d(a) = \int_1^a \chi_t^d(\alpha) m_t^d(d\alpha)$$

Distributions evolve in response to firm entry, e_t and changes in export status, χ_t^e

Labor market clearing

The supply of labor is fixed at $\bar{N}$ and is allocated among 3 activities: production, entering export markets, and entering the domestic market

$$\sum_{s} \int \left(n_t^d(a)\,\mu_t^d(da) + n_t^x(a)\,\mu_t^x(da) + f^x \chi_t^e(a)\,\mu_t^d(da) \right) + f^e e_t = \bar{N}.$$

Measuring productivity

Labor productivity in the data is a measure of real value added per worker or per hour

Standard way of calculating real value added is to use base-period prices

Measuring real value added per worker

Value added at current prices:

$$y_t = \int_{z \in Z_t^d} p_t(z)\, y_t(z)\, dz$$

Value added at base-period (period-0) prices:

$$Y_t = \int_{z \in Z_t^d} p_0(z)\, y_t(z)\, dz$$

Real value added per worker is $Y_t / \bar{N}$

What if a good was not produced in the base period?

This is an issue in the data as well

The standard recommendation for obtaining a proxy for the base-period price is to deflate the current price by the price index for a basket of goods that were produced in both periods, say $\tilde{Z}$:

$$\tilde{P}_t = \frac{\int_{\tilde{Z}} p_t(z) y_0(z) dz}{\int_{\tilde{Z}} p_0(z) y_0(z) dz}$$

Proxy for the period-0 price of a good not produced in period 0:

$$p_0(z) = \frac{p_t(z)}{\tilde{P}_t}$$

Measuring social welfare

Ideal real income index:

$$\frac{\bar{N} + \Pi_t + \mathrm{T}_t}{P_t} = C_t = \left(\int_{z \in Z_t} c_t(z)^{\rho} \, dz \right)^{1/\rho}$$

The ideal price index P_t takes into account changes in variety and the consumer’s elasticity of substitution — in contrast to price indices in the data

To what extent can reallocation following trade liberalization account for long-term productivity gains?

To determine the long-term effects of trade liberalization, we compare stationary equilibria of the model

two versions of the model:

Static version with $\beta \to 1$ (similar to Melitz (2003)): analytical result

Dynamic version with $0 < \beta < 1$: illustrative numerical example

Static model: An analytical finding

Proposition: In a stationary equilibrium with $\beta \to 1$, real value added per worker does not depend on the level of the tariff

To see why:

With $\beta \to 1$, $\Pi = 0$, so the budget constraint gives

$$\int_{z \in Z_t^d} p_t(z) c_t(z) dz + \int_{z \in Z_t^x} p_t(z) c_t(z) dz = \bar{N}$$

The balanced trade condition is

$$\int_{z \in Z_t^d} p_t(z) \left(y_t(z) - c_t(z) \right) dz = \int_{z \in Z_t^x} p_t(z) c_t(z)$$

Add them together to get

$$\int_{z\in Z_t^d} p_t(z)\,y_t(z)\,dz = \bar{N}$$

So value added at current prices is constant, does not depend on τ

What about base-period prices? Without technology adoption, the price of each good in the economy is constant: $p(z;a) = 1/(\rho a)$

So base-period prices are equal to current prices and the prices of new goods do not get deflated

Result:

$$Y_t = \int_{z\in Z_t^d} p_0(z)\,y_t(z)\,dz = \int_{z\in Z_t^d} p_t(z)\,y_t(z)\,dz = \bar{N}$$

Intuition for the result

Reallocation following trade liberalization has no long-term effect on measured productivity

Why? Two factors:

Prices — they are inversely related to the efficiency with which a good is produced

General equilibrium effects — changes in the real wage (partial equilibrium analysis would predict a substantial increase in measured productivity)

Parameterization for illustrative numerical experiment

$\bar{N}=1$	Normalization
$\rho=0.5$	Elasticity of substitution of 2 (Ruhl 2003)
$\eta=1.5$	
$\delta=0.05$	
$f^{e}=1$	
f^{x}	20 percent of firms export initially
f^{p}	Efficiency cutoff for operating is 1 initially

Illustrative numerical experiment in the static model

$\beta \to 1$

Policy experiment: Eliminate a 10 percent tariff between 2 countries

Compare stationary equilibria to assess long-term effects of trade liberalization:

Percent change in measured productivity	0.0
Percent change in welfare	0.5

A note on the welfare increase

The increase in welfare following trade liberalization is not due to an increase in variety — the measure of varieties available to the consumer decreases

Reallocation toward more efficient firms drives the welfare increase

This is in sharp contrast to trade models with homogeneous firms, in which the increase in welfare is driven by an increase in variety

Main point: Reallocation matters for welfare but not for measured productivity

Illustrative numerical experiment in the dynamic model

To what extent can the fully dynamic model account for measured productivity gains?

$\beta = 0.96$ Real interest rate of 4 percent

Same numerical experiment:

Percent change in measured productivity	0.7
Percent change in welfare	1.8