

# How and Why Does Trade Grow?

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## **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.

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

In the 1980s and 1990s trade economists reached a consensus that North-North trade — trade among rich countries — was driven by forces captured by the New Trade Theory and North-South trade — trade between rich countries and poor countries — was driven by forces captured by Heckscher-Ohlin theory. (South-South trade was negligible.)

A. V. Deardorff, “Testing Trade Theories and Predicting Trade Flows,” in R. W. Jones and P. B. Kenen, editors, *Handbook of International Economics*, volume 1, North-Holland, 1984, 467-517.

J. Markusen, “Explaining the Volume of Trade: An Eclectic Approach,” *American Economic Review*, 76 (1986), 1002-1011.

**In fact, a calibrated version of this hybrid model does not match the data.**

R. Bergoeing and T. J. Kehoe, “Trade Theory and Trade Facts,”  
Federal Reserve Bank of Minneapolis, 2003.

# TRADE THEORY

Traditional trade theory — Ricardo, Heckscher-Ohlin — says countries trade because they are different.

In 1990 by far the largest bilateral trade relation in the world was U.S.-Canada. The largest two-digit SITC export of the United States to Canada was 78 Road Vehicles. The largest two-digit SITC export of Canada to the United States was 78 Road Vehicles.

The New Trade Theory — increasing returns, taste for variety, monopolistic competition — explains how similar countries can engage in a lot of intraindustry trade.

Helpman and Krugman (1985)

Markusen (1986)

# **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.

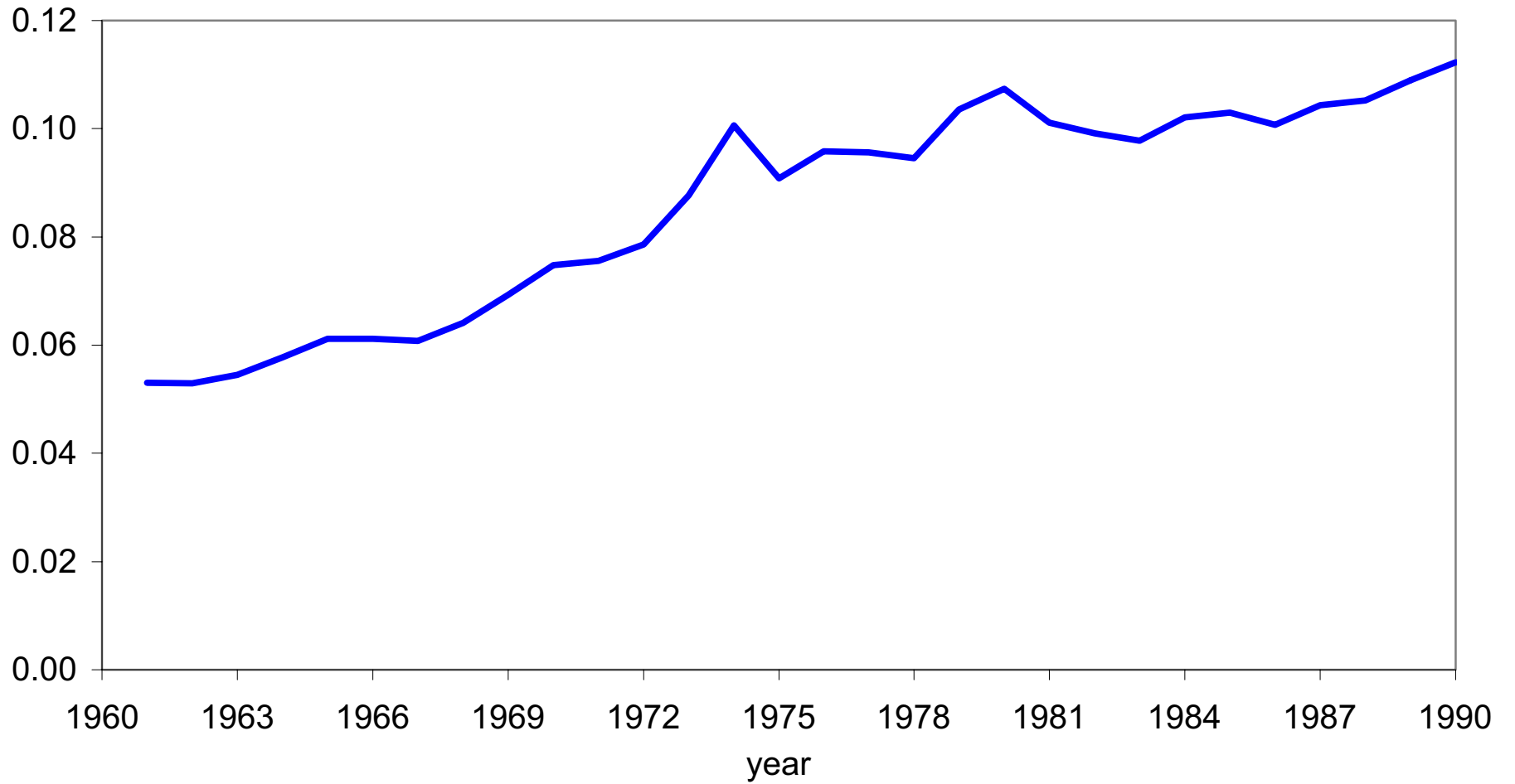
- **Trade among industrialized countries is mostly intraindustry trade**

Grubel-Lloyd index for OECD-OECD trade in 1990 is 68.4.

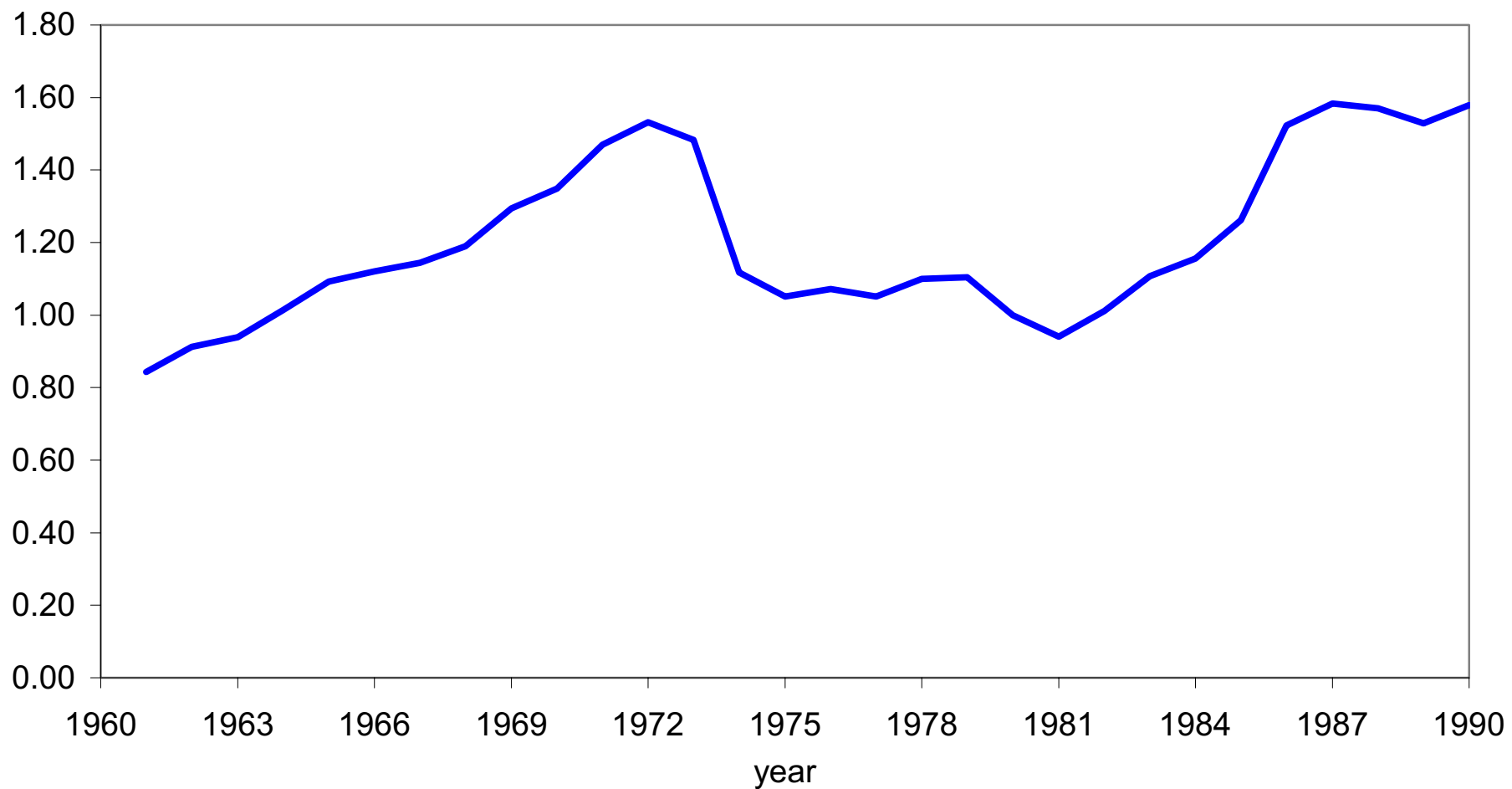
Grubel-Lloyd index for OECD-RW trade in 1990 is 38.1.



# OECD-OECD Trade / OECD GDP



## OECD-OECD Trade / OECD-RW Trade



**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:

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

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:

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

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



## 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  $j$ ,  $j = 1, \dots, n, rw$ , 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 Manufacturing 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)

	<b>Primaries</b>	<b>Manufactures</b>	<b>Services</b>	<b>Total</b>
$H_i^{oe}$	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)

	<b>Primaries</b>	<b>Manufactures</b>	<b>Services</b>	<b>Total</b>
$Y_i^{rw}$	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  $\gamma_p$ ,  $\gamma_s$ , and  $\eta$ .



## 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  $\eta$  ( $0.5 \geq 1/(1-\eta) \geq 0.1$ )

	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?

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

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

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

## 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%

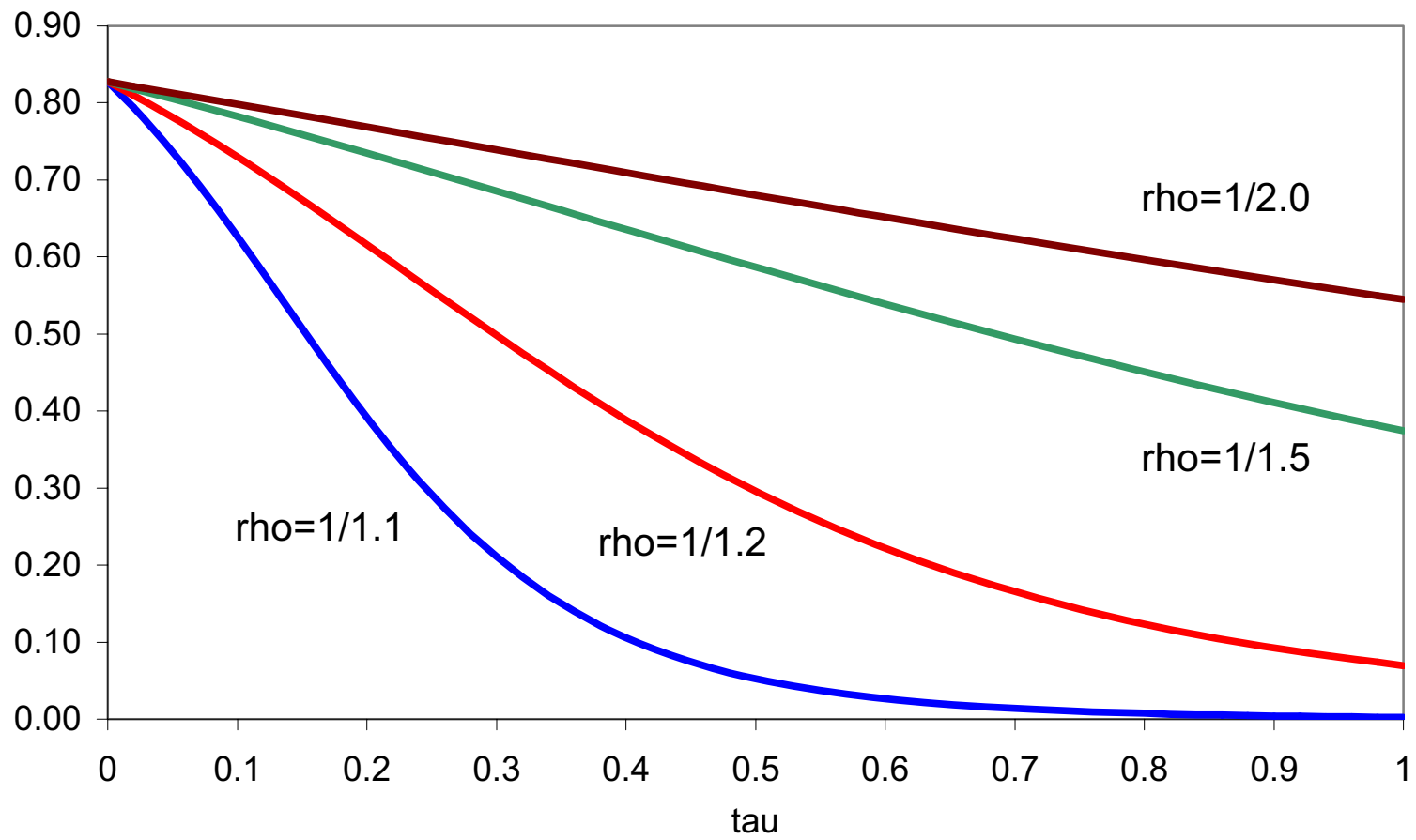
## POLICY?

In a version of our model with  $n$  OECD countries, a manufacturing sector, and a uniform ad valorem tariff  $\tau$ , 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  $\tau$  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



## **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 <i>a</i>		0.00	0.00	0.00
regression coefficient <i>b</i>		-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:

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

- 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 <i>a</i>		-0.52	-0.52	-0.52
regression coefficient <i>b</i>		0.44	0.75	0.67

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

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

## 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 <i>a</i>		0.00	0.00	0.00
regression coefficient <i>b</i>		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 <i>a</i>		0.00	0.00	0.00
regression coefficient <i>b</i>		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.



## Changes in Trade/GDP in Brown-Deardorff-Stern Model (Percent)

variable	data 1988-1999	model
Canadian exports	52.9	4.3
Canadian imports	57.7	4.2
Mexican exports	240.6	50.8
Mexican imports	50.5	34.0
U.S. exports	19.1	2.9
U.S. imports	29.9	2.3
weighted correlation with data		0.64
variance decomposition of change		0.08
regression coefficient $a$		23.20
regression coefficient $b$		2.43

## Changes in Canadian Trade/GDP in Cox-Harris Model (Percent)

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<b>variable</b>	<b>data 1988-2000</b>	<b>model</b>
<b>total trade</b>	<b>57.2</b>	<b>10.0</b>
<b>trade with Mexico</b>	<b>280.0</b>	<b>52.2</b>
<b>trade with United States</b>	<b>76.2</b>	<b>20.0</b>
<b>weighted correlation with data</b>		<b>0.99</b>
<b>variance decomposition of change</b>		<b>0.52</b>
<b>regression coefficient <i>a</i></b>		<b>38.40</b>
<b>regression coefficient <i>b</i></b>		<b>1.93</b>

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## Changes in Canadian Exports/GDP in the Brown-Deardorff-Stern Model (Percent)

sector	exports to Mexico		exports to United States	
	1988–1999	model	1988–1999	model
agriculture	122.6	3.1	78.8	3.4
mining and quarrying	-34.0	-0.3	77.4	0.4
food	257.1	2.2	121.1	8.9
textiles	2066.0	-0.9	277.5	15.3
clothing	3956.0	1.3	234.3	45.3
leather products	3171.2	1.4	76.9	11.3
footwear	427.0	3.7	102.6	28.3
wood products	9248.7	4.7	140.2	0.1
furniture and fixtures	10385.3	2.7	150.3	12.5
paper products	158.1	-4.3	8.2	-1.8
printing and publishing	1100.6	-2.0	105.4	-1.6
chemicals	534.6	-7.8	104.0	-3.1
petroleum and products	86.3	-8.5	26.7	0.5
rubber products	4710.3	-1.0	162.6	9.5
nonmetal mineral products	3016.7	-1.8	113.1	1.2
glass products	1518.3	-2.2	104.9	30.4
iron and steel	176.1	-15.0	36.9	12.9
nonferrous metals	34.7	-64.7	8.0	18.5
metal products	1380.0	-10.0	127.0	15.2
nonelectrical machinery	1297.1	-8.9	85.4	3.3
electrical machinery	2919.2	-26.2	246.4	14.5
transportation equipment	4906.7	-4.4	85.9	10.7
miscellaneous manufactures	898.7	-12.1	195.9	-2.1
weighted correlation with data		-0.24		0.25
variance decomposition of change		0.0005		0.02
regression coefficient <i>a</i>		452.48		76.55
regression coefficient <i>b</i>		-11.35		1.64

## Changes in Mexican Exports/GDP in the Brown-Deardorff-Stern Model (Percent)

sector	exports to Canada		exports to United States	
	1988–1999	model	1988–1999	model
agriculture	-21.8	-4.1	-17.2	2.5
mining and quarrying	-35.5	27.3	-20.7	26.9
food	-11.7	10.8	-10.0	7.5
textiles	77.2	21.6	521.3	11.8
clothing	689.3	19.2	320.3	18.6
leather products	160.7	36.2	22.7	11.7
footwear	196.2	38.6	-13.0	4.6
wood products	59.6	15.0	-17.8	-2.7
furniture and fixtures	1772.9	36.2	111.8	7.6
paper products	63.5	32.9	-62.0	13.9
printing and publishing	2918.1	15.0	297.3	3.9
chemicals	126.4	36.0	5.5	17.0
petroleum and products	273.5	32.9	-61.5	34.1
rubber products	1172.1	-6.7	107.6	-5.3
nonmetal mineral products	108.1	5.7	1.9	3.7
glass products	74.9	13.3	39.2	32.3
iron and steel	41.7	19.4	59.8	30.8
nonferrous metals	-33.6	138.1	-53.4	156.5
metal products	316.2	41.9	162.4	26.8
nonelectrical machinery	128.9	17.3	194.6	18.5
electrical machinery	252.3	137.3	75.1	178.0
transportation equipment	94.8	3.3	155.1	6.2
miscellaneous manufactures	622.2	61.1	202.2	43.2
weighted correlation with data		0.82		-0.03
variance decomposition of change		0.56		0.40
regression coefficient <i>a</i>		80.14		75.18
regression coefficient <i>b</i>		1.23		-0.02

## Changes in U.S. Exports/GDP in the Brown-Deardorff-Stern Model (Percent)

sector	exports to Canada		exports to Mexico	
	1988–1999	model	1988–1999	model
agriculture	-24.8	5.1	5.9	7.9
mining and quarrying	-22.9	1.0	-19.7	0.5
food	40.8	12.7	67.4	13.0
textiles	45.3	44.0	1326.3	18.6
clothing	147.6	56.7	1322.2	50.3
leather products	-37.1	7.9	998.9	15.5
footwear	-2.5	45.7	222.9	35.4
wood products	0.2	6.7	275.7	7.0
furniture and fixtures	181.0	35.6	330.2	18.6
paper products	56.9	18.9	160.6	-3.9
printing and publishing	0.7	3.9	239.8	-1.1
chemicals	53.8	21.8	160.7	-8.4
petroleum and products	-57.8	0.8	154.6	-7.4
rubber products	57.4	19.1	659.6	12.8
nonmetal mineral products	-11.5	11.9	393.1	0.8
glass products	28.1	4.4	771.7	42.3
iron and steel	41.1	11.6	115.6	-2.8
nonferrous metals	-1.1	-6.7	223.1	-55.1
metal products	48.5	18.2	783.0	5.4
nonelectrical machinery	-5.3	9.9	242.0	-2.9
electrical machinery	38.5	14.9	1192.6	-10.9
transportation equipment	-4.0	-4.6	586.9	9.9
miscellaneous manufactures	46.9	11.5	330.6	-9.4
weighted correlation with data		0.82		-0.20
variance decomposition of change		0.40		0.0007
regression coefficient <i>a</i>		2.47		346.92
regression coefficient <i>b</i>		1.55		-7.25

## Changes in Canadian Trade/GDP in the Cox-Harris Model (Percent)

sector	total exports		total imports	
	1988-2000	model	1988-2000	model
agriculture	-13.7	-4.1	4.6	7.2
forestry	215.5	-11.5	-21.5	7.1
fishing	81.5	-5.4	107.3	9.5
mining	21.7	-7.0	32.1	4.0
food, beverages, and tobacco	50.9	18.6	60.0	3.8
rubber and plastics	194.4	24.5	87.7	13.8
textiles and leather	201.1	108.8	24.6	18.2
wood and paper	31.9	7.3	97.3	7.2
steel and metal products	30.2	19.5	52.2	10.0
transportation equipment	66.3	3.5	29.7	3.0
machinery and appliances	112.9	57.1	65.0	13.3
nonmetallic minerals	102.7	31.8	3.6	7.3
refineries	20.3	-2.7	5.1	1.5
chemicals and misc. manufactures	53.3	28.1	92.5	10.4
weighted correlation with data		0.49		0.85
variance decomposition of change		0.32		0.08
regression coefficient <i>a</i>		41.85		22.00
regression coefficient <i>b</i>		0.81		3.55

## Changes in Mexican Trade/GDP in the Sobarzo Model (Percent)

sector	exports to North America		imports from North America	
	1988–2000	model	1988–2000	model
agriculture	-15.3	-11.1	-28.2	3.4
mining	-23.2	-17.0	-50.7	13.2
petroleum	-37.6	-19.5	65.9	-6.8
food	5.2	-6.9	11.8	-5.0
beverages	42.0	5.2	216.0	-1.8
tobacco	-42.3	2.8	3957.1	-11.6
textiles	534.1	1.9	833.2	-1.2
wearing apparel	2097.3	30.0	832.9	4.5
leather	264.3	12.4	621.0	-0.4
wood	415.1	-8.5	168.9	11.7
paper	12.8	-7.9	68.1	-4.7
chemicals	41.9	-4.4	71.8	-2.7
rubber	479.0	12.8	792.0	-0.1
nonmetallic mineral products	37.5	-6.2	226.5	10.9
iron and steel	35.9	-4.9	40.3	17.7
nonferrous metals	-40.3	-9.8	101.2	9.8
metal products	469.5	-4.4	478.7	9.5
nonelectrical machinery	521.7	-7.4	129.0	20.7
electrical machinery	3189.1	1.0	749.1	9.6
transportation equipment	224.5	-5.0	368.0	11.2
other manufactures	975.1	-4.5	183.6	4.2
weighted correlation with data		0.61		0.23
variance decomposition of change		0.0004		0.002
regression coefficient <i>a</i>		495.08		174.52
regression coefficient <i>b</i>		30.77		5.35

## 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

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

**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?

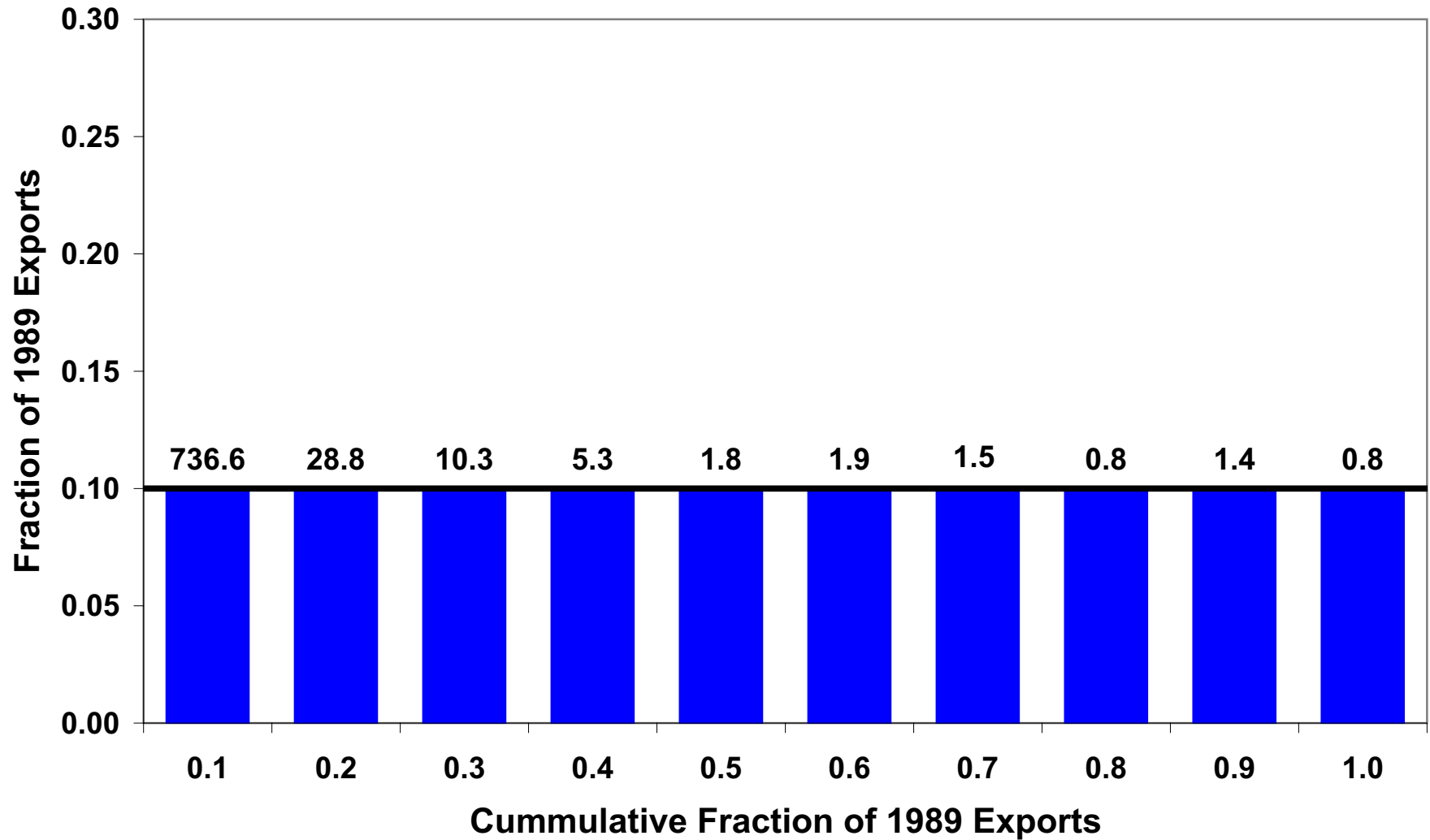
During trade liberalization?

Indirect evidence on the extensive margin

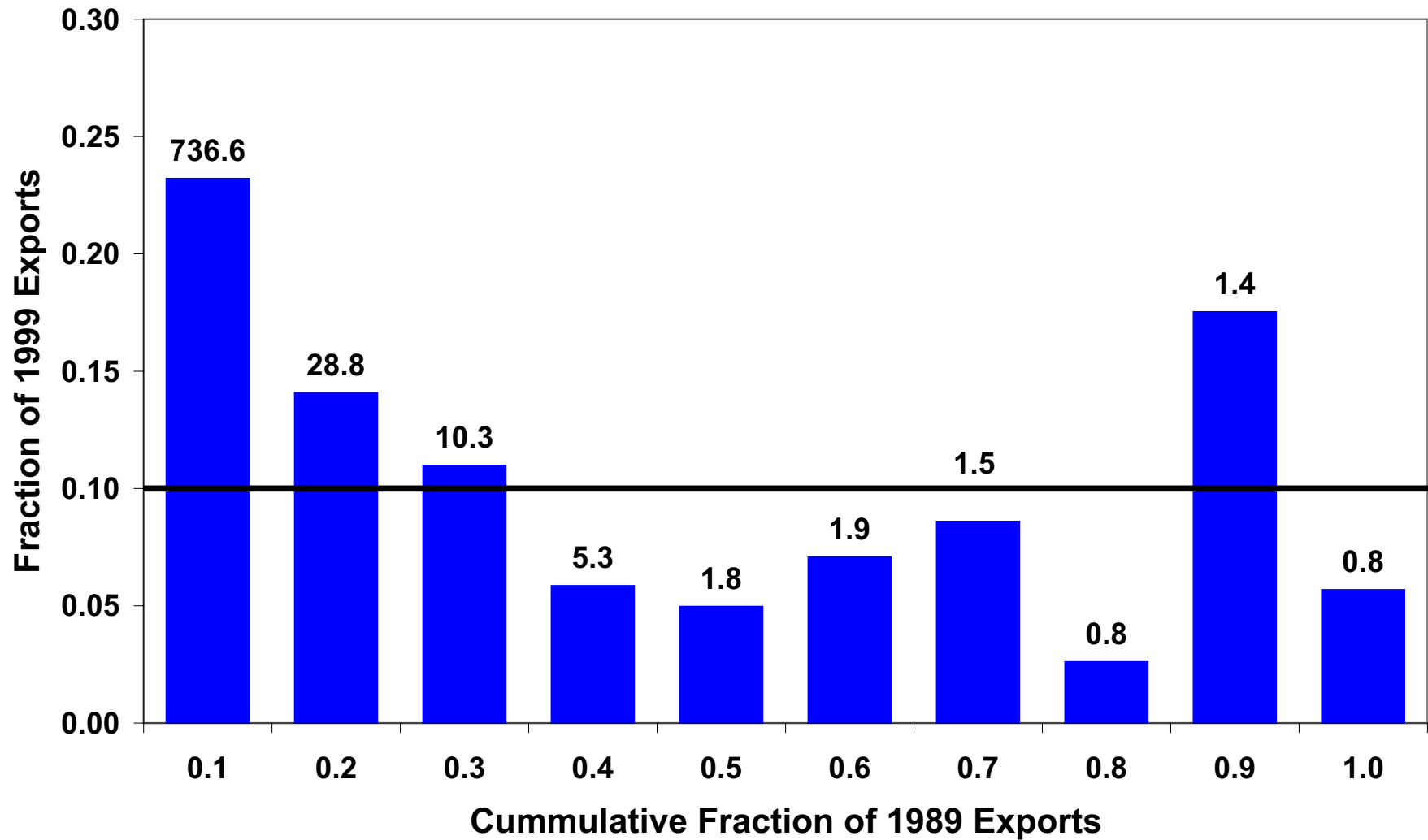
## Evidence on the Extensive Margin

- 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

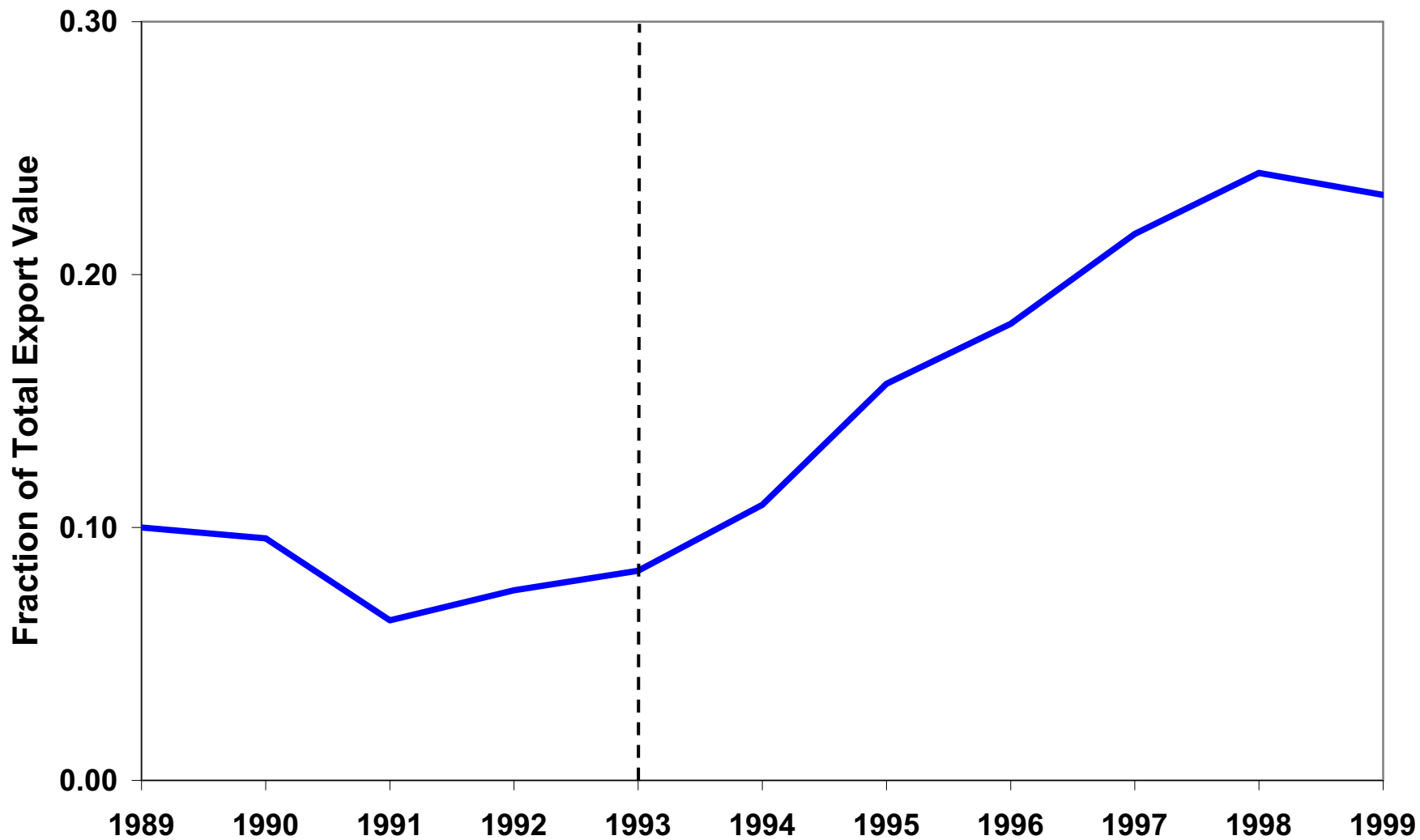
## Composition of Exports: Mexico to Canada



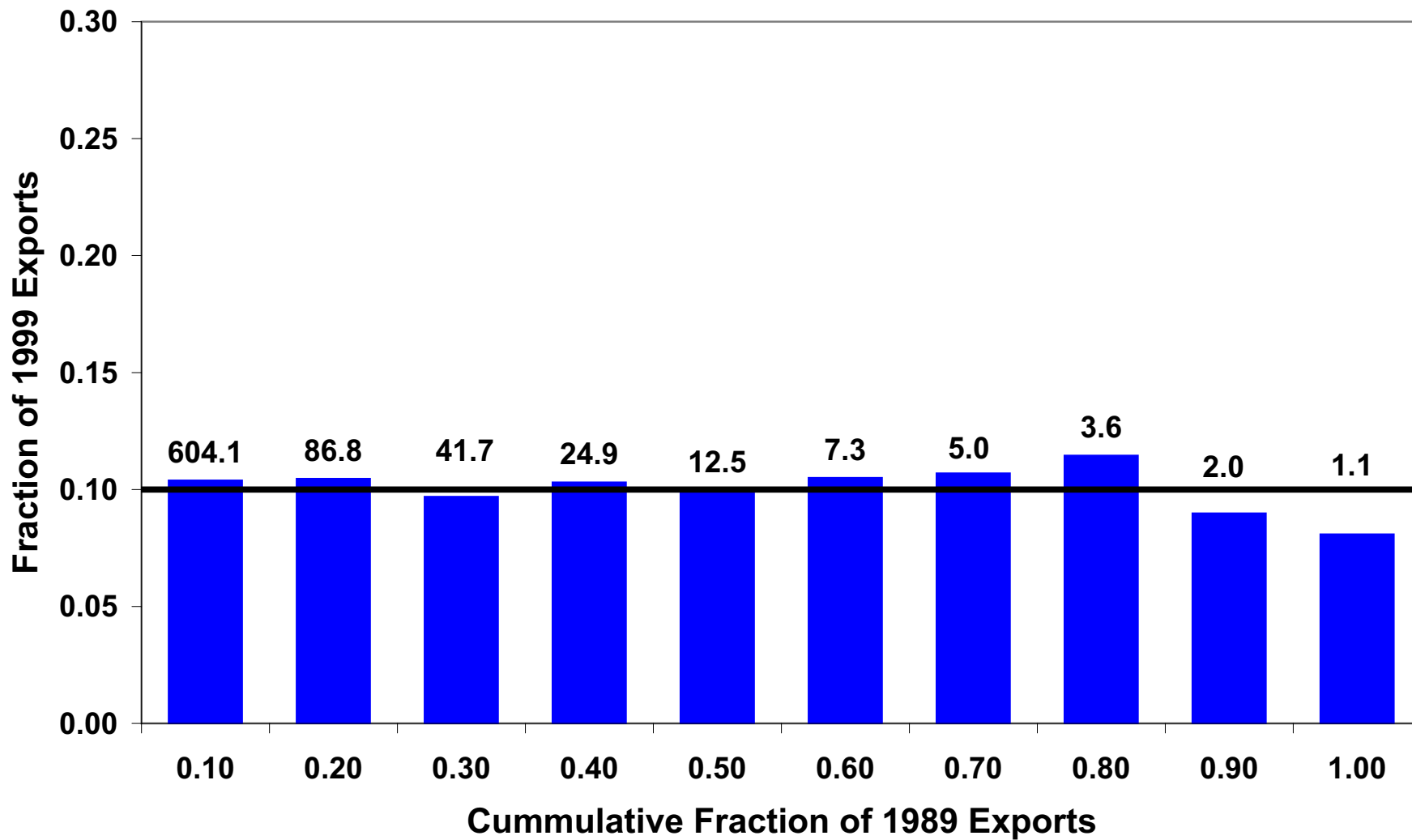
## Composition of Exports: Mexico to Canada



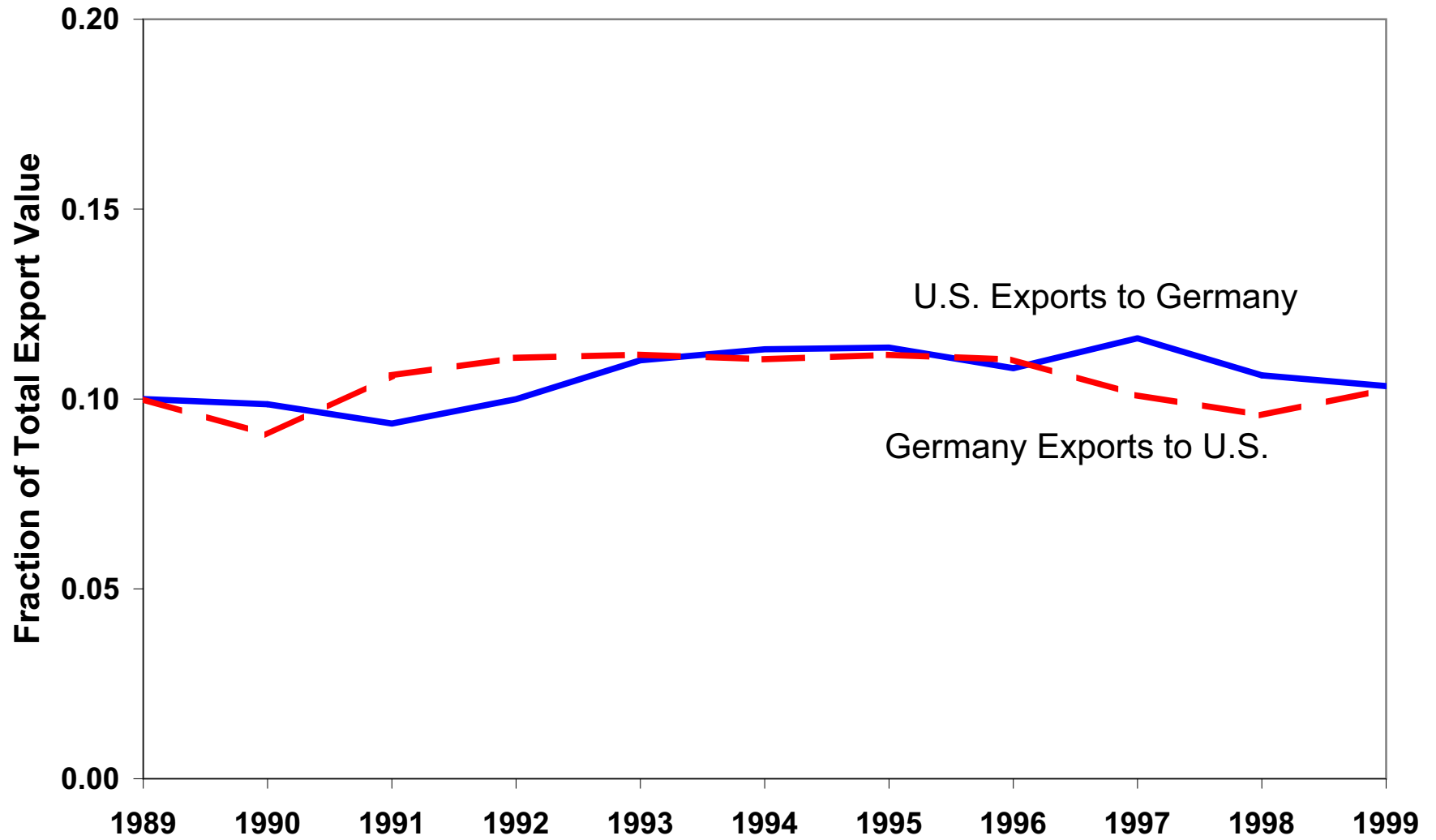
## Exports: Mexico to the Canada



## Composition of Exports: U.S. to Germany



## United States and Germany





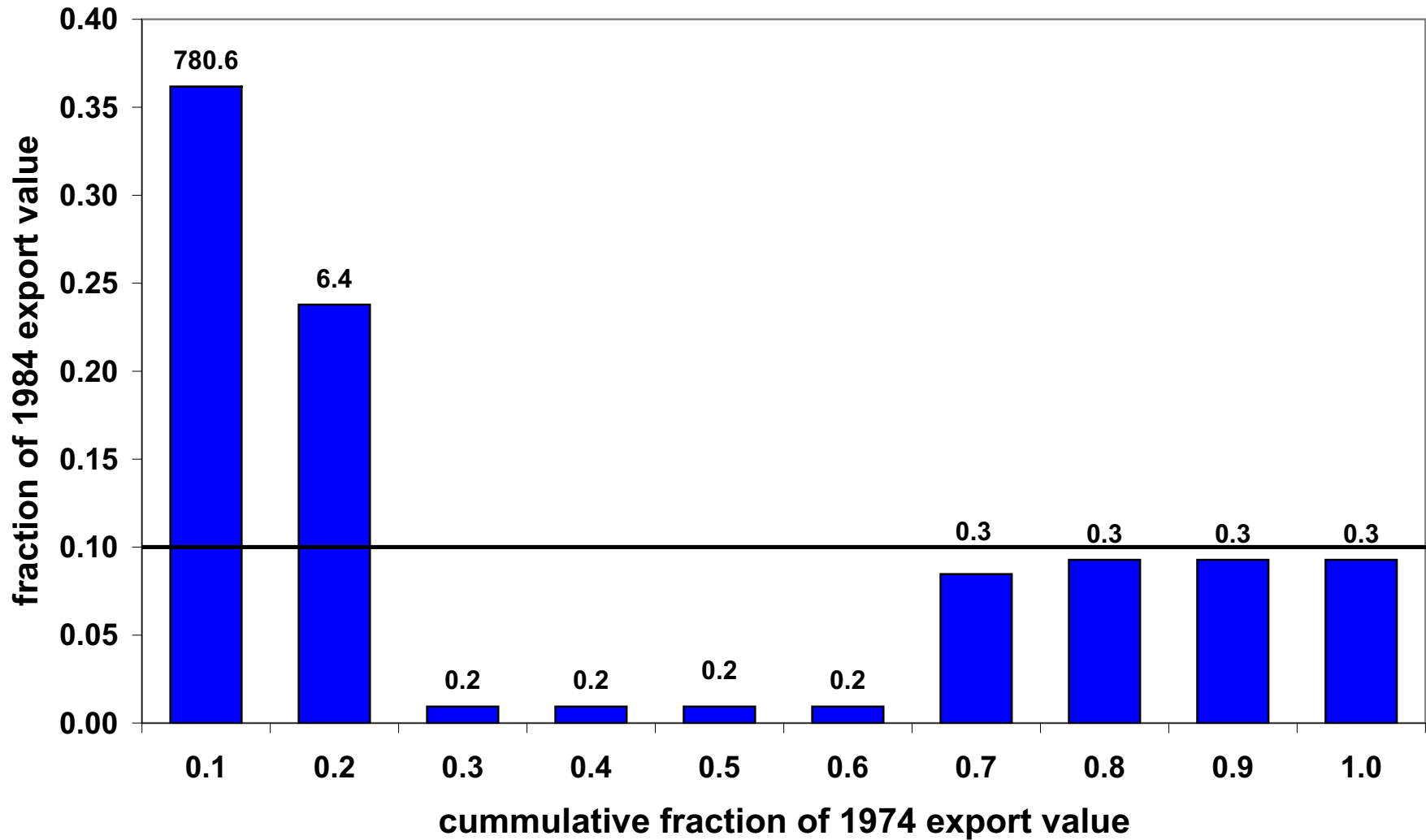
## **Lessons from data**

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

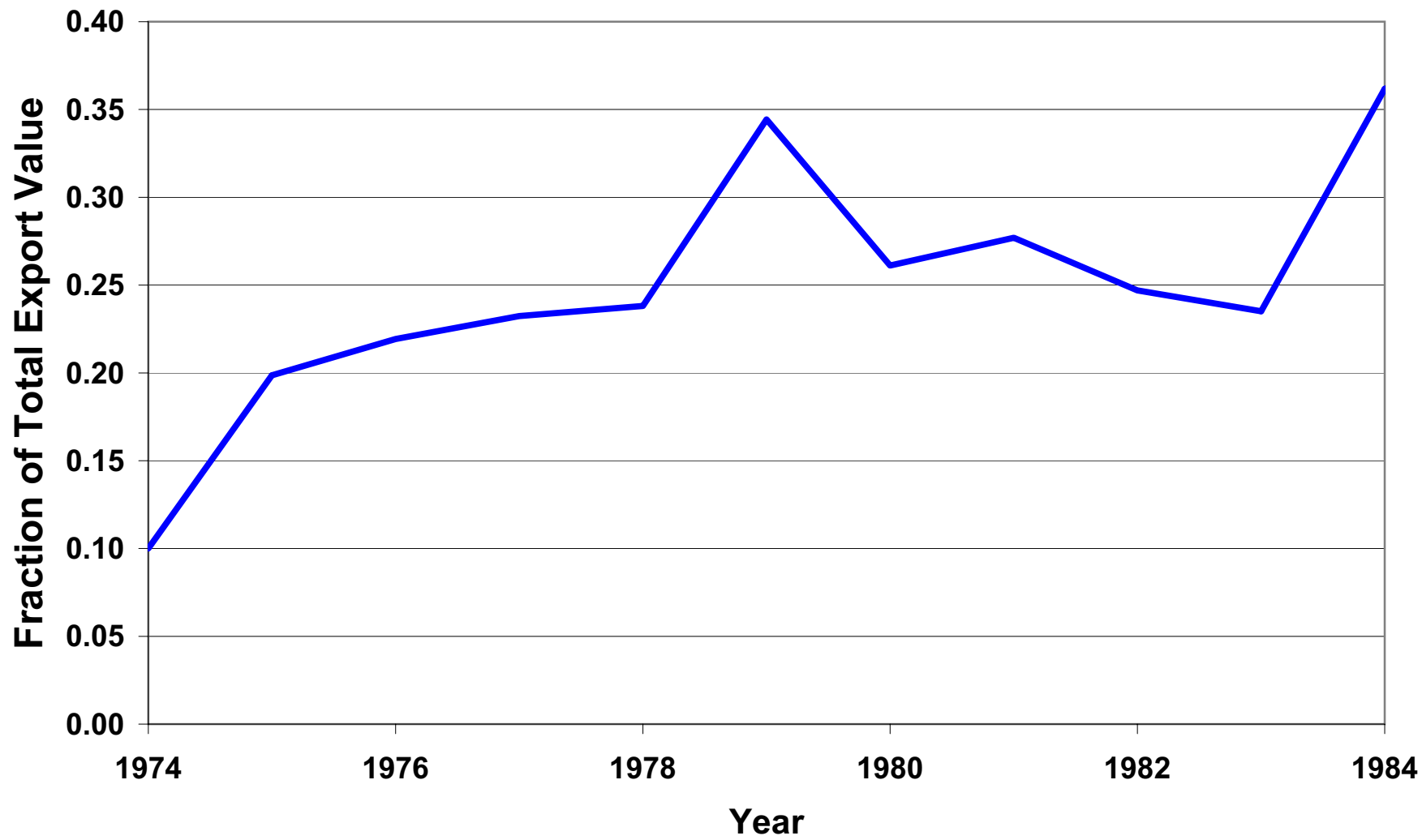
Structural changes may increase trade on the extensive margin.

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

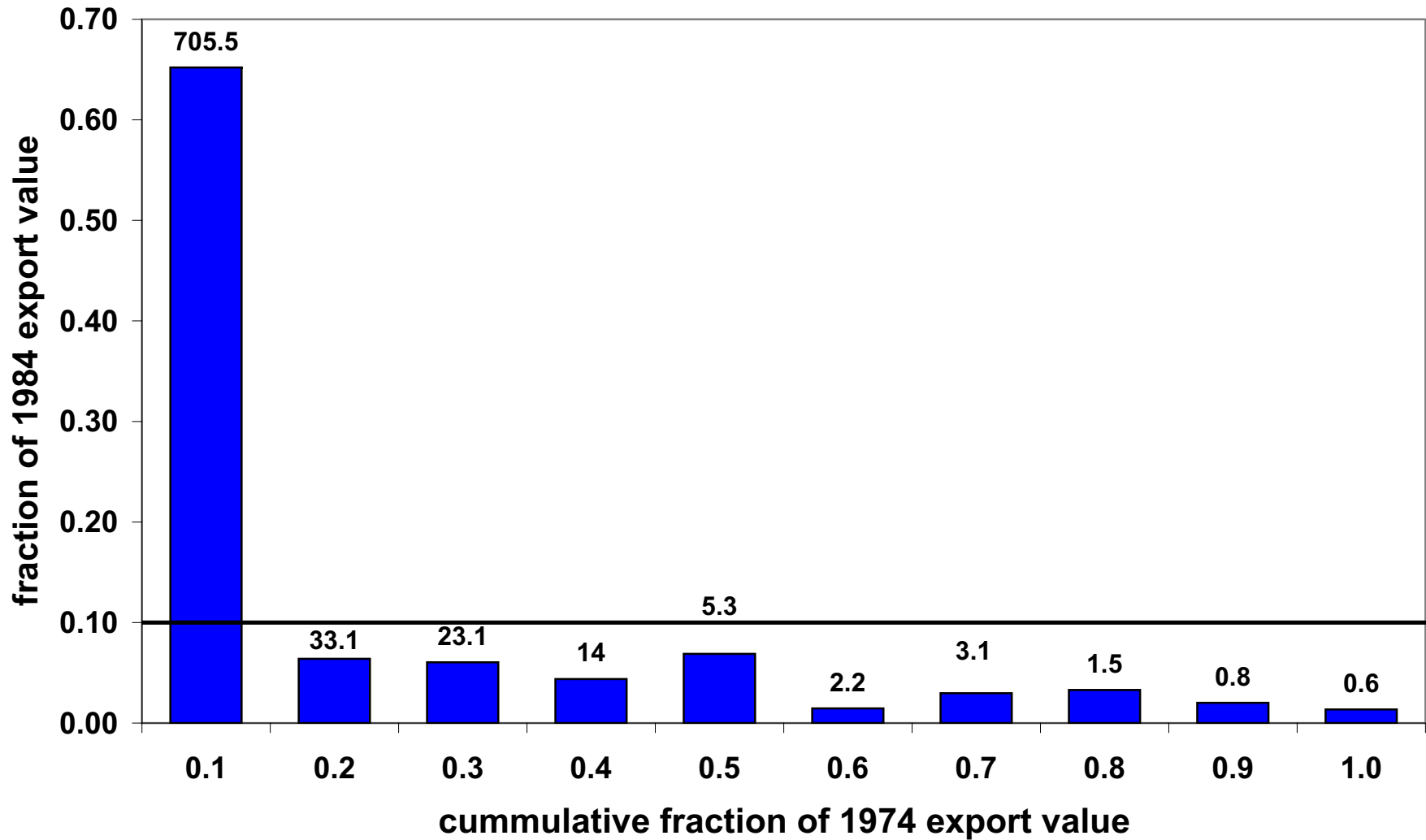
## Composition of Exports: Chile to the United States



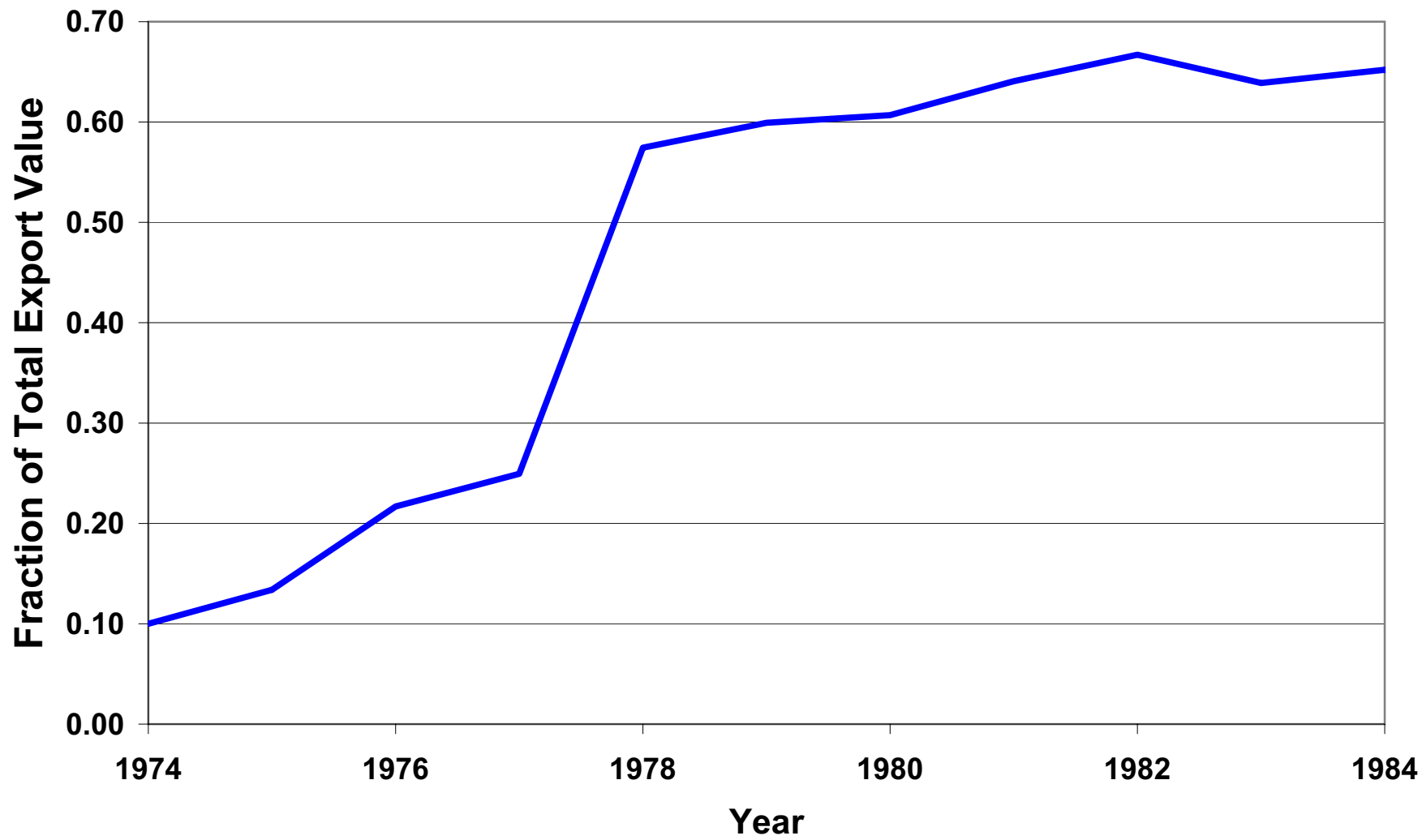
## Exports: Chile to the United States



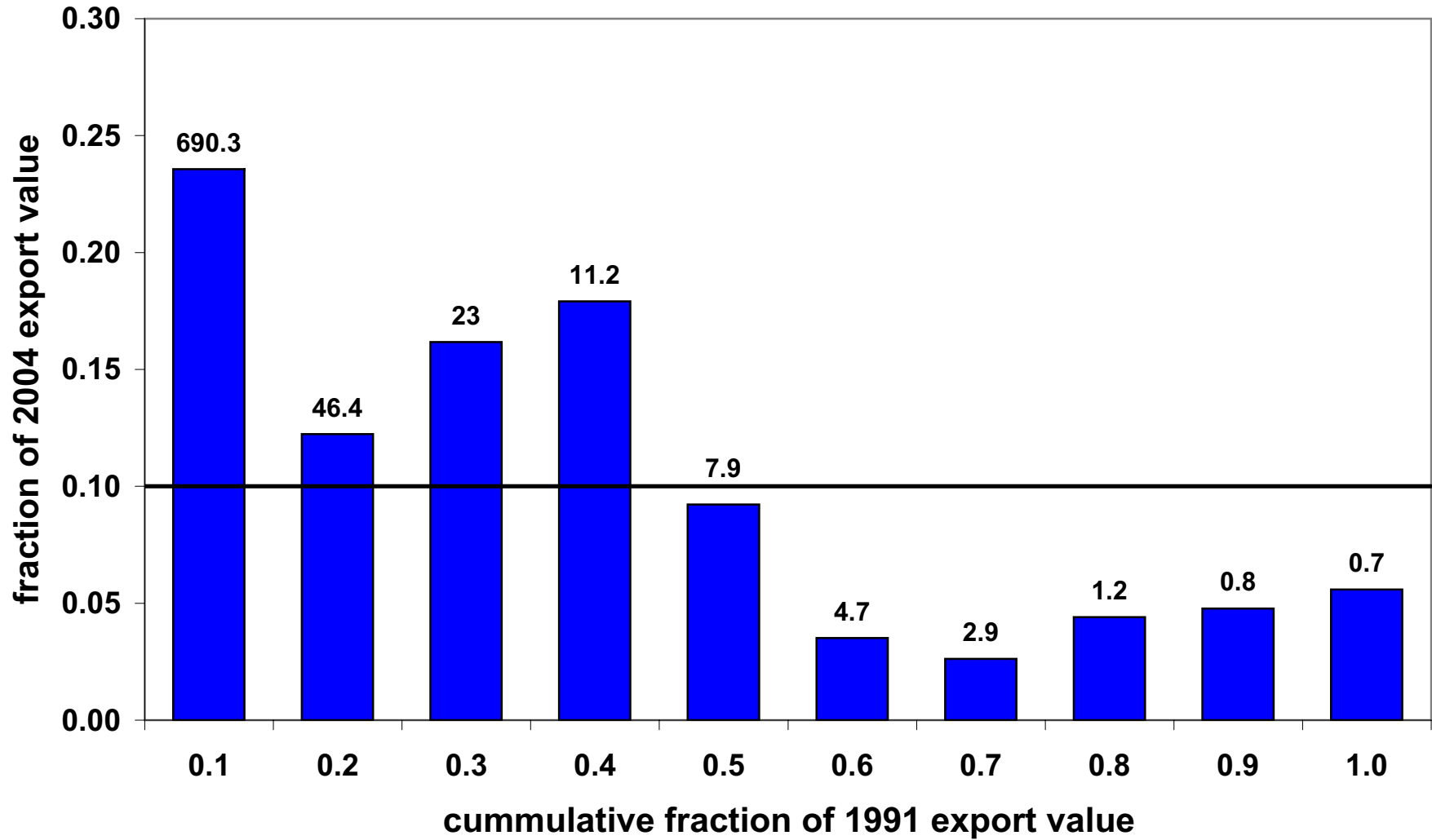
## Composition of Exports: United States to Chile



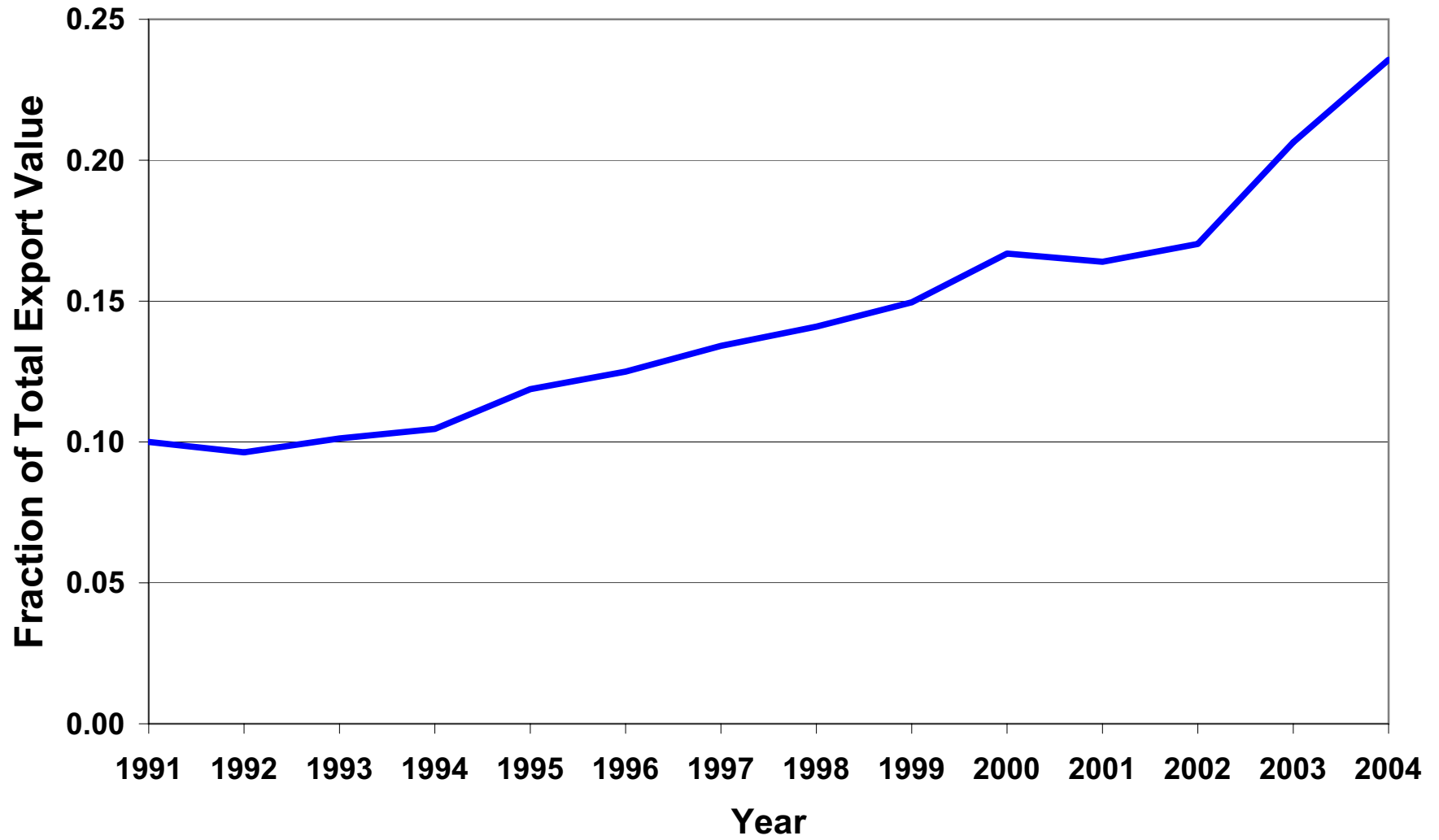
## Exports: United States to Chile



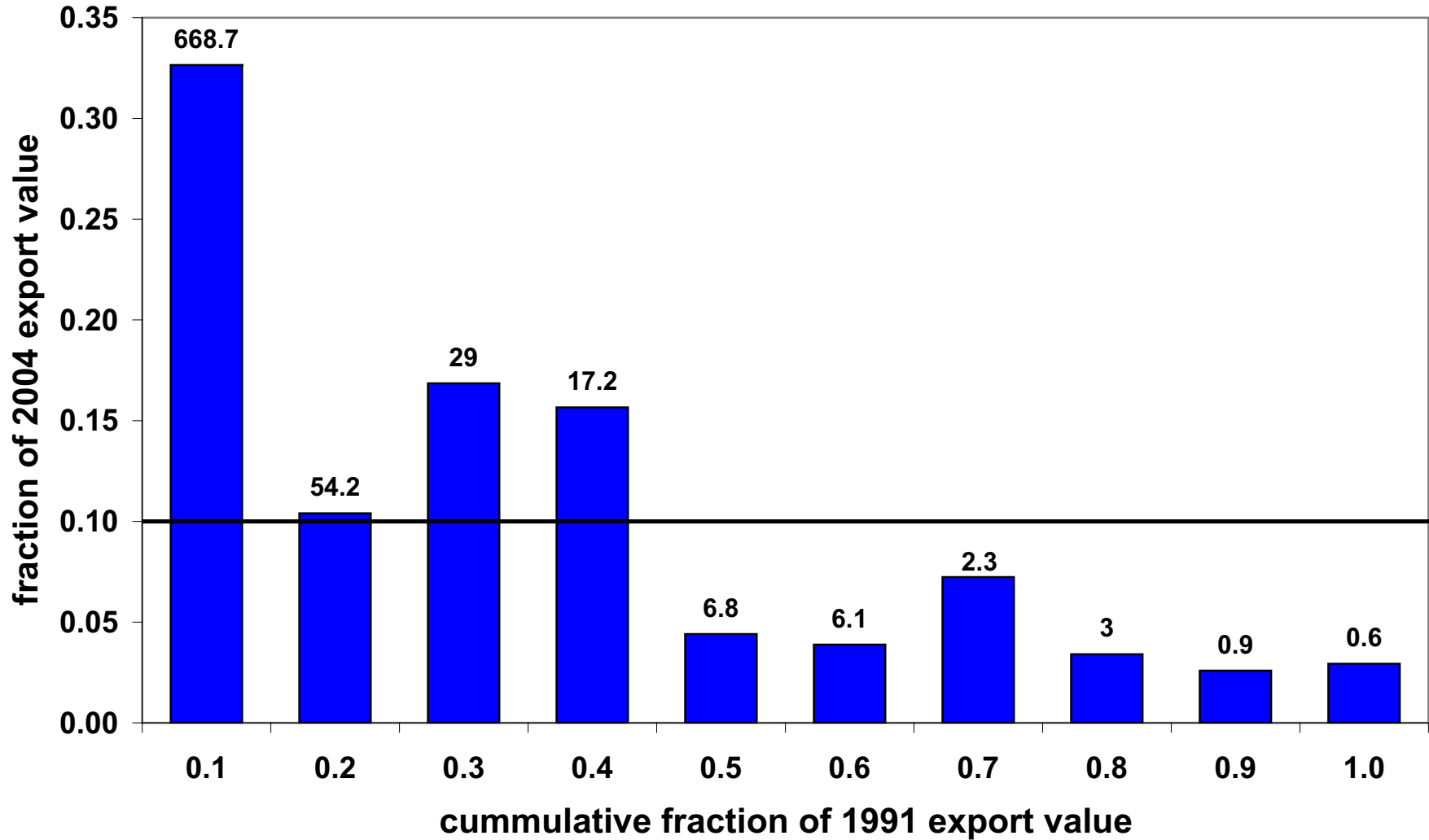
## Composition of Exports: China to the United States



## Exports: China to the United States

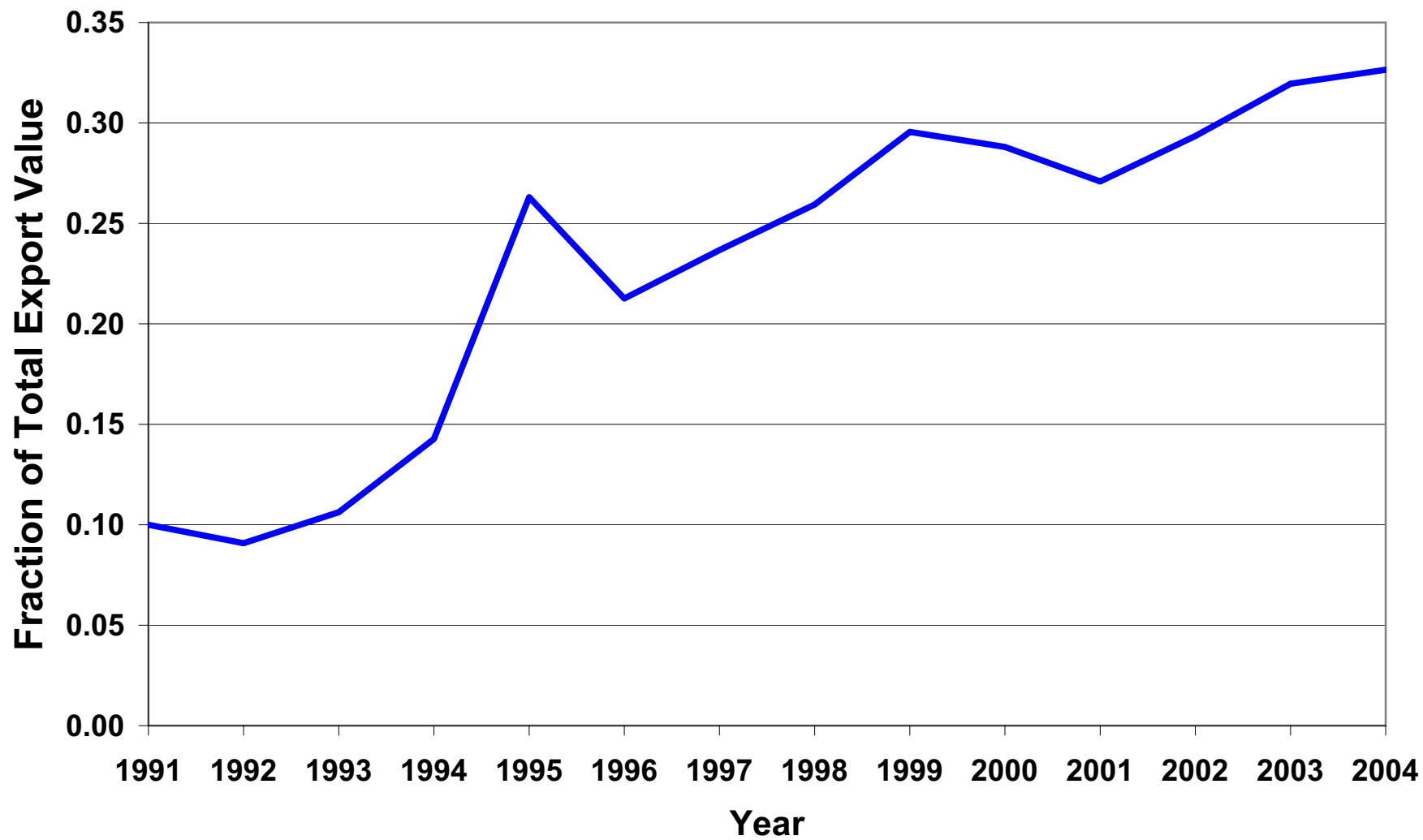


## Composition of Exports: United States to China

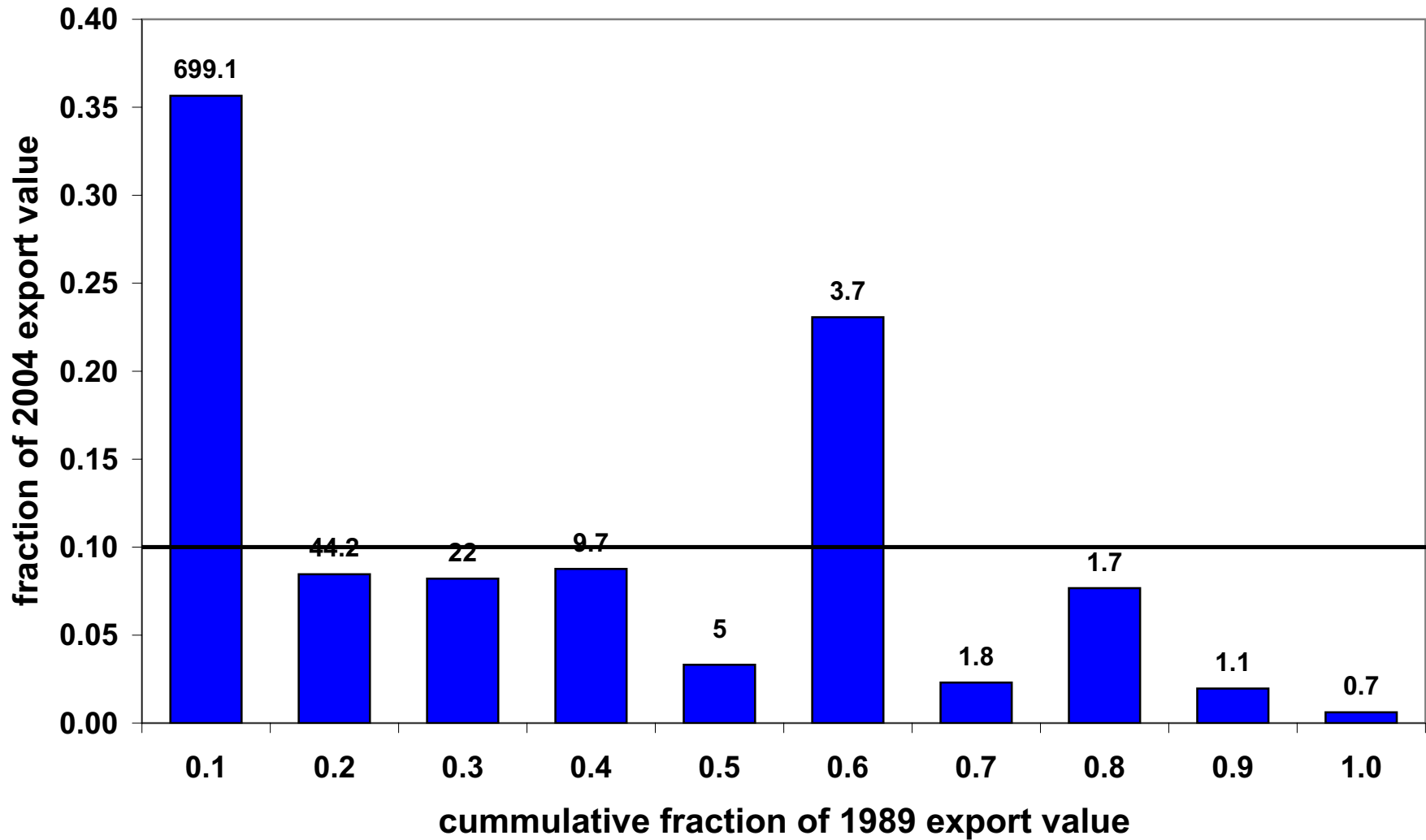




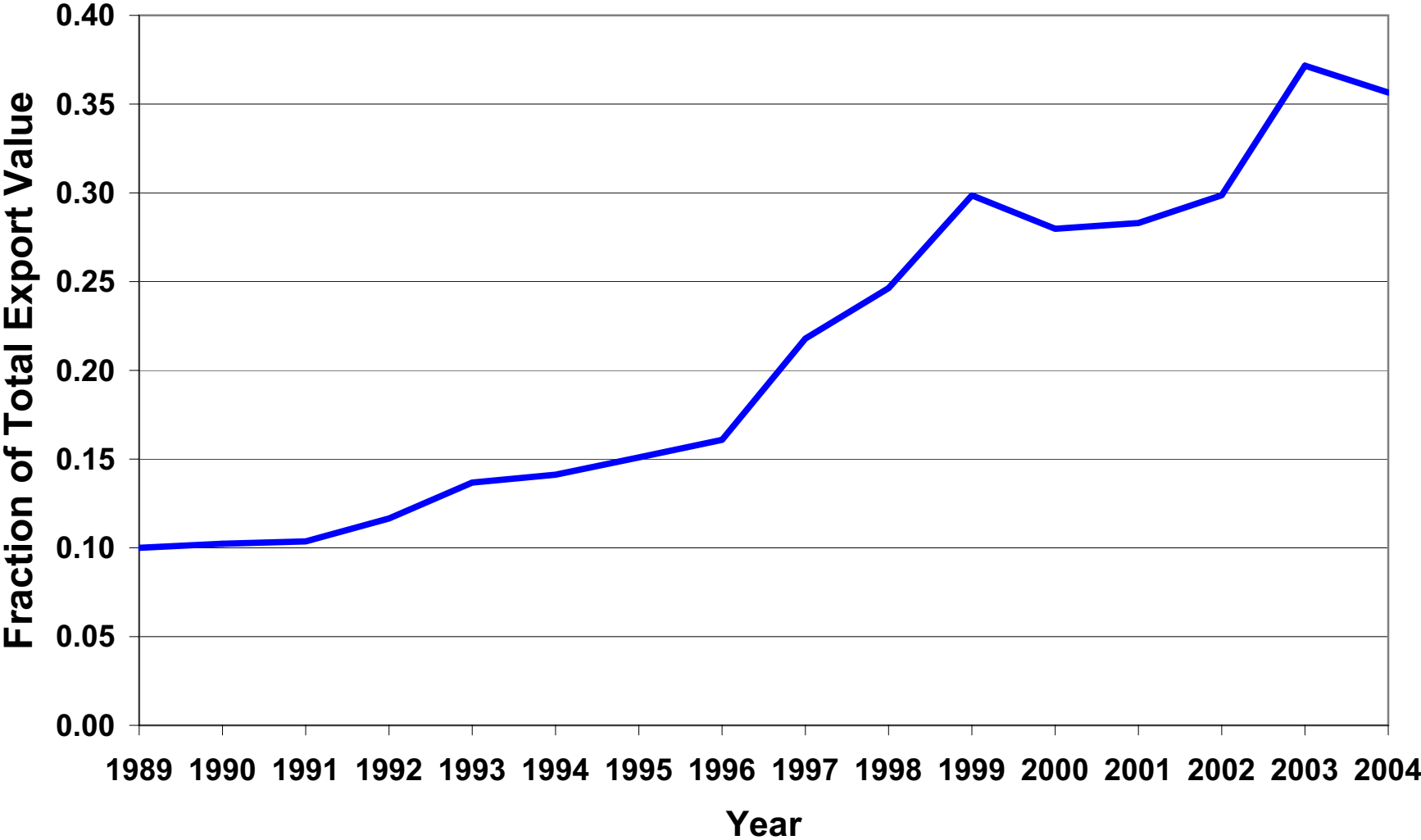
## Exports: United States to China



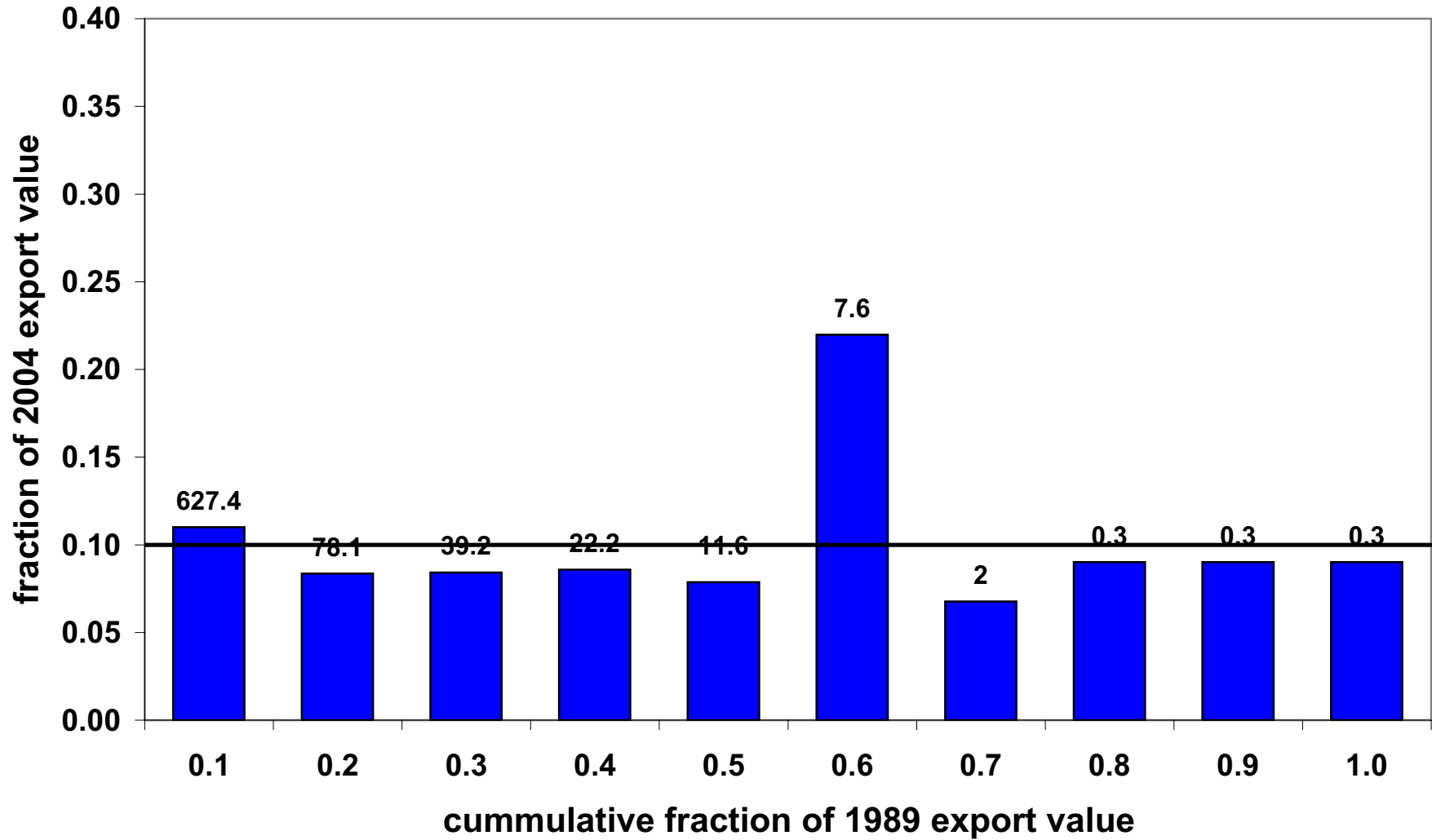
## Composition of Exports: Canada to the United Kingdom



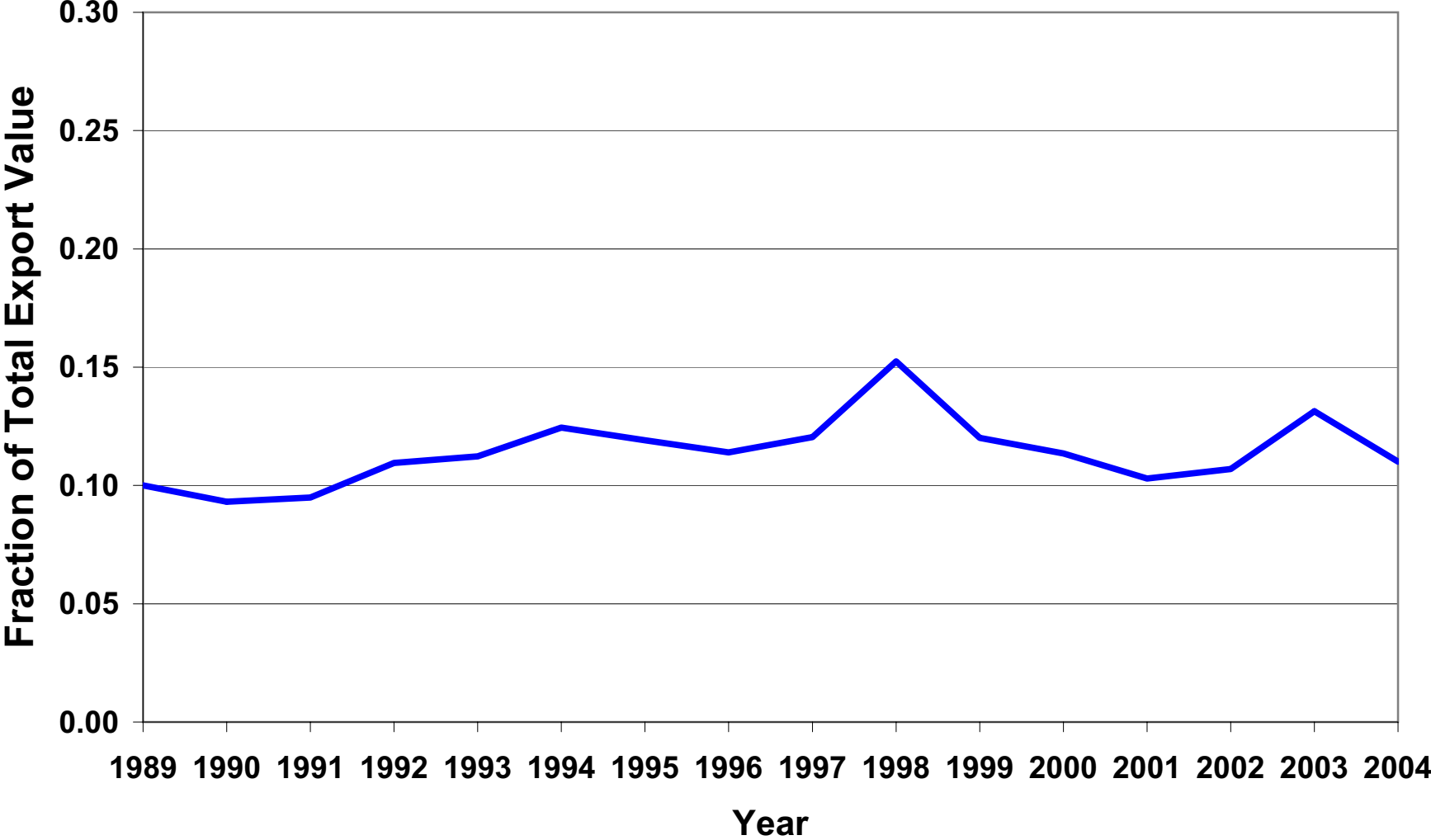
# Exports: Canada to the United Kingdom



## Composition of Exports: United Kingdom to Canada



# Exports: United Kingdom to Canada



## 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  $\tau$ ,  $\tau^*$

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

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

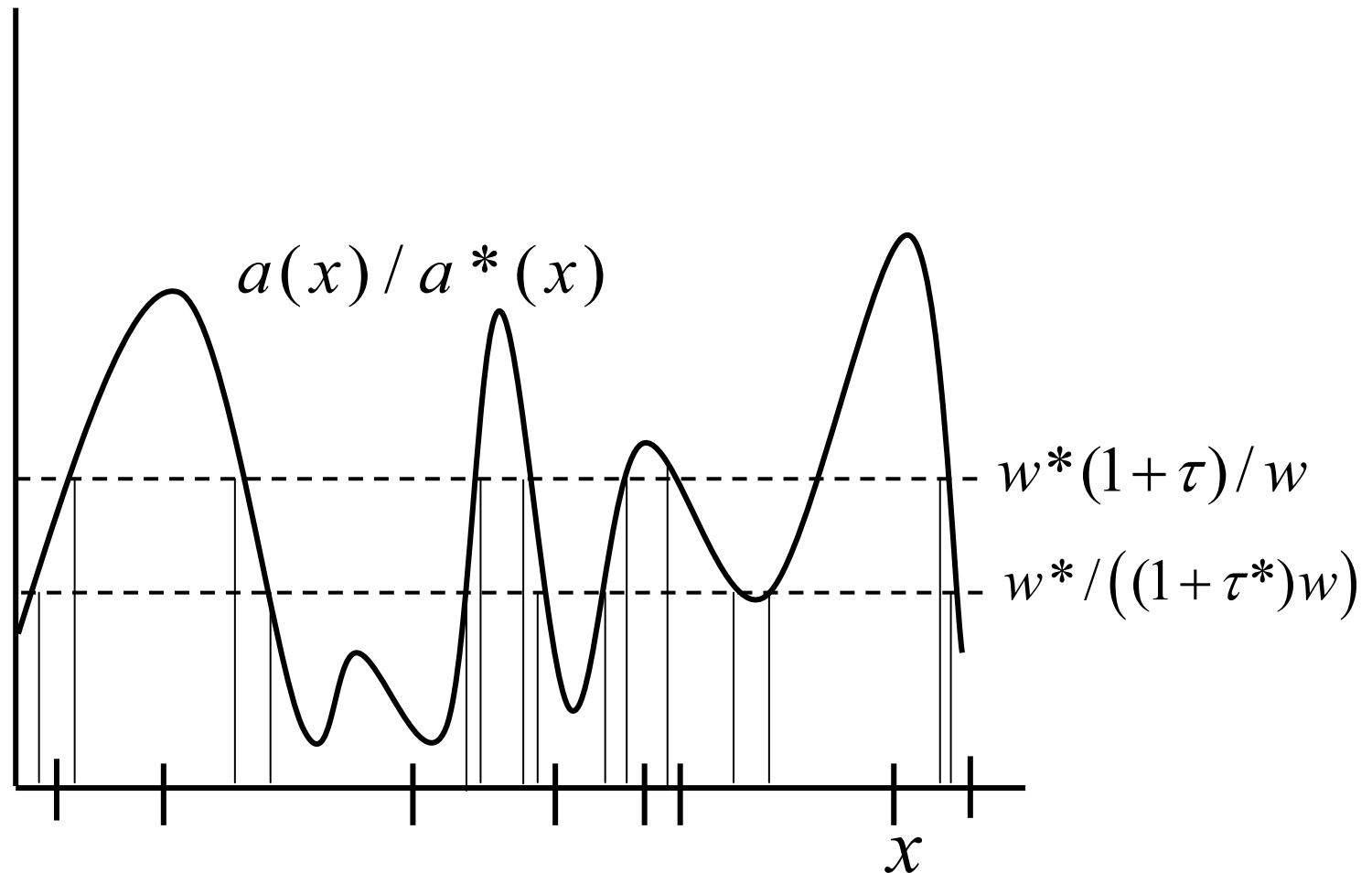
$$\frac{a(x)}{a^*(x)} > \frac{(1 + \tau)w^*}{w}$$

$\Rightarrow$  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, 2008.



## **Melitz (2003) – Chaney (2008) Model**

2 symmetric countries

Monopolistically competitive firms that are heterogeneous in technological efficiency

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

Fixed cost of production — not all firms choose to operate

Representative consumer  
utility

$$u(c_i) = (1/\rho) \log \int_{Z_i} c_i(z)^\rho dz$$

endowment of labor

$$\bar{\ell}$$

Measure  $\mu$  of potential firms in each country

Firms differ in their productivity levels:

$$y_i(z) = \max \left[ x(z) (\ell_i(z) - f_d), 0 \right]$$

$f_d$  is the fixed cost of operating

$f_e$  the fixed cost of exporting

Potential firms draw their productivities from a Pareto distribution:

$$F(x) = 1 - x^{-\gamma}, \quad x \geq 1$$

$$\gamma > \max \left[ 2, \rho / (1 - \rho) \right]$$

Autarky

If  $\mu$  is sufficiently large, there is a cutoff  $\bar{x}_d > 1$  such that a firm with productivity  $x$  produces only if  $x \geq \bar{x}_d$ .

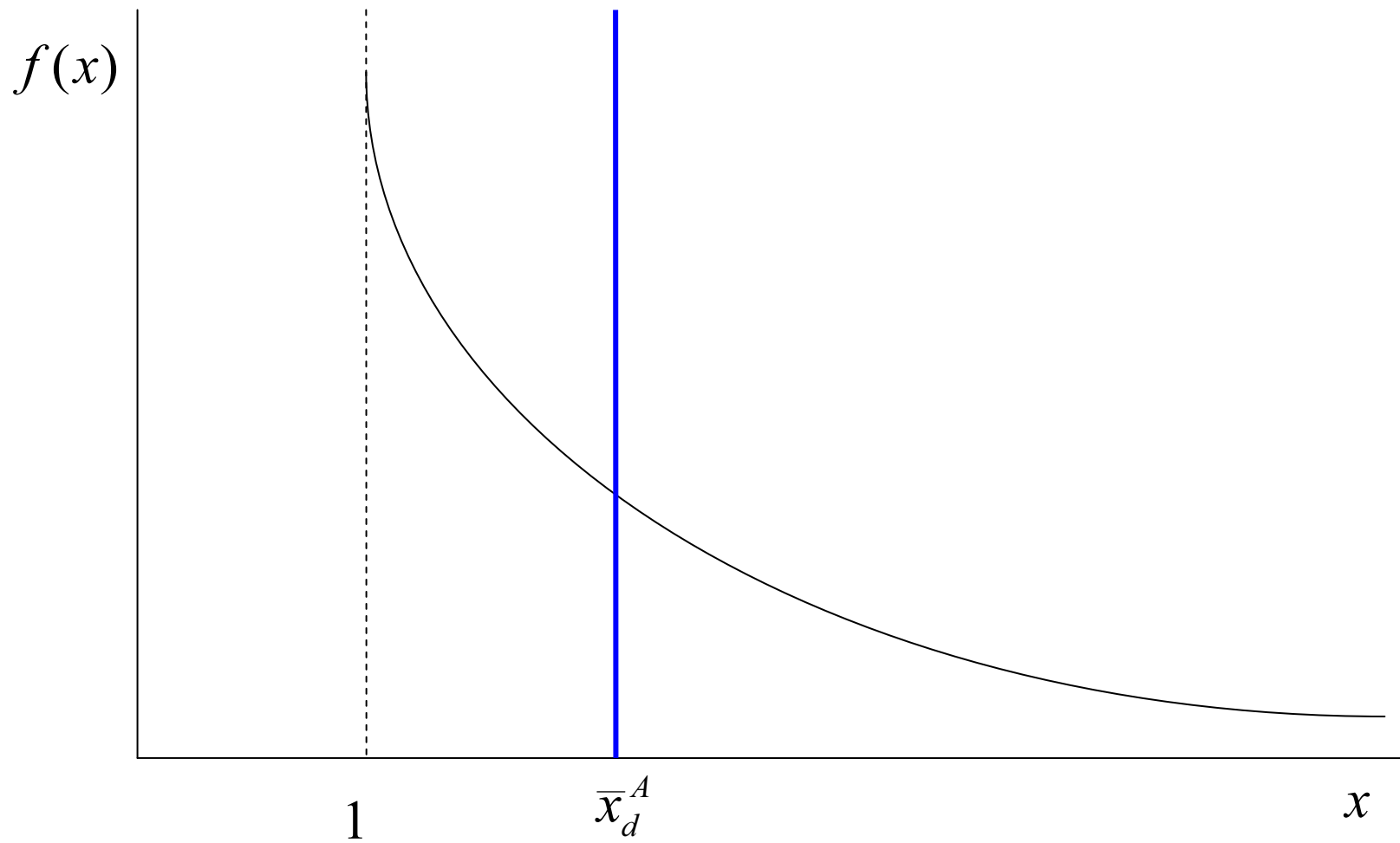
Normalize  $w = 1$ .

The profit-maximizing prices are

$$p^A(x) = \frac{1}{\rho x}.$$

The productivity cutoff point is

$$\bar{x}_d^A = \left( \frac{\mu(\gamma - \rho) f_d}{(\gamma(1 - \rho) - \rho) \bar{\ell}} \right)^{1/\gamma}.$$



$$c^A(x) = y^A(x) = \frac{\rho(\gamma(1-\rho) - \rho)(\bar{\ell} + \pi^A)x^{\frac{1}{1-\rho}}}{(1-\rho)\gamma\mu(\bar{x}_d^A)^{\frac{\rho-\gamma(1-\rho)}{1-\rho}}}, \quad x \geq \bar{x}_d^A,$$

where  $\pi^A = \rho\bar{\ell} / (\gamma - \rho)$ .

Real GDP is

$$GDP^A = \mu \int_{\bar{x}_d^A}^{\infty} p^A(x) y^A(x) dF(x) = \frac{\gamma}{\gamma - \rho} \bar{\ell}.$$

Ideal real income index is

$$v^A = \left( \mu \int_{\bar{x}_d^A}^{\infty} c^A(x)^\rho dF(x) \right)^{1/\rho} = \frac{\gamma}{(\gamma - \rho) P^A} \bar{\ell},$$

where

$$\begin{aligned} P^A &= \left( \mu \int_{\bar{x}_d^A}^{\infty} p^A(x)^{\frac{-\rho}{1-\rho}} dF(x) \right)^{\frac{-(1-\rho)}{\rho}} \\ &= \frac{(\gamma(1-\rho) - \rho)^{\frac{1}{\gamma}} \bar{\ell}^{\frac{\rho - \gamma(1-\rho)}{\gamma\rho}}}{\rho \mu^{\frac{1}{\gamma}} ((1-\rho)\gamma)^{\frac{1-\rho}{\rho}} ((\gamma - \rho) f_d)^{\frac{\rho - \gamma(1-\rho)}{\gamma\rho}}} \end{aligned}$$

## Trade

There are now two cutoffs if  $\mu$  is sufficiently high:

$$\bar{x}_e > \bar{x}_d > 1$$

Firm  $z$  produces if  $x(z) > \bar{x}_d$  and firm  $z$  exports if  $x(z) \geq \bar{x}_e$ .

Again, profit-maximizing prices are

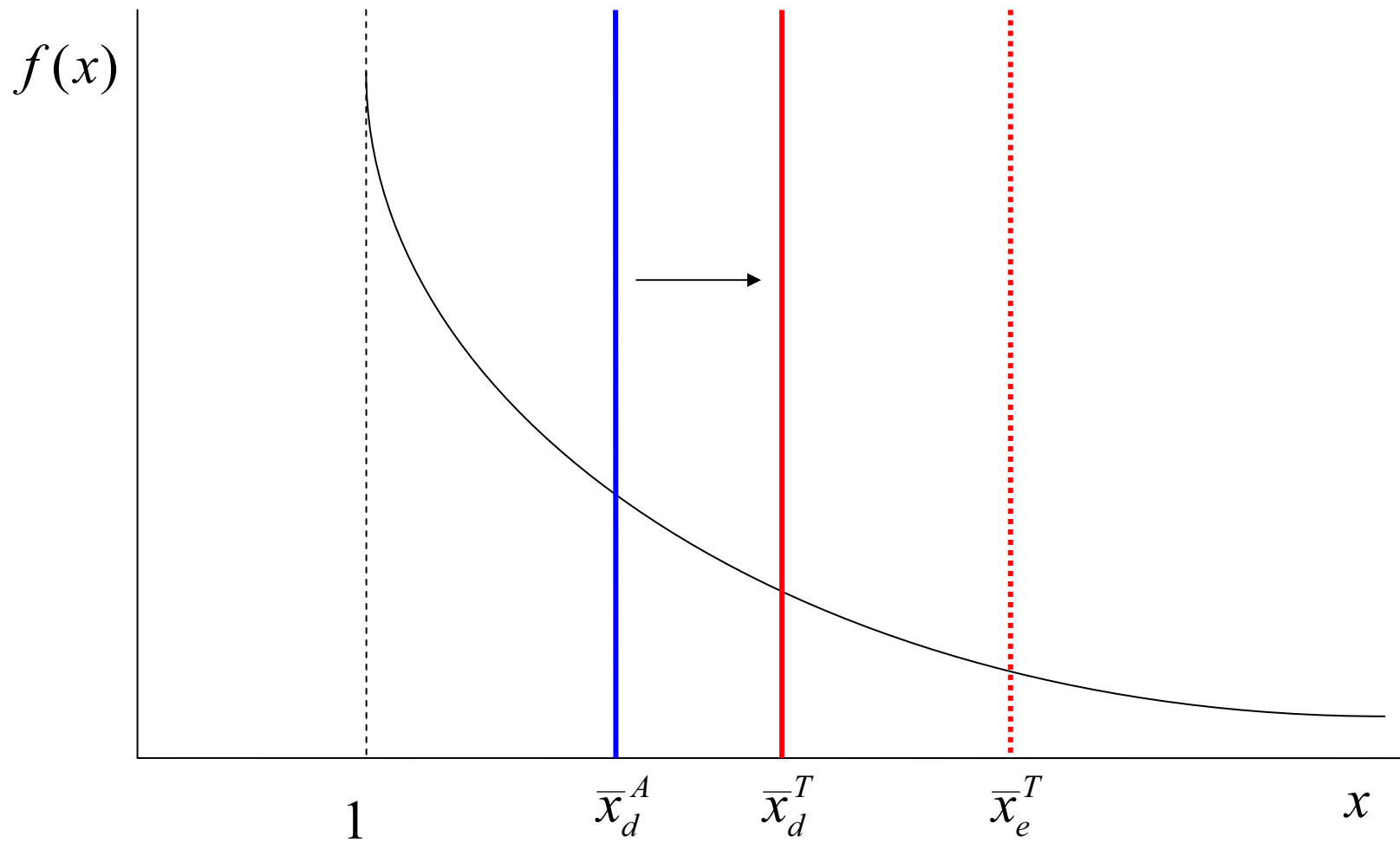
$$p^T(x) = \frac{1}{\rho x}.$$



Cutoffs are

$$\bar{x}_d^T = \left( \frac{\mu(\gamma - \rho) f_d \left( 1 + (f_e/f_d)^{\frac{\rho - \gamma(1 - \rho)}{\rho}} \right)}{(\gamma(1 - \rho) - \rho) \bar{\ell}} \right)^{1/\gamma}$$

$$\bar{x}_e^T = \left( \frac{f_e}{f_d} \right)^{\frac{1 - \rho}{\rho}} \left( \frac{\mu(\gamma - \rho) f_d \left( 1 + (f_e/f_d)^{\frac{\rho - \gamma(1 - \rho)}{\rho}} \right)}{(\gamma(1 - \rho) - \rho) \bar{\ell}} \right)^{1/\gamma} .$$



$$\begin{aligned}
c^T(x) &= p^T(x)^{\frac{-1}{1-\rho}} (P^T)^{\frac{\rho}{1-\rho}} (\bar{\ell} + \pi^T) \\
&= \frac{\rho(\gamma(1-\rho) - \rho)(\bar{\ell} + \pi^T) x^{\frac{1}{1-\rho}}}{(1-\rho)\gamma\mu \left( (\bar{x}_d^T)^{\frac{\rho-\gamma(1-\rho)}{1-\rho}} + (\bar{x}_e^T)^{\frac{\rho-\gamma(1-\rho)}{1-\rho}} \right)},
\end{aligned}$$

where  $\pi^T = \rho \bar{\ell} / (\gamma - \rho)$ .

$$y^T(x) = \begin{cases} c^T(x) & \bar{x}_d^T \leq x < \bar{x}_e^T \\ 2c^T(x) & x \geq \bar{x}_e^T \end{cases}.$$

Real GDP is

$$\begin{aligned} GDP^T &= \mu \int_{\bar{x}_d^T}^{\infty} p^A(x) y^T(x) dF(x) \\ &= \mu \int_{\bar{x}_d^T}^{\infty} p^T(x) y^T(x) dF(x) = \frac{\gamma}{\gamma - \rho} \bar{\ell} \end{aligned}$$

**Unchanged!**

Real income index is

$$v^T = \frac{\gamma}{(\gamma - \rho) P^T} \bar{\ell}.$$

Since  $P^T < P^A$ , ideal index of real income increases even though measured GDP and productivity stay the same.

## 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)	[0.1, 3.5]
Reinert and Shiells (1993)	[0.1, 1.5]
Gallaway et al. (2003)	[0.2, 4.9]

---

## **Trade Liberalization Estimates: High Elasticity (9.0)**

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

---

## 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):  $\tau$

## Uncertainty

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

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

- First-order Markov process with transition matrix  $\Lambda$

$$\lambda_{\eta\eta'} = \text{pr}(\eta_{t+1} = \eta' | \eta_t = \eta)$$

## Traded Good Plants

- Traded good technology:

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

- Plant heterogeneity  $(\phi, \kappa)$

- constant, idiosyncratic productivity:  $\phi$
- export entry cost:  $\kappa$
- plant of type  $(\phi, \kappa)$

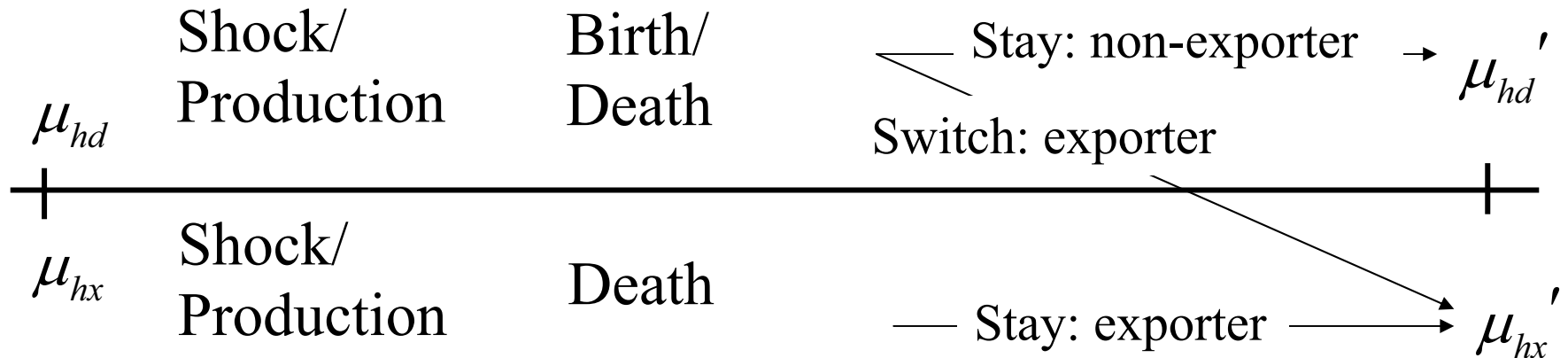
- $\nu$  plants born each period with distribution  $F(\phi, \kappa)$
- Fraction  $\delta$  of plants exogenously die each period

## Timing

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

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

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



## Consumers

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

s.t.

$$C = \left[ \int_{\iota \in I_h^h(\mu)} c_h^h(\iota)^\rho d\iota + \int_{\iota \in I_f^h(\mu)} c_f^h(\iota)^\rho d\iota \right]^{\frac{1}{\rho}}$$

$$\int_{\iota \in I_h^h(\mu)} p_h^h(\iota) c_h^h(\iota) d\iota + \int_{\iota \in I_f^h(\mu)} (1 + \tau) p_f^h(\iota) c_f^h(\iota) d\iota + p_{hA} A = L + \Pi_h$$

## Non-traded Good

$$\begin{aligned} \max \quad & p_{hA}(\eta, \mu) A - l \\ \text{s.t.} \quad & A = z_h(\eta) l \end{aligned}$$

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



## Traded Goods: Static Profit Maximization

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

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

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

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

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:

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

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

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

- Non-exporter's Value Function:

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

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

## Equilibrium

- Cutoff level of productivity for each value of the entry cost
- For a plant of type  $(\phi, \kappa)$

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

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

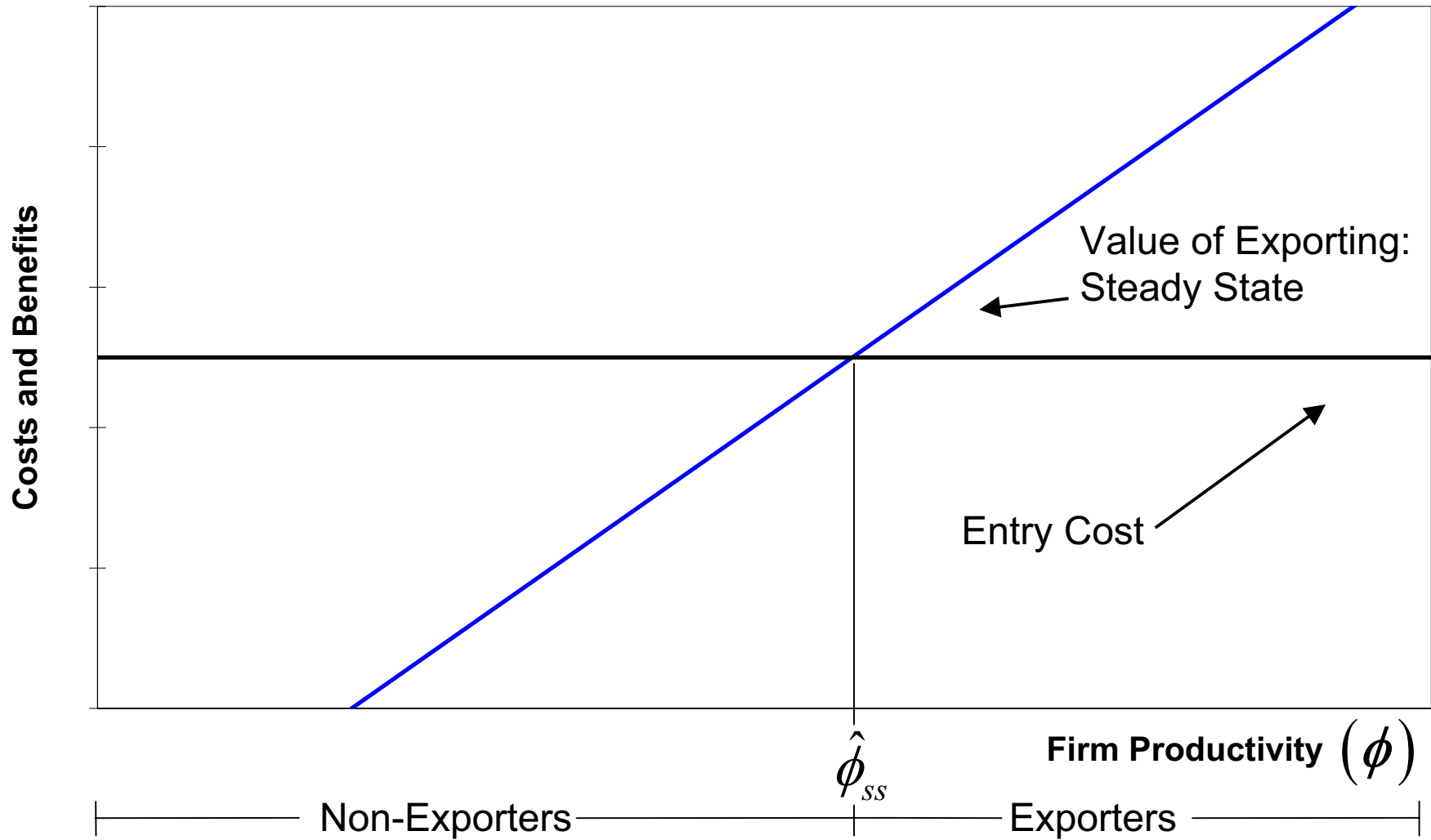
- In Equilibrium
  - “Low” productivity/“high” entry cost plants sell domestic
  - “High” productivity/“low” entry cost plants also export
  - Similar to Melitz (2003)

## Determining Cutoffs

- For the cutoff plant:
  - entry cost = discounted, expected value of exporting
- $\hat{\phi}_\kappa(\eta, \mu)$  is the level of productivity,  $\phi$ , that solves:

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

## Finding the Cutoff Producer



## Choosing Parameters

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

---

### Parameters

---

$\beta$	Annual real interest rate (4%)
$\gamma$	Share of manufactures in GDP (18%)
$\delta$	Annual loss of jobs from plant deaths as percentage of employment (Davis et. al., 1996) (6%)

---

## Other Parameters

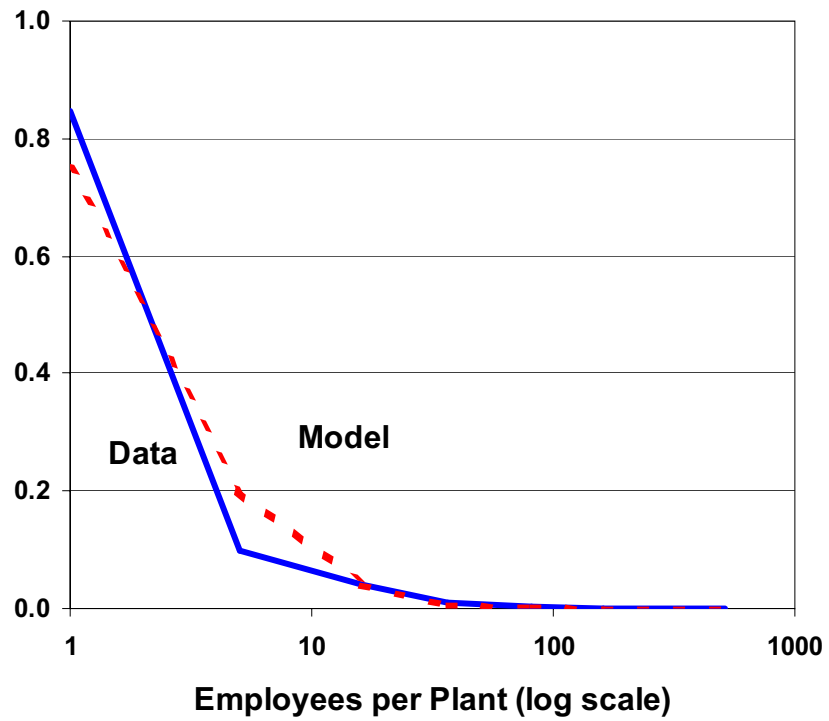
- Distribution over new plants:

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

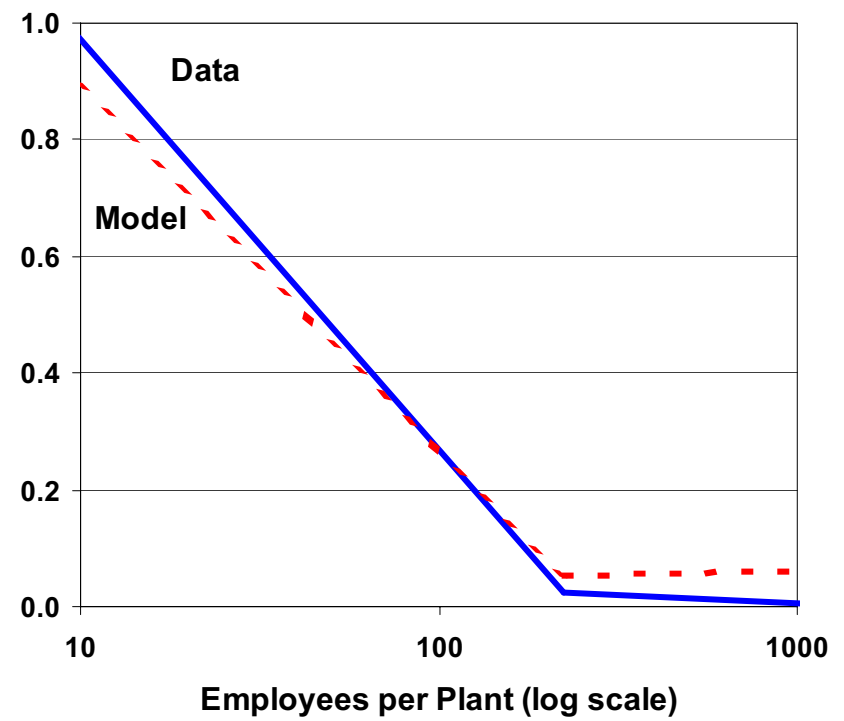
- $\bar{\kappa}, \bar{\phi}, \nu, \theta_{\phi}, \theta_{\kappa}$  jointly determine:
  - Average plant size (12 employees)
  - Standard deviation of plant sizes (892)
  - Average exporting plant size (15 employees)
  - Standard deviation of exporting plant sizes (912)
  - Fraction of production that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



**Plant Size Distribution:  
All Plants**



**Plant Size Distribution:  
Exporting Plants**



## Productivity Process

- Two shocks, low and high:

$$z_i = 1 - \varepsilon$$

$$z_i = 1 + \varepsilon$$

- Countries have symmetric processes with Markov Matrix

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

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

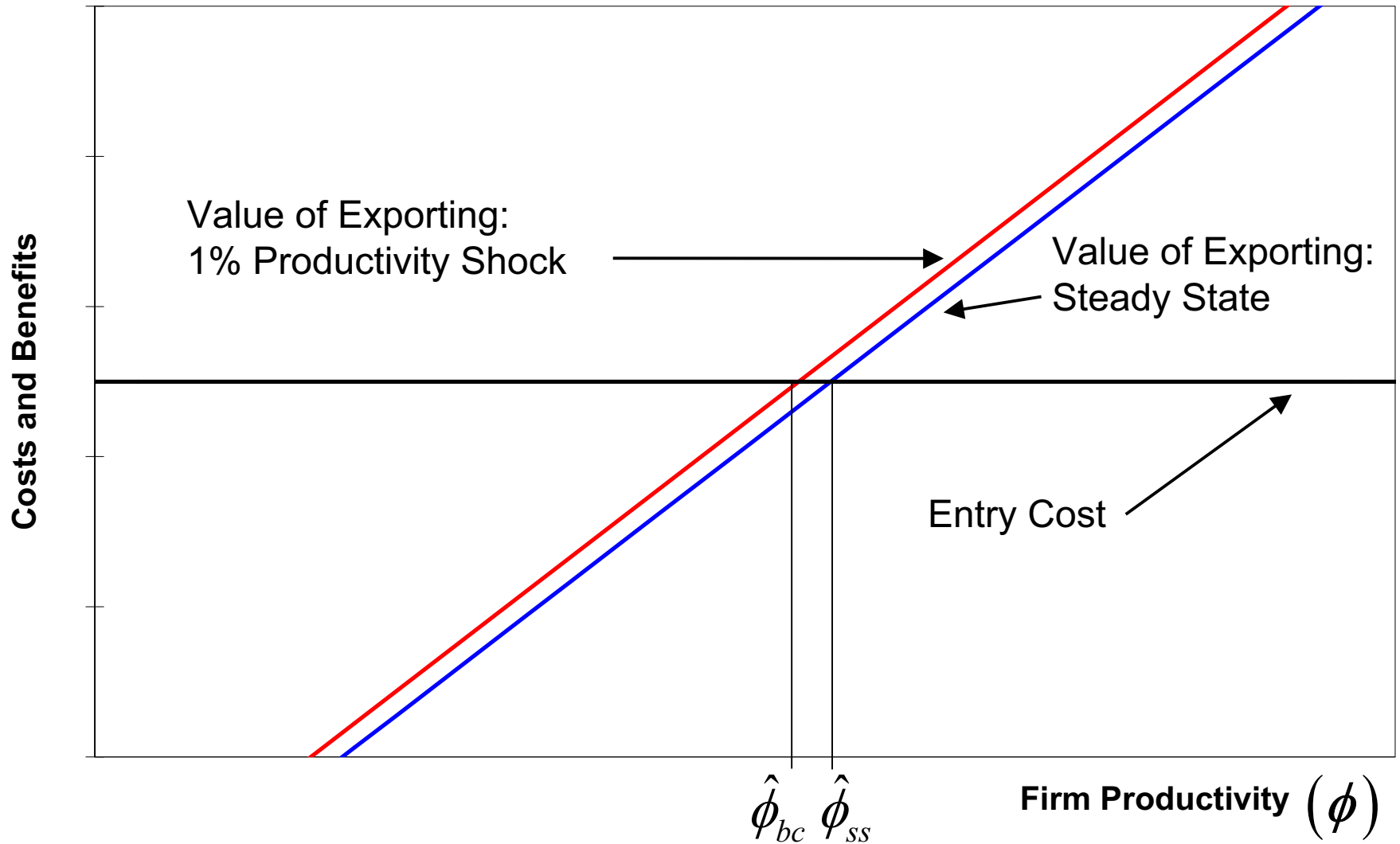
## **How does Trade Liberalization Differ from Business Cycles?**

- 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**



## Response to a 1% Foreign Productivity Shock

Increase in imports on intensive margin = 1.89%

Increase in imports on extensive margin = 0.16%

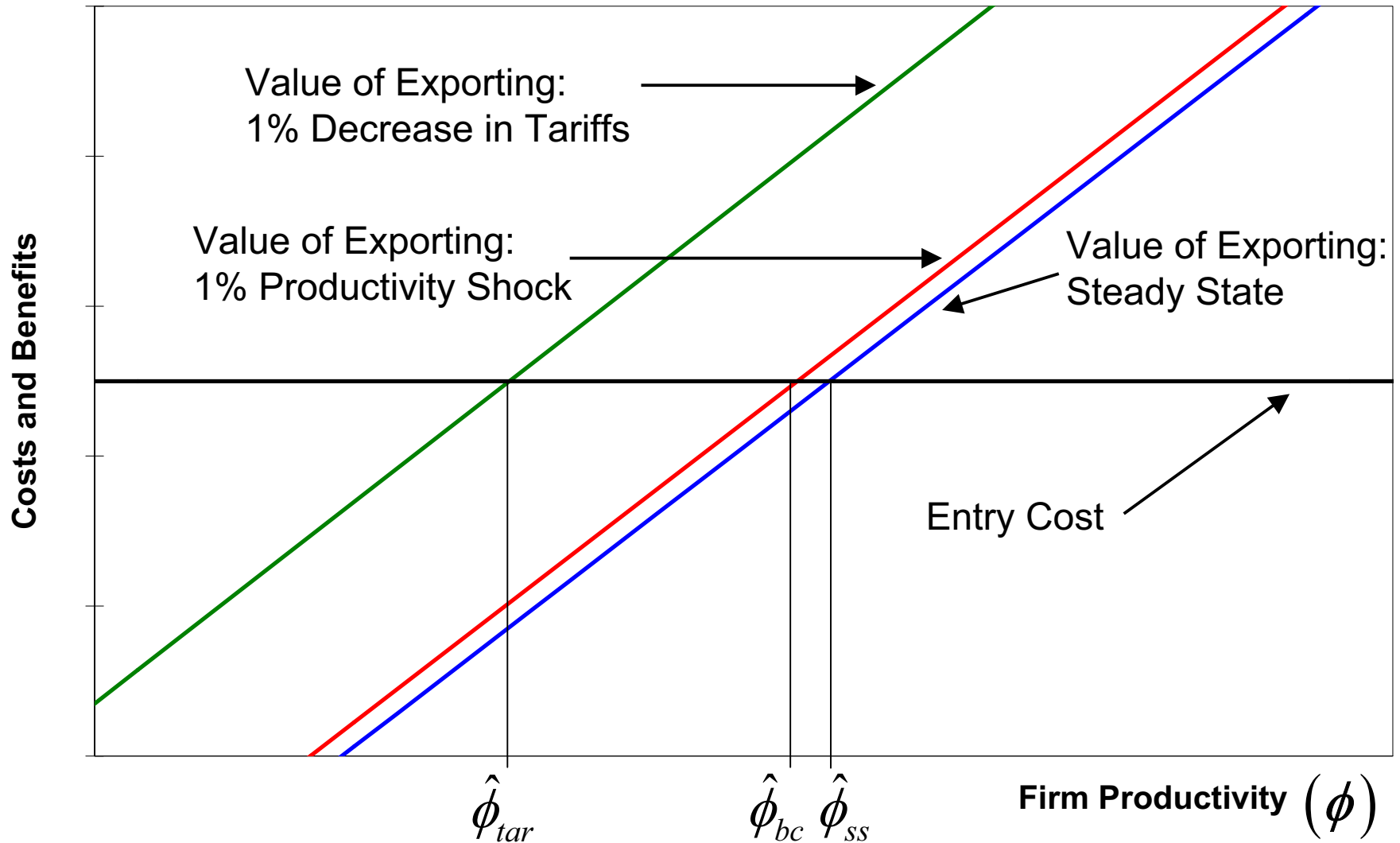
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Total increase in imports = 2.05%

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



## Response to a 1% Tariff Reduction

Increase in imports on intensive margin	=	1.42%
Increase in imports on extensive margin	=	3.04%
<hr/>		
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

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<b>Variable</b>	<b>Entry Costs</b> (% change)	<b>No Entry Costs</b> (% 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
$\alpha$ (standard error)	-0.015 (6.36e-04)
$\sigma$ (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

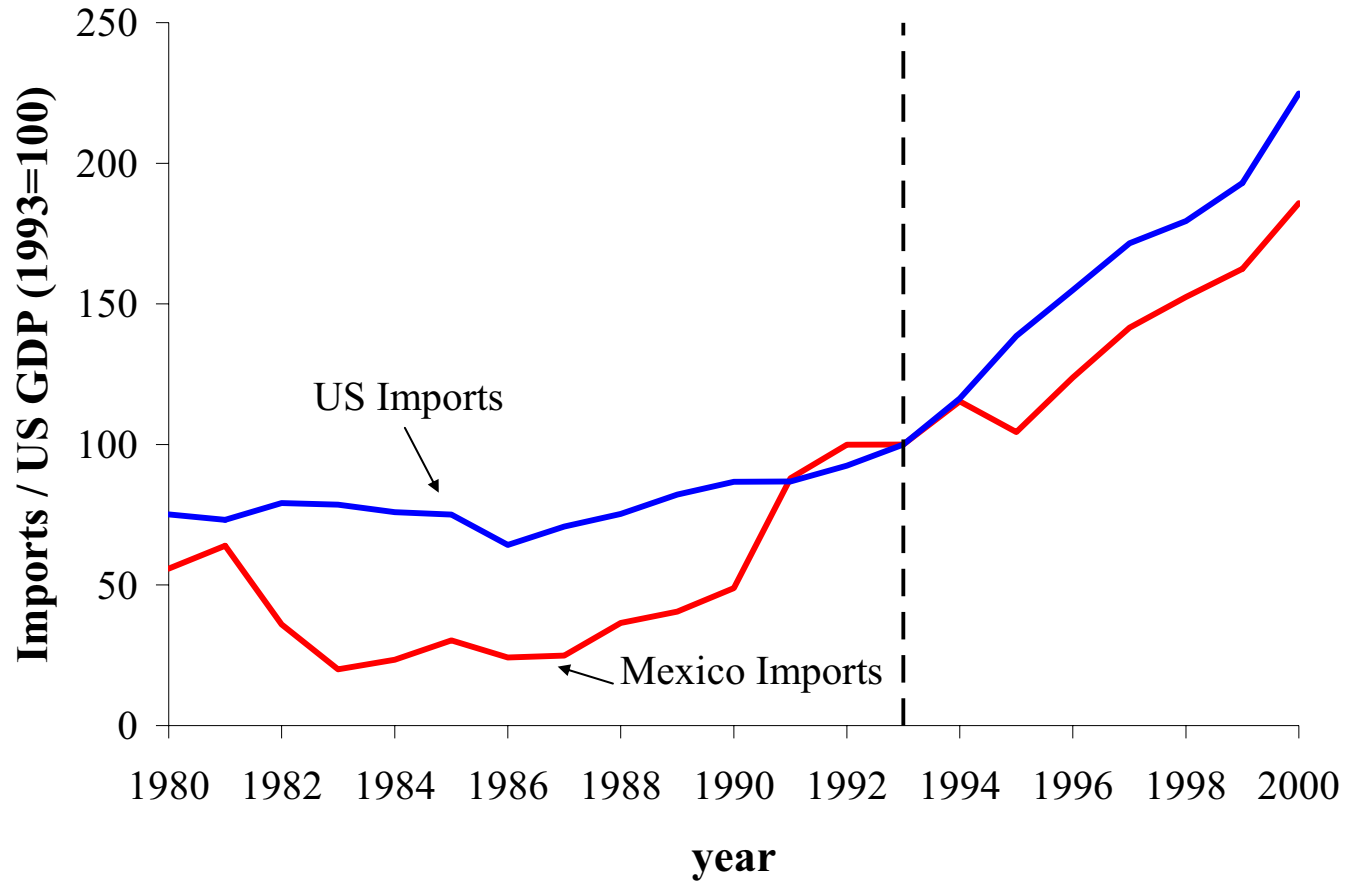
Low estimates from time-series data ( $< 2$ )

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%	<b>79</b>	<b>26</b>	<b>-10</b>	<b>3</b>	<b>2</b>
7-year change	-77%	<b>74</b>	<b>42</b>	<b>-30</b>	<b>5</b>	<b>10</b>

# 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  $t = 0, 1, 2, \dots$

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

$$\Pr(s_t | s^{t-1}) = \phi(s_t | s_{t-1})$$

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

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

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:

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

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

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

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

$\gamma$ : 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:  $\frac{1}{\gamma} (\omega + (1 + \tau) p_t (1 - \omega))$

## 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  $\gamma$  from plant data

Check that inequality holds along equilibrium path

## Dynamic problem: Timing

Plant pays cost  $\kappa_e$  to get a draw of  $z$  from distribution  $g$

Decide whether to start producing or exit

Pay sunk investment

$\kappa_c$  to use non-importing technology, or

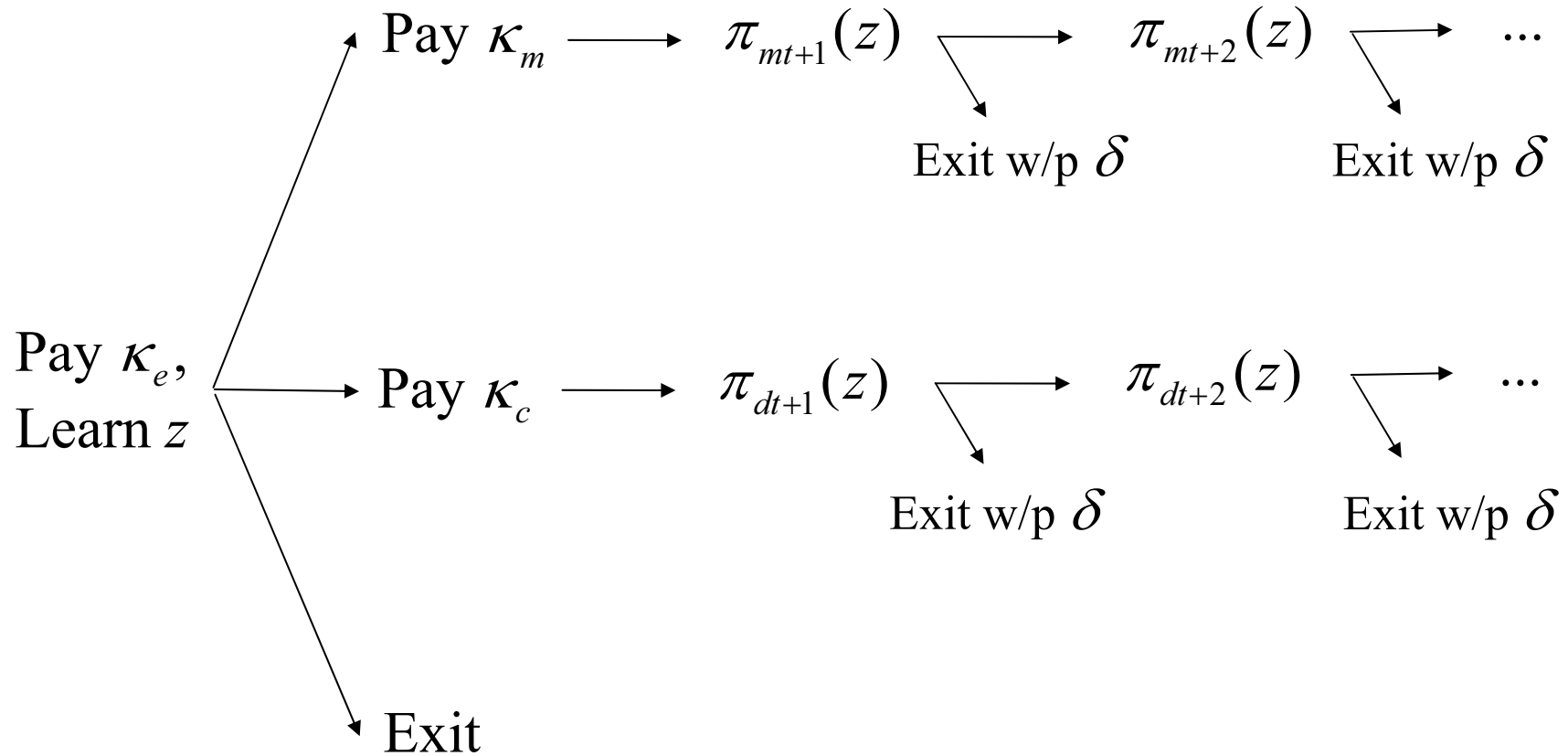
$\kappa_m$  to use importing technology

$$\kappa_m > \kappa_c$$

Face static profit maximization problem each period

Probability  $\delta$  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  $P_{t,t+k} = \beta^k \frac{U_{C_{t+k}}}{U_{C_t}}$  (consumer owns plants)

## Technology Choice

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

Produce using non-importing technology if

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

Produce using importing technology if

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

Otherwise exit

## Technology Choice

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

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

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

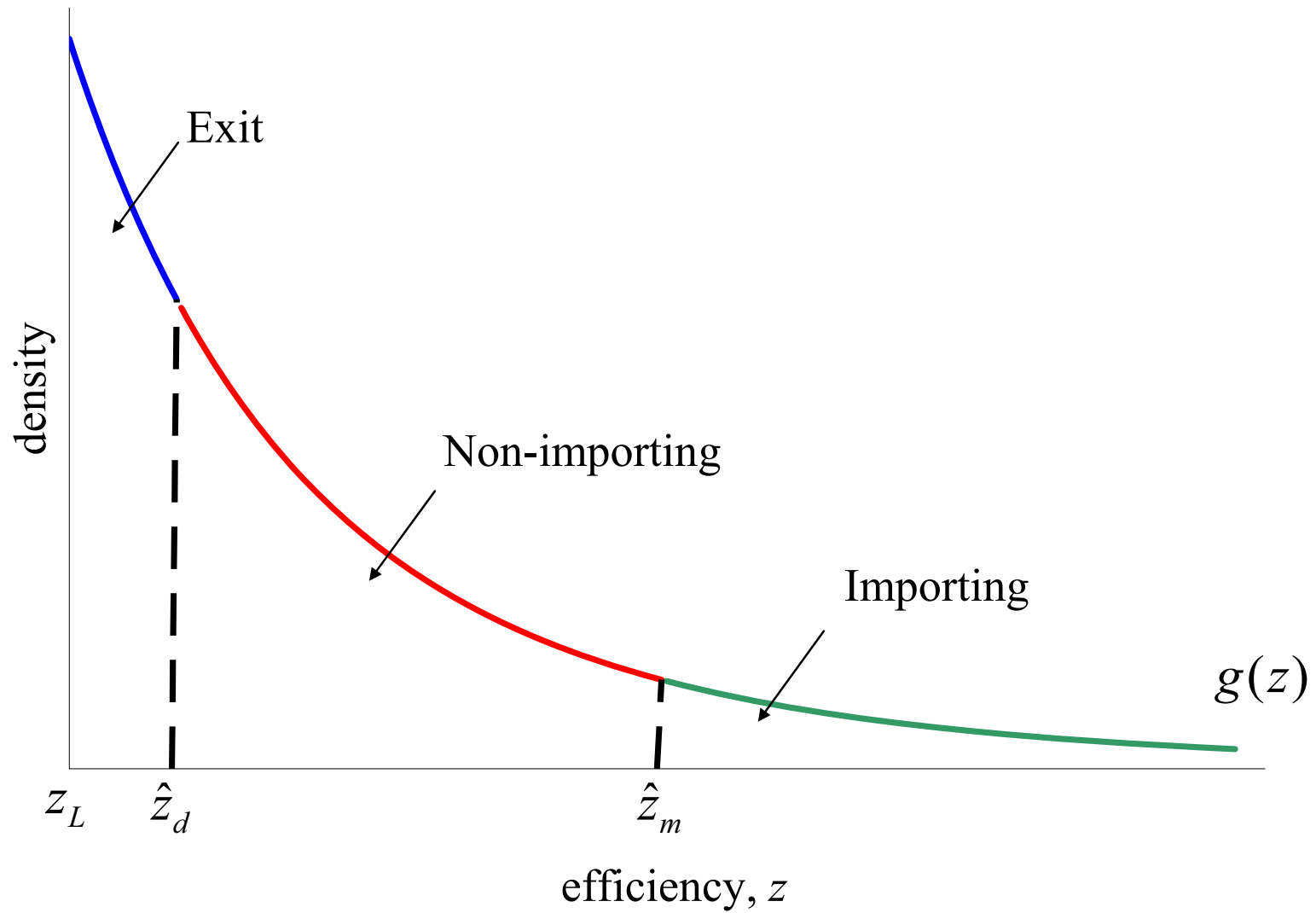
$$V_{mt}(\hat{z}_{mt}) - V_{dt}(\hat{z}_{mt}) = \kappa_m$$

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

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

Labor

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

## Equilibrium Conditions: Free Entry and Asset Market

Expected value of entry is

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

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:  $\int n_{dt}(z)\mu_{dt}(z)dz$

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

Plants make decisions proportional to efficiency  $z$ :

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

So,

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

## Aggregation

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

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

⇓

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

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,  $\frac{m_t(z)}{d_{mt}(z)} = \frac{1-\omega}{\omega}$

## Import / domestic ratio

Aggregate:

$$\begin{aligned}\frac{M_t}{D_{mt} + D_{dt}} &= \frac{\tilde{m}_t Z_{mt}}{\tilde{d}_{mt} Z_{mt} + \tilde{d}_{dt} Z_{dt}} \\ &= \frac{\frac{1-\omega}{\omega} \tilde{d}_{mt} Z_{mt}}{\tilde{d}_{mt} Z_{mt} + \tilde{d}_{dt} Z_{dt}}\end{aligned}$$

Increasing in:

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

$\frac{Z_{mt}}{Z_{dt}}$  : 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*,

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

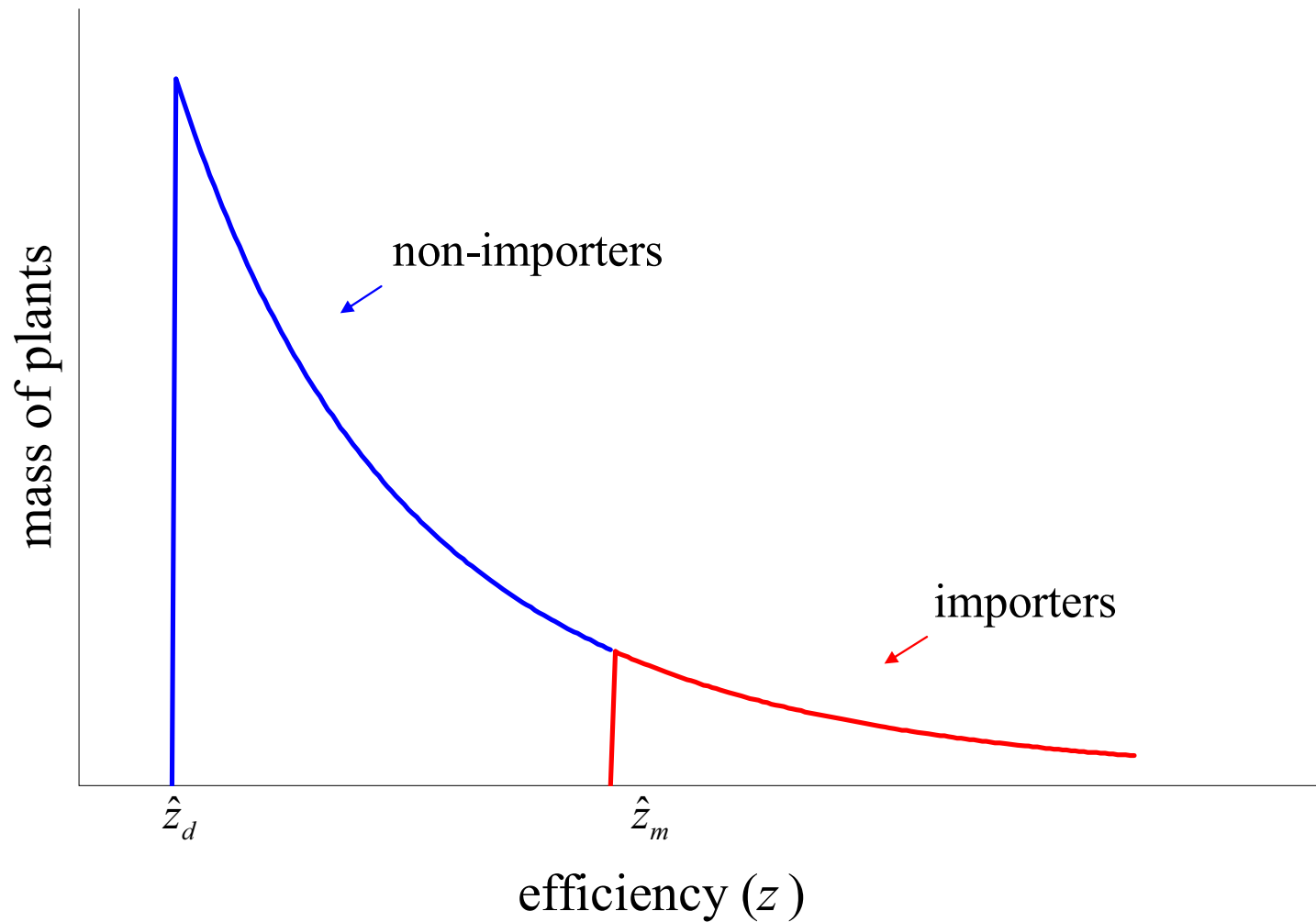
Decreasing in  $(1 + \tau)p_t$

Importing less profitable; fewer new plants choose importing.

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

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

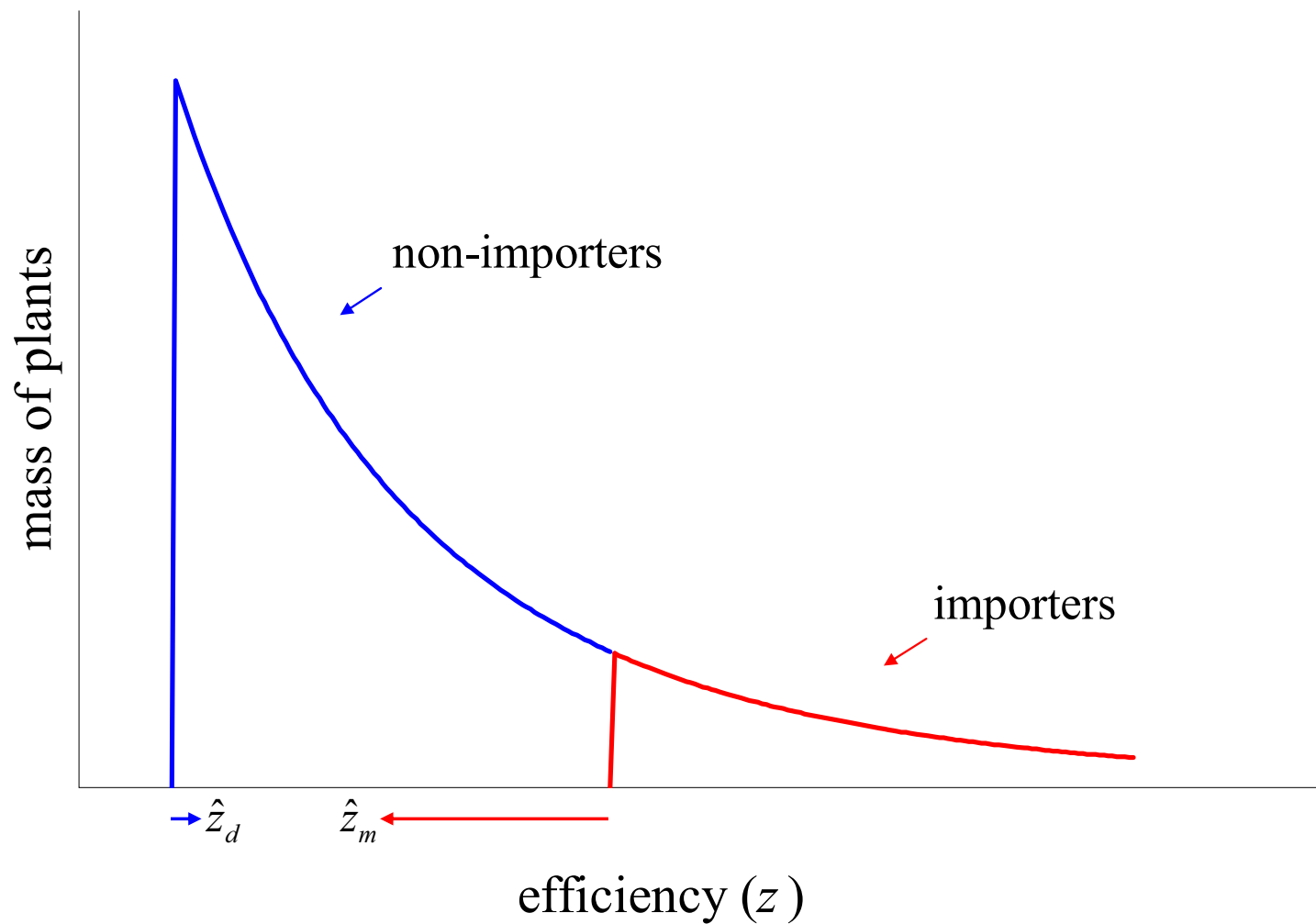
Distribution of Plants,  $t$





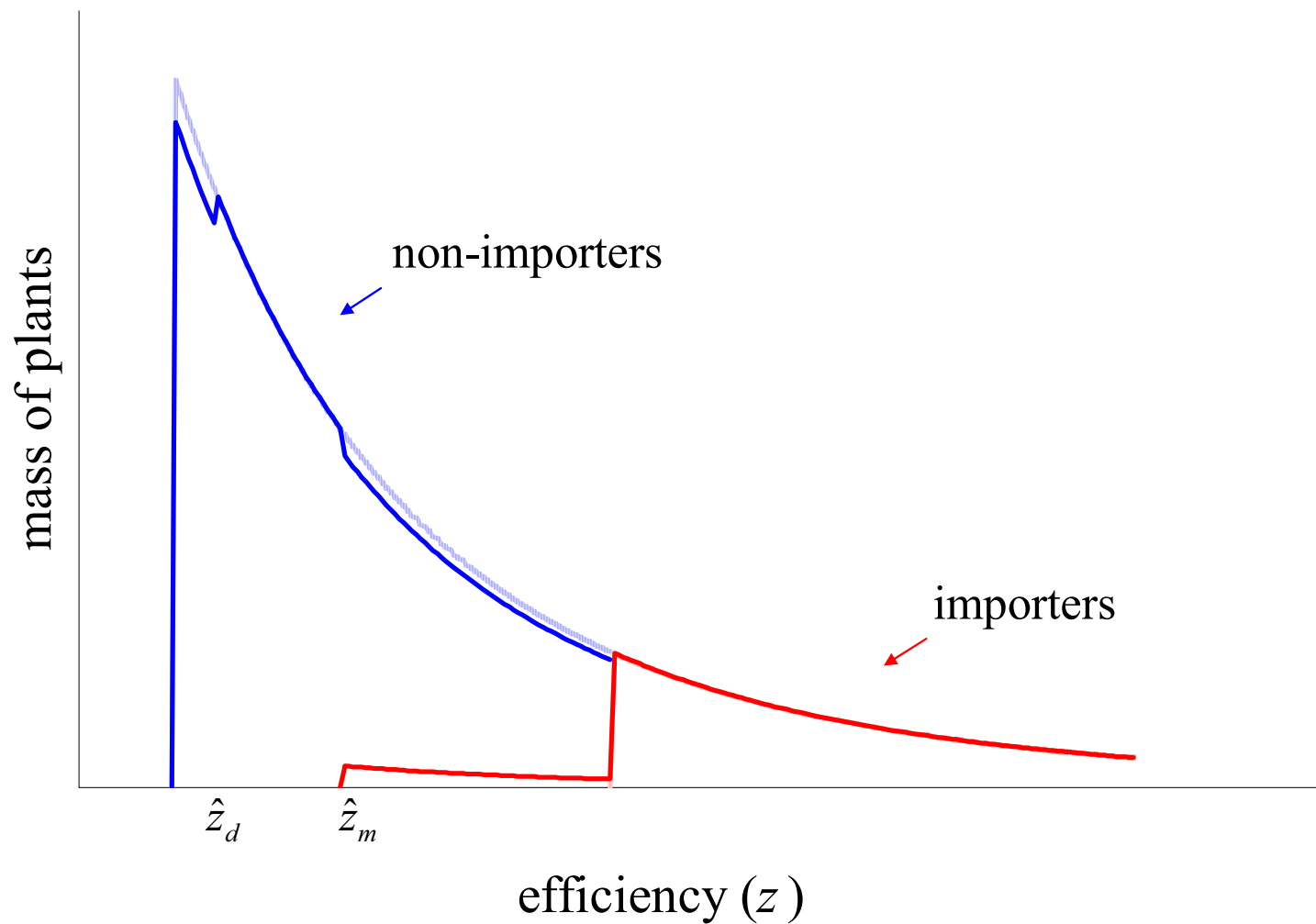
# Dynamic effect of decrease in $(1 + \tau)p_t$

Distribution of Plants,  $t$



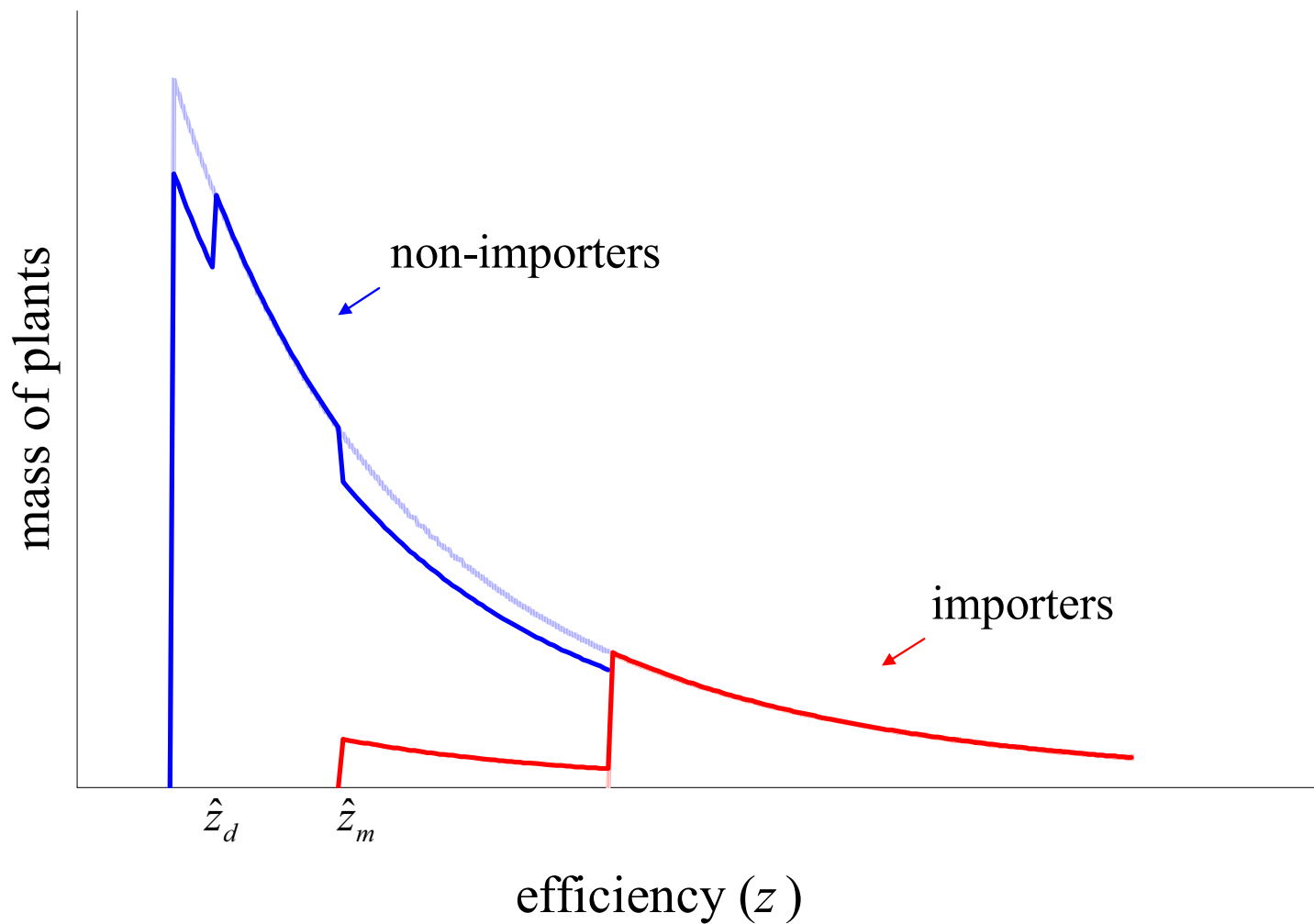
# Dynamic effect of decrease in $(1 + \tau)p_t$

Distribution of Plants,  $t+1$



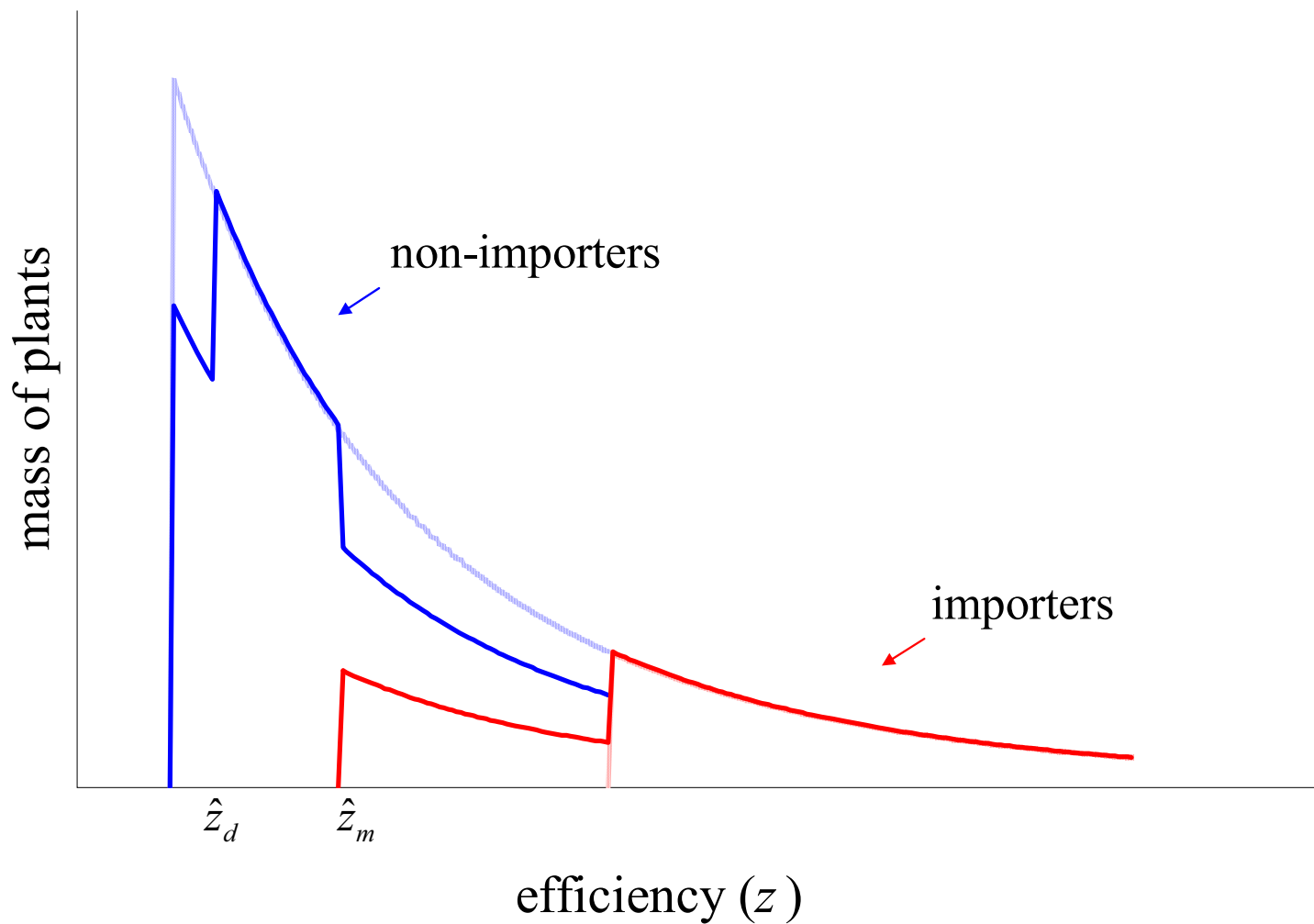
# Dynamic effect of increase in $(1 + \tau)p_t$

Distribution of Plants,  $t+2$



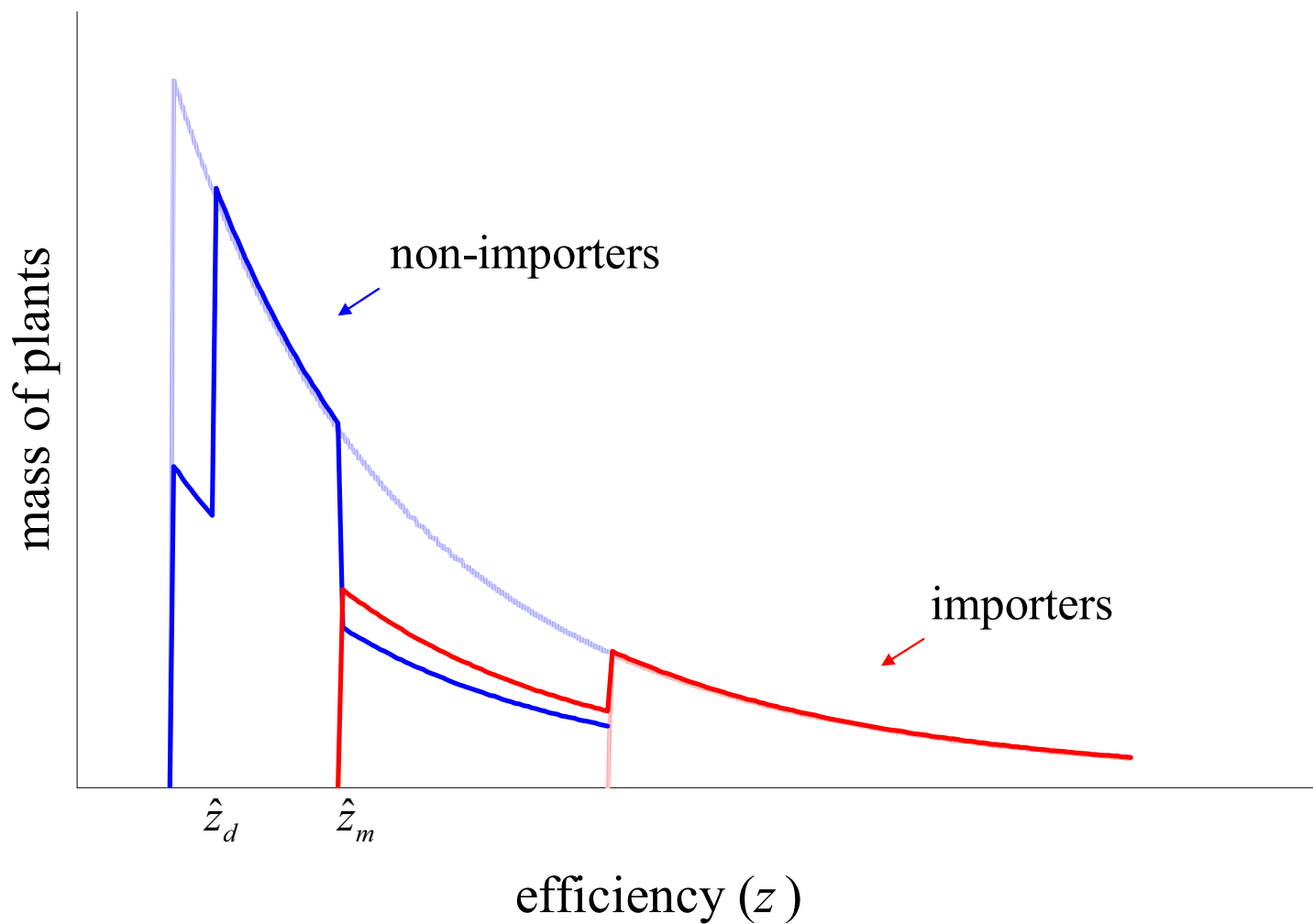
# Dynamic effect of decrease in $(1 + \tau)p_t$

Distribution of Plants,  $t+5$



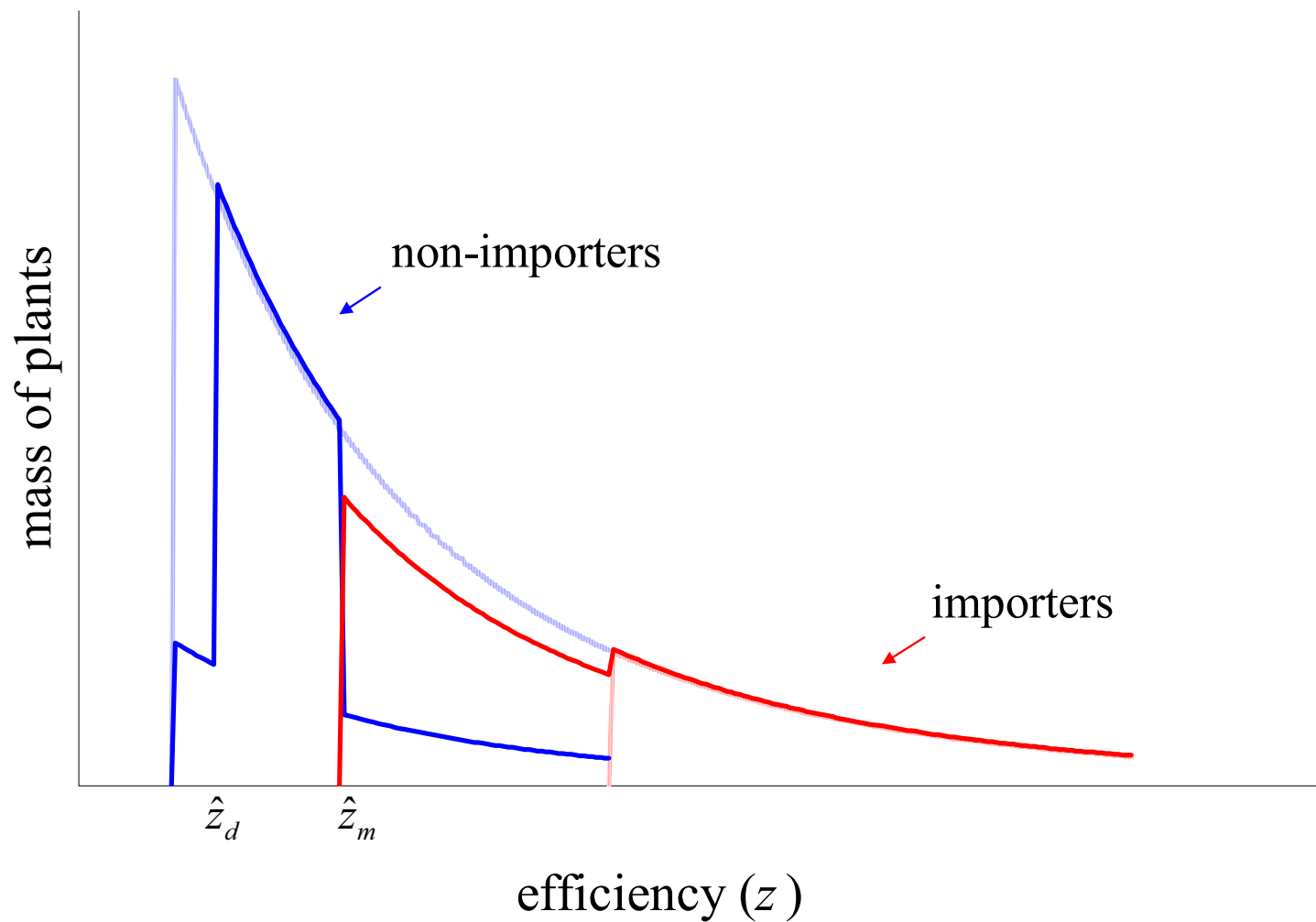
# Dynamic effect of decrease in $(1 + \tau)p_t$

Distribution of Plants,  $t+10$



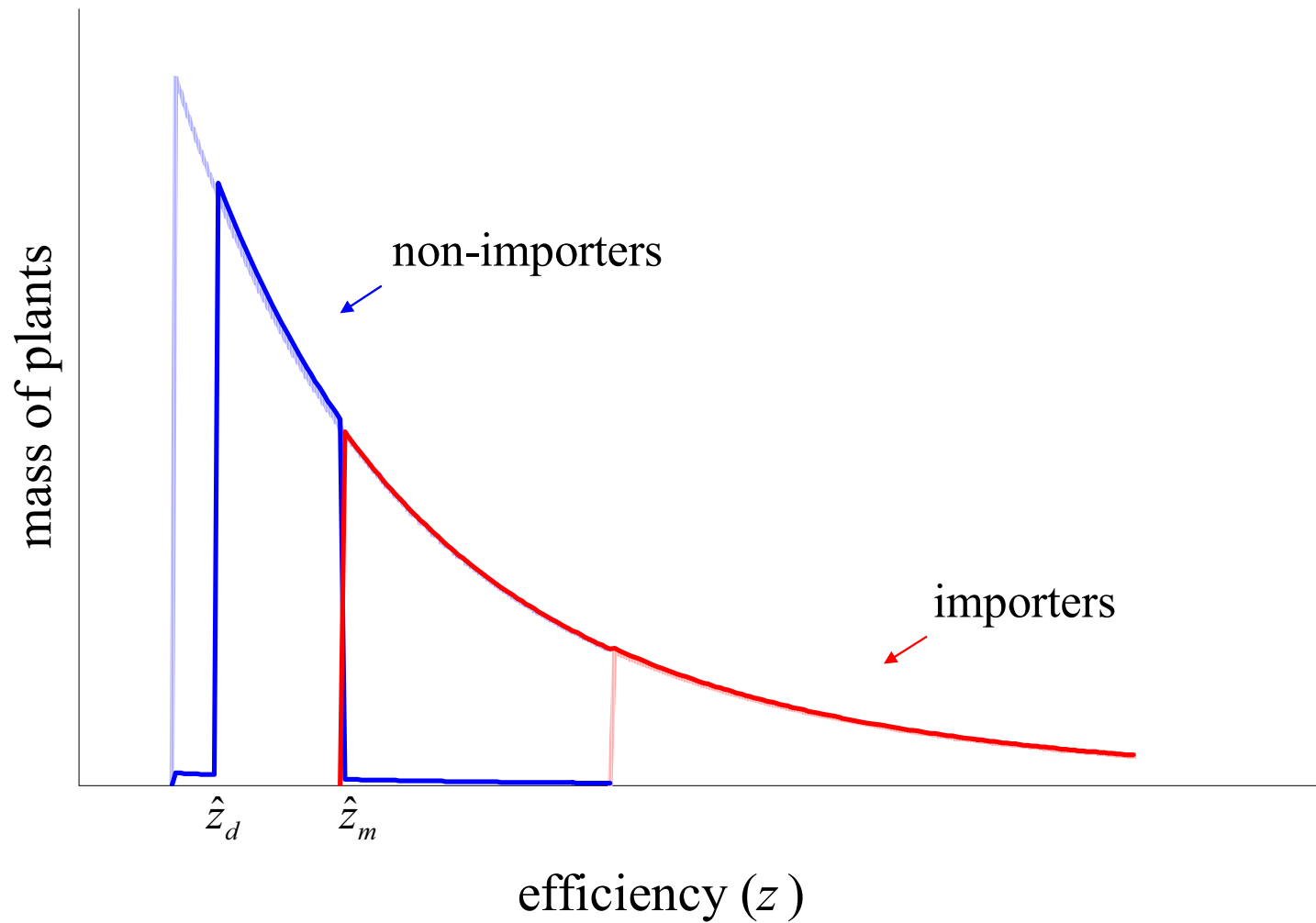
# Dynamic effect of decrease in $(1 + \tau)p_t$

Distribution of Plants,  $t+20$



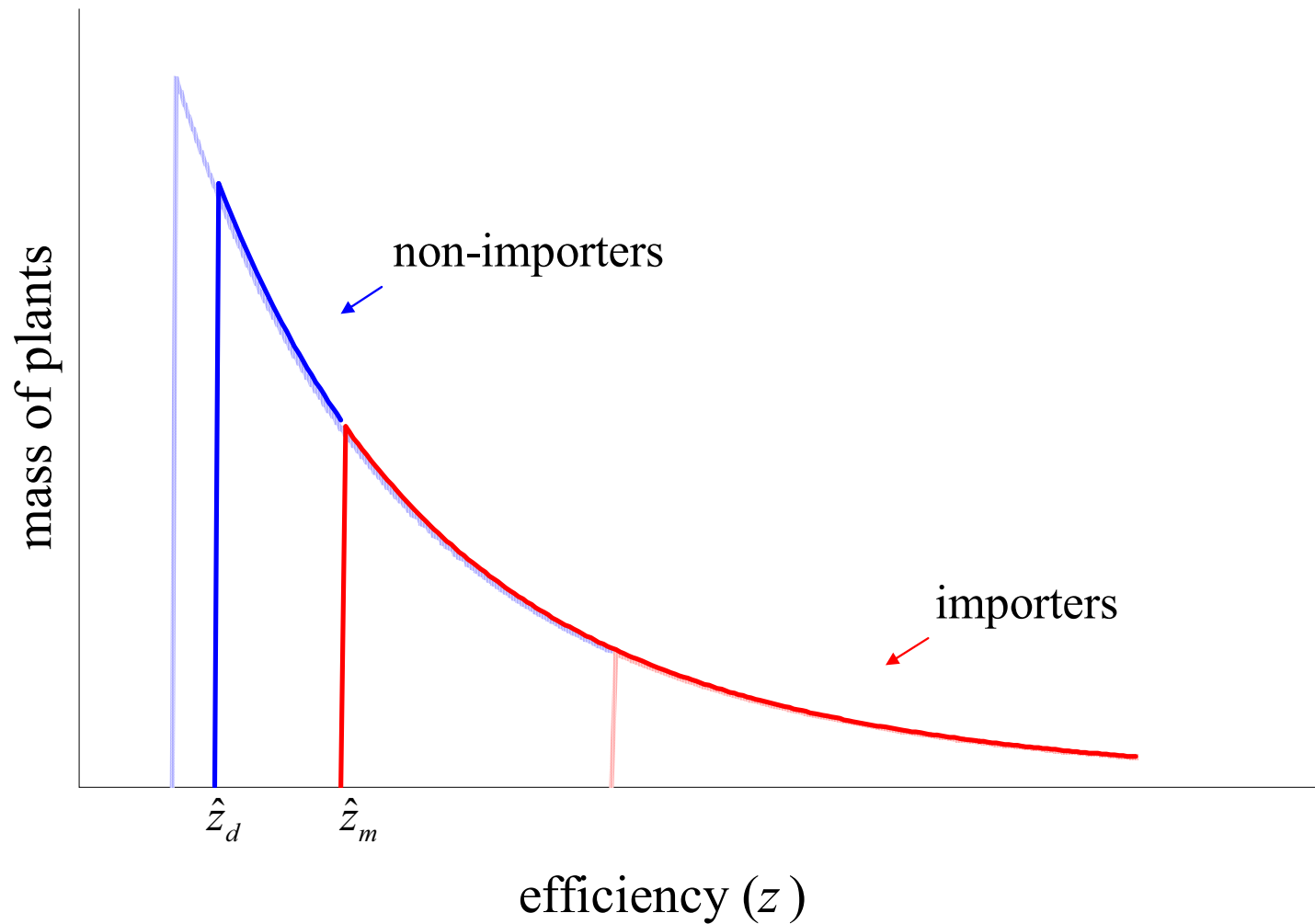
# Dynamic effect of decrease in $(1 + \tau)p_t$

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 ( $\sim 1.3$ )
2. Trade liberalization: gradual change in ratio of plants  
High aggregate elasticity of substitution ( $\sim 7$ )  
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

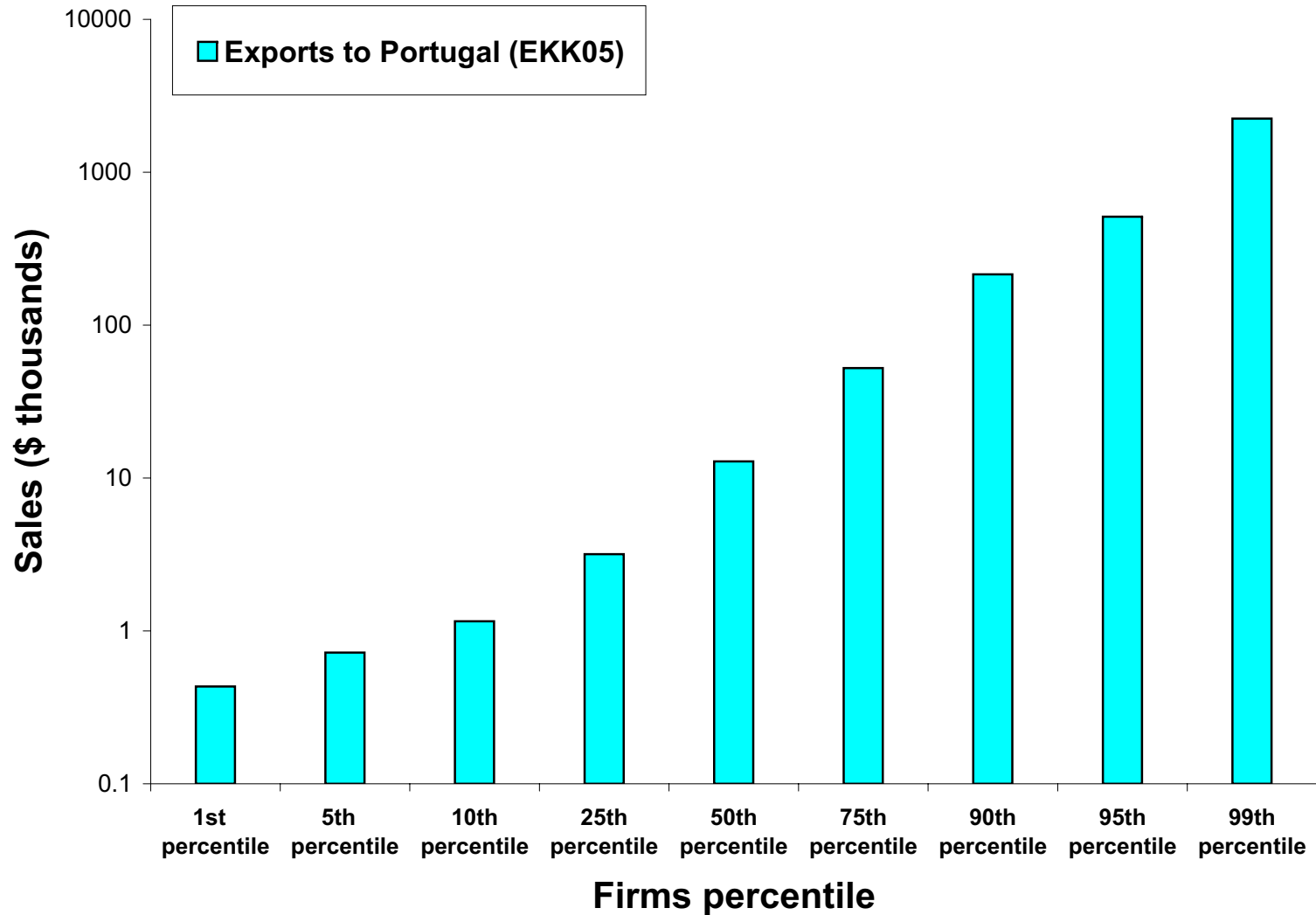
(Eaton Kortum and Kramarz '05)

- 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**

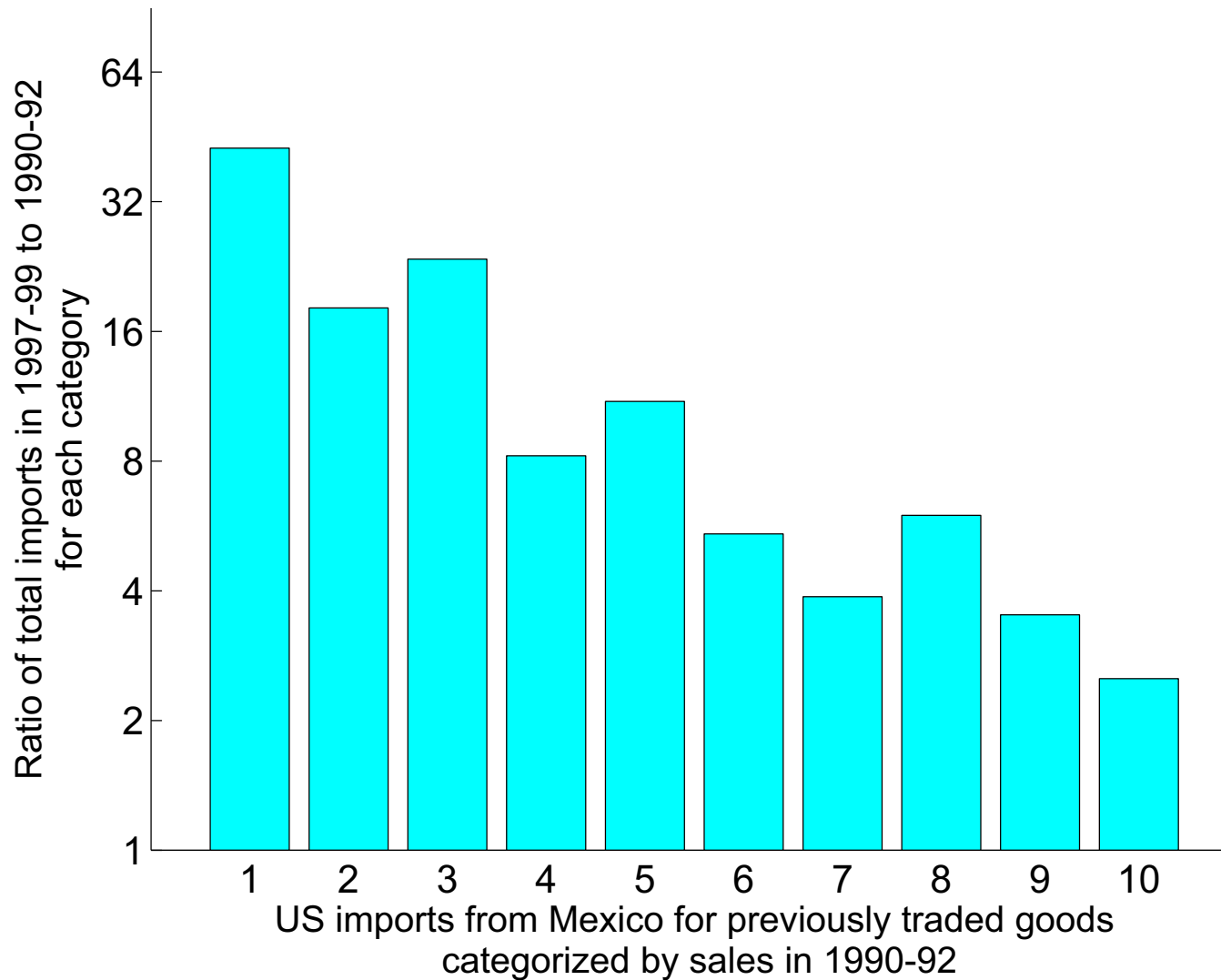
- Most firms do not export **and**
- Large fraction of firms exporting to each country sell tiny amounts there

## **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

	<b>1st ad</b>	<b>2nd ad</b>	<b>3rd ad</b>
fraction reached	50%		
cost per consumer	2		

# A Theory of Marketing: The Basic Idea

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

	<b>1st ad</b>	<b>2nd ad</b>	<b>3rd ad</b>
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

	<b>1st ad</b>	<b>2nd ad</b>	<b>3rd ad</b>
fraction reached	50%	+25%	+12.5%
cost per consumer	2	4	8

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## **Properties of marketing cost per consumer**

- a) Costly to reach first consumer
- b) Increasing marketing cost per consumer to reach additional consumers

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## **Properties of marketing cost per consumer**

- a) Costly to reach first consumer
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*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

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## **Properties of marketing cost per consumer**

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- c) More ads bring fewer new consumers (saturation)

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## **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,  $i, j = 1, \dots, N$
- $L_j$  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  $\phi$  (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 $\phi$ Firm from Country $i$

- $n_{ij}(\phi)$  : probability a type  $\phi$  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  $\phi$ :

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

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

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

# Firm's Problem

Type  $\phi$  firm from country  $i$  solves for each country  $j = 1, \dots, N$

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

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

- Uses production function  $q_{ij} = \phi l_{ij}$  to produce good
- $\tau_{ij}$ : 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,

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

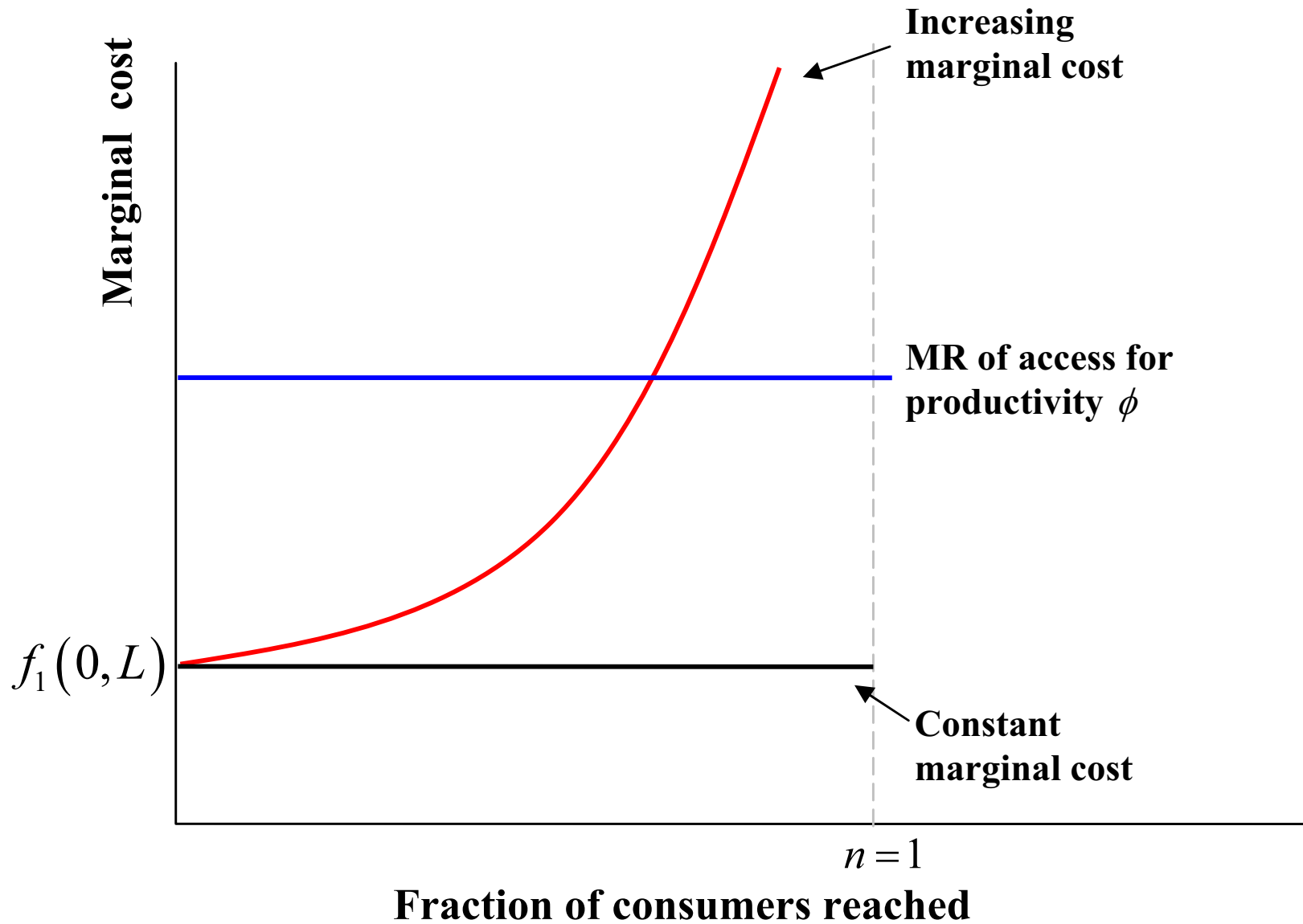
- Given price markup rule firm solves:

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

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

- Look at marginal decision of reaching additional fractions of consumers

# Marginal Revenue & Cost from Reaching Additional Consumers



# The Market Access Cost Function

- Solve the differential equation

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

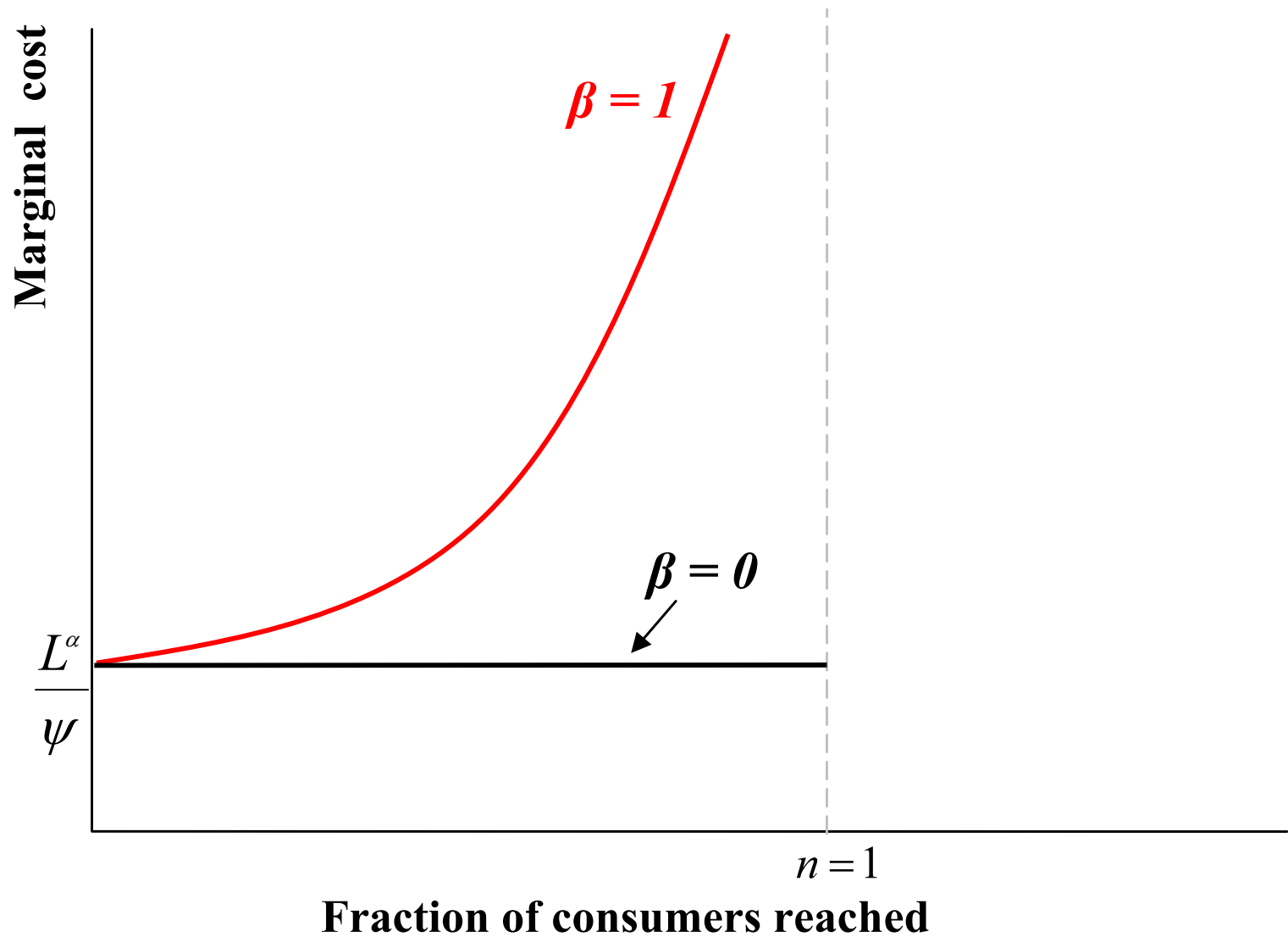
- Obtain Market Access Cost function

- Assuming that  $\frac{1}{\psi}$  is the labor required for each ad

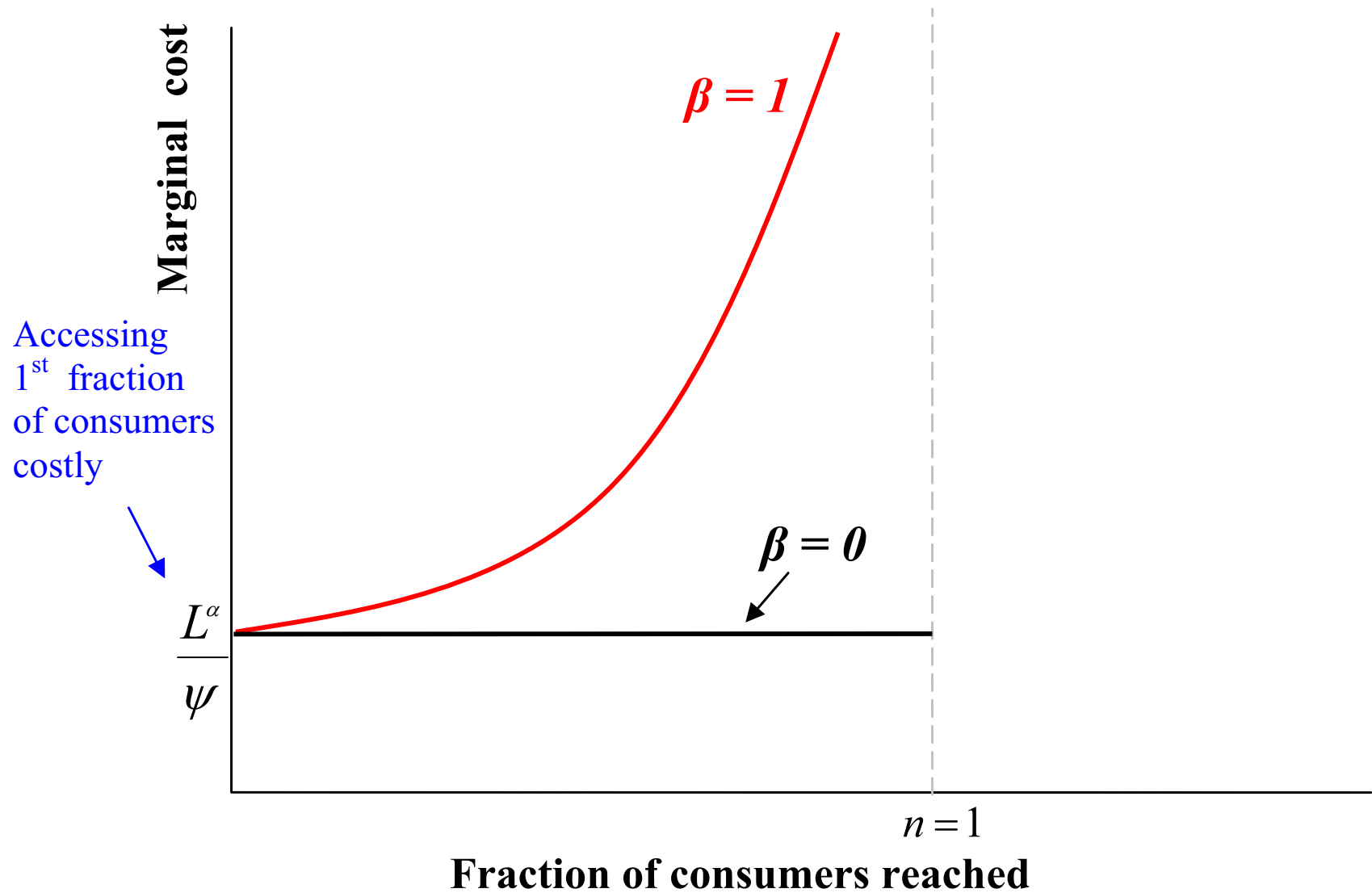
$$f(n, L) = \begin{cases} \frac{L^\alpha}{\psi} \frac{1 - (1-n)^{-\beta+1}}{-\beta+1} & \text{if } \beta \in [0, 1) \cup (1, +\infty) \\ -\frac{L^\alpha}{\psi} \log(1-n) & \text{if } \beta = 1 \end{cases}$$

where  $\alpha \in [0, 1]$

# The properties of the Market Access Cost function

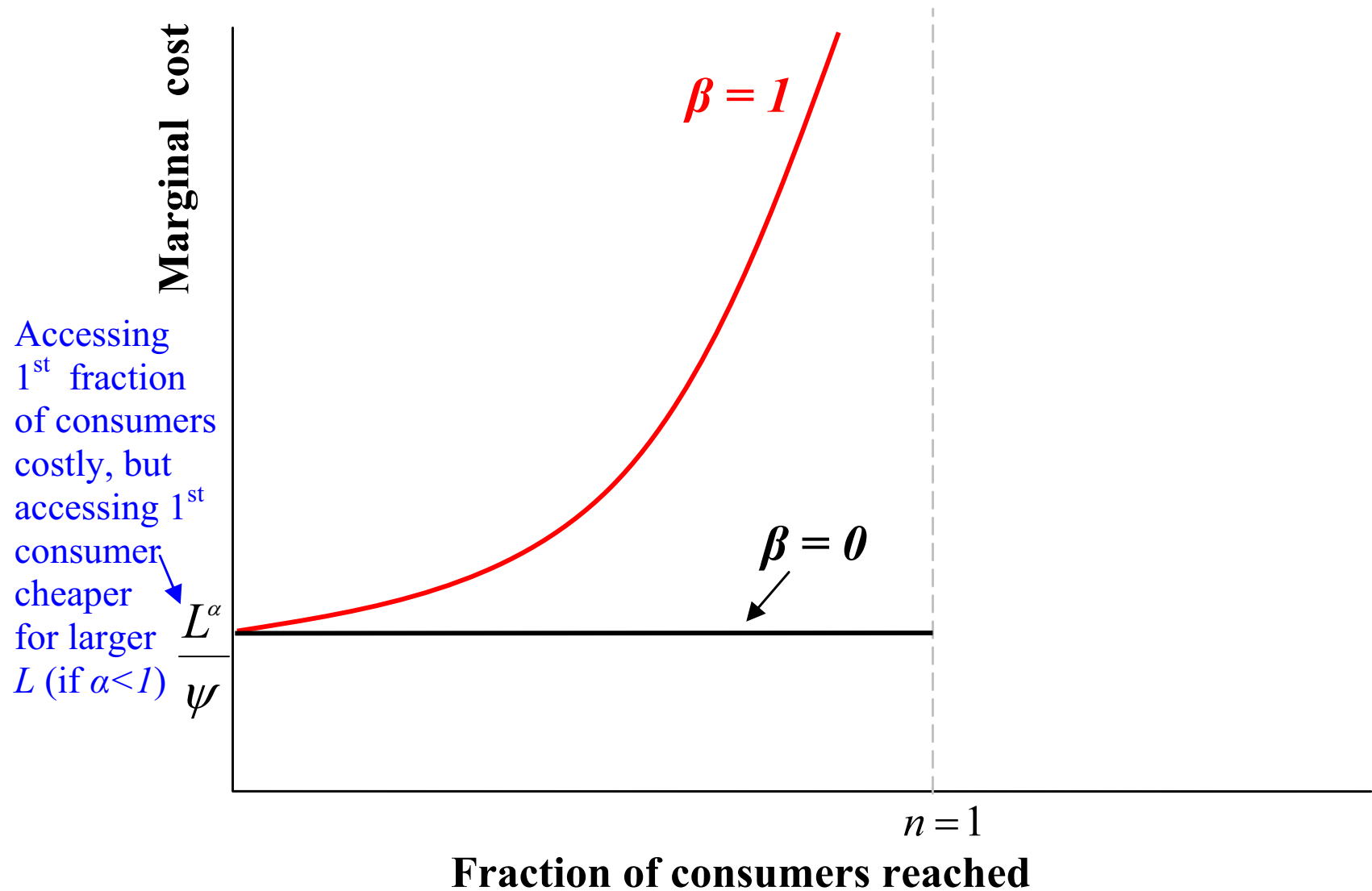


# The properties of the Market Access Cost function

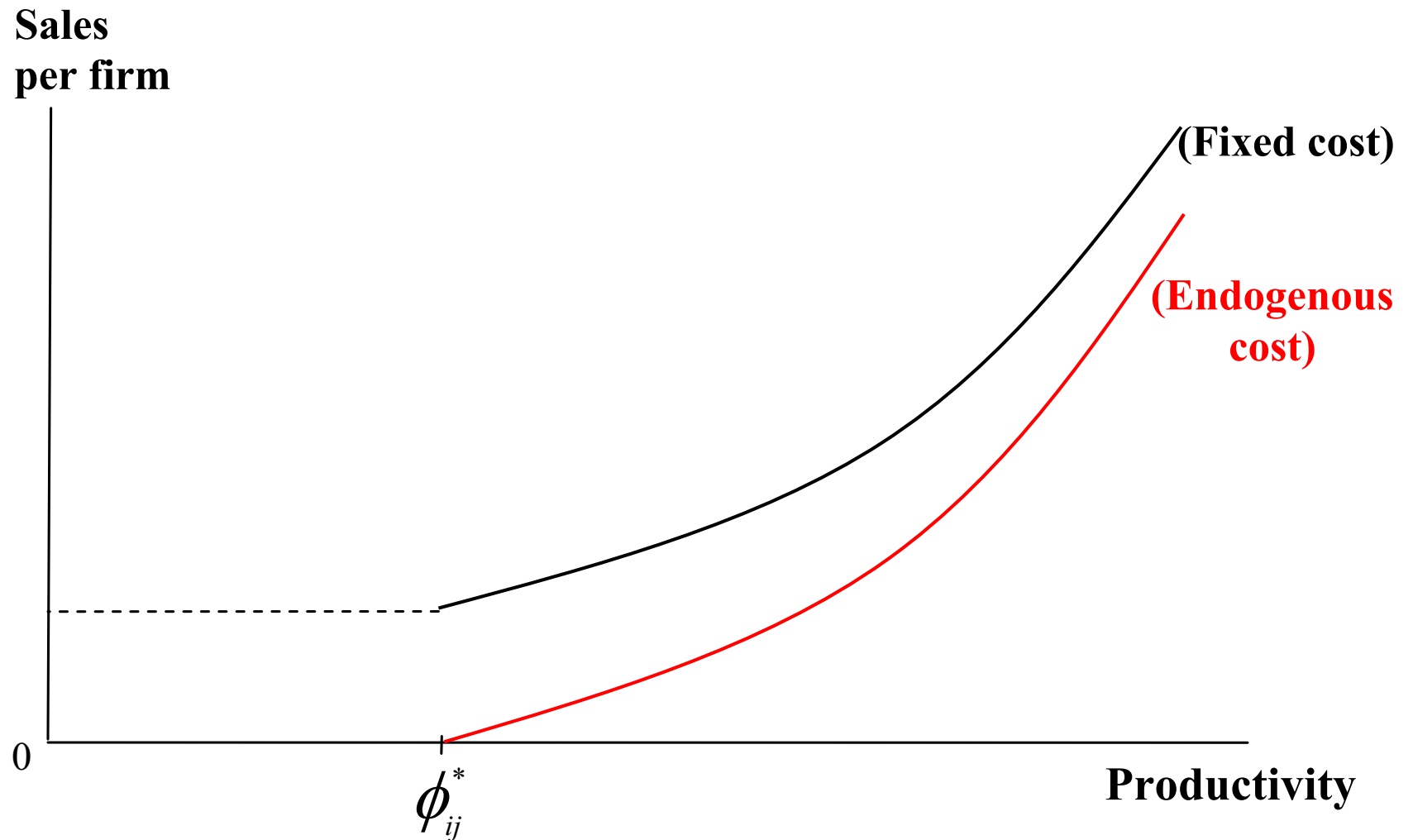




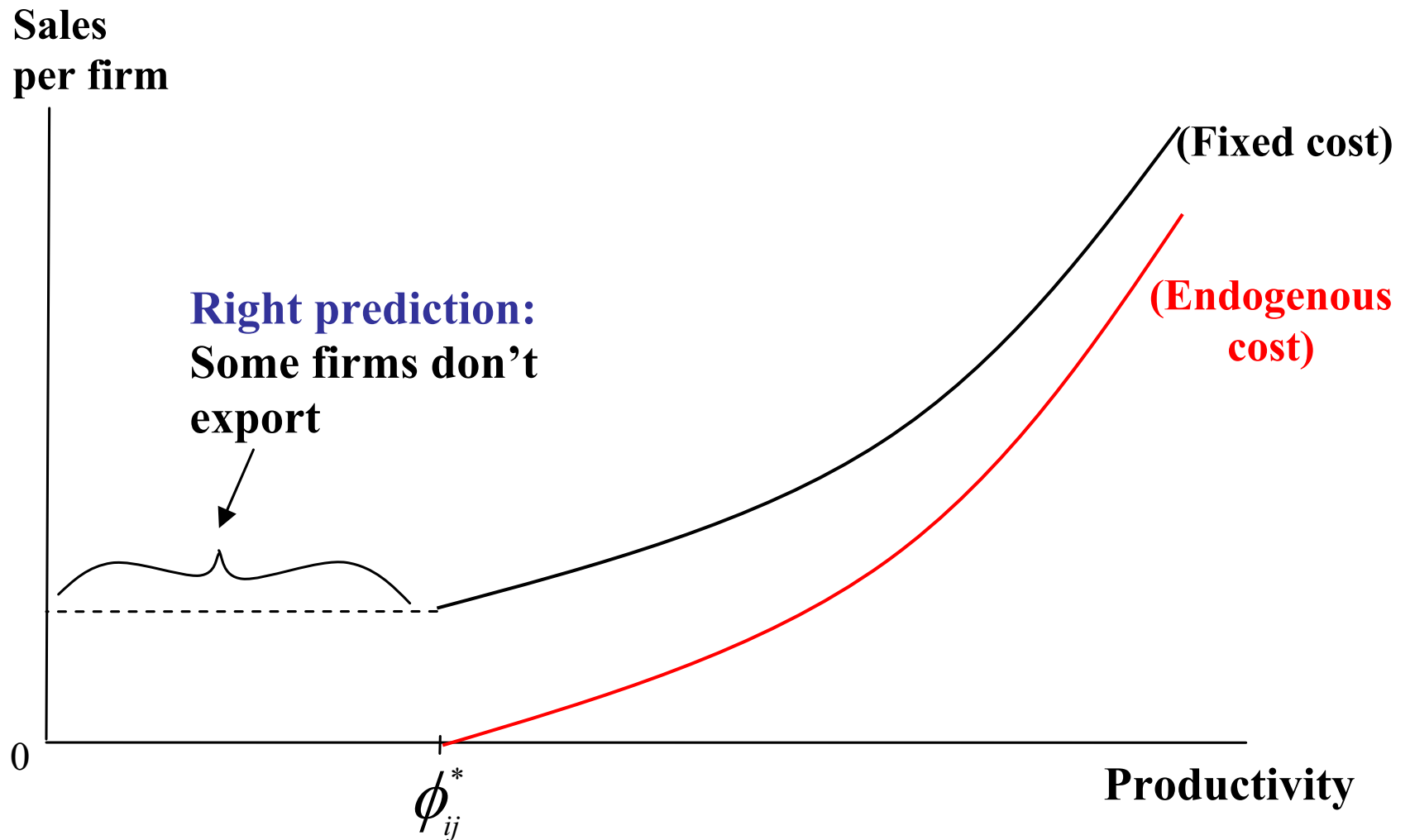
# The properties of the Market Access Cost function



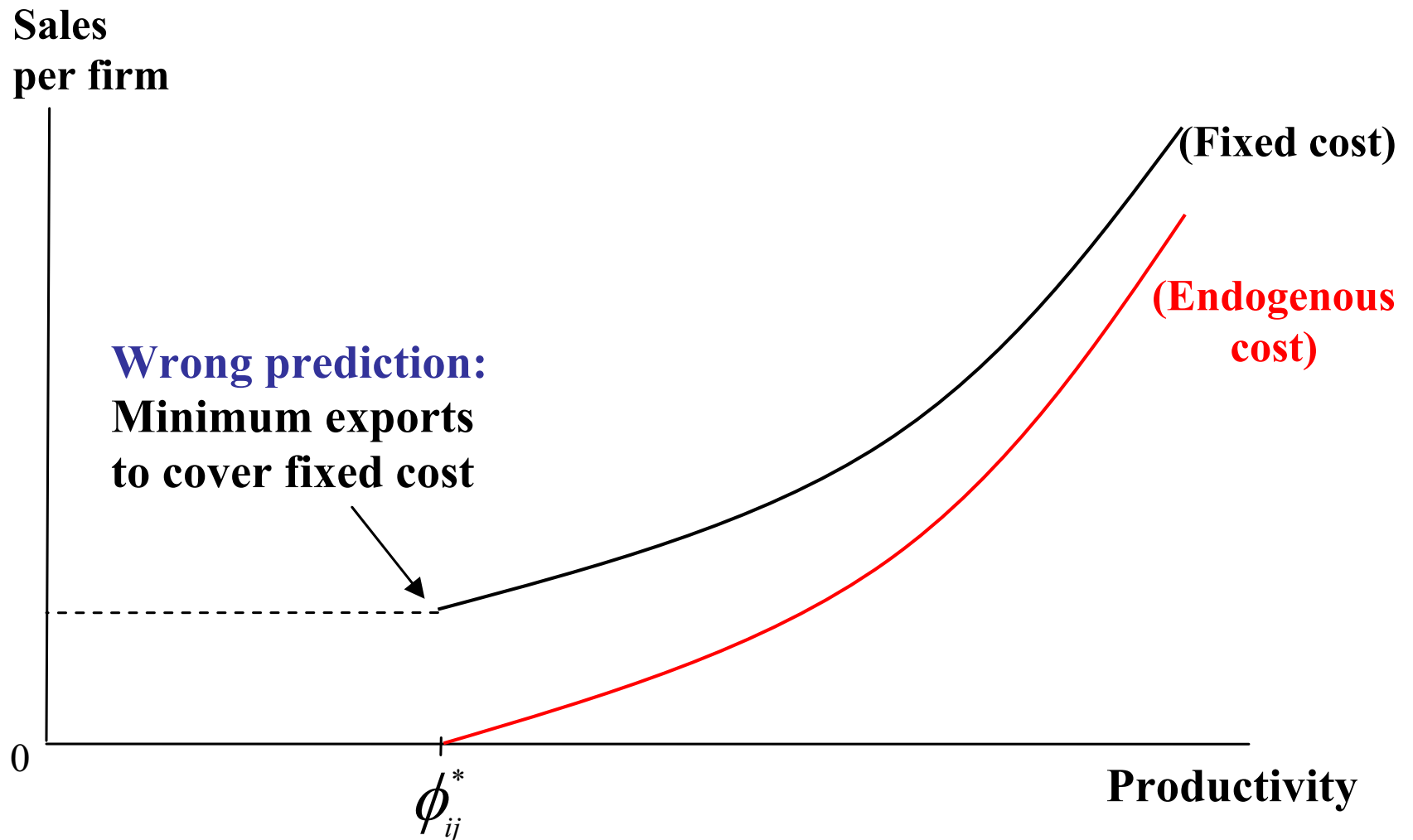
The product of the two margins: total sales per firm



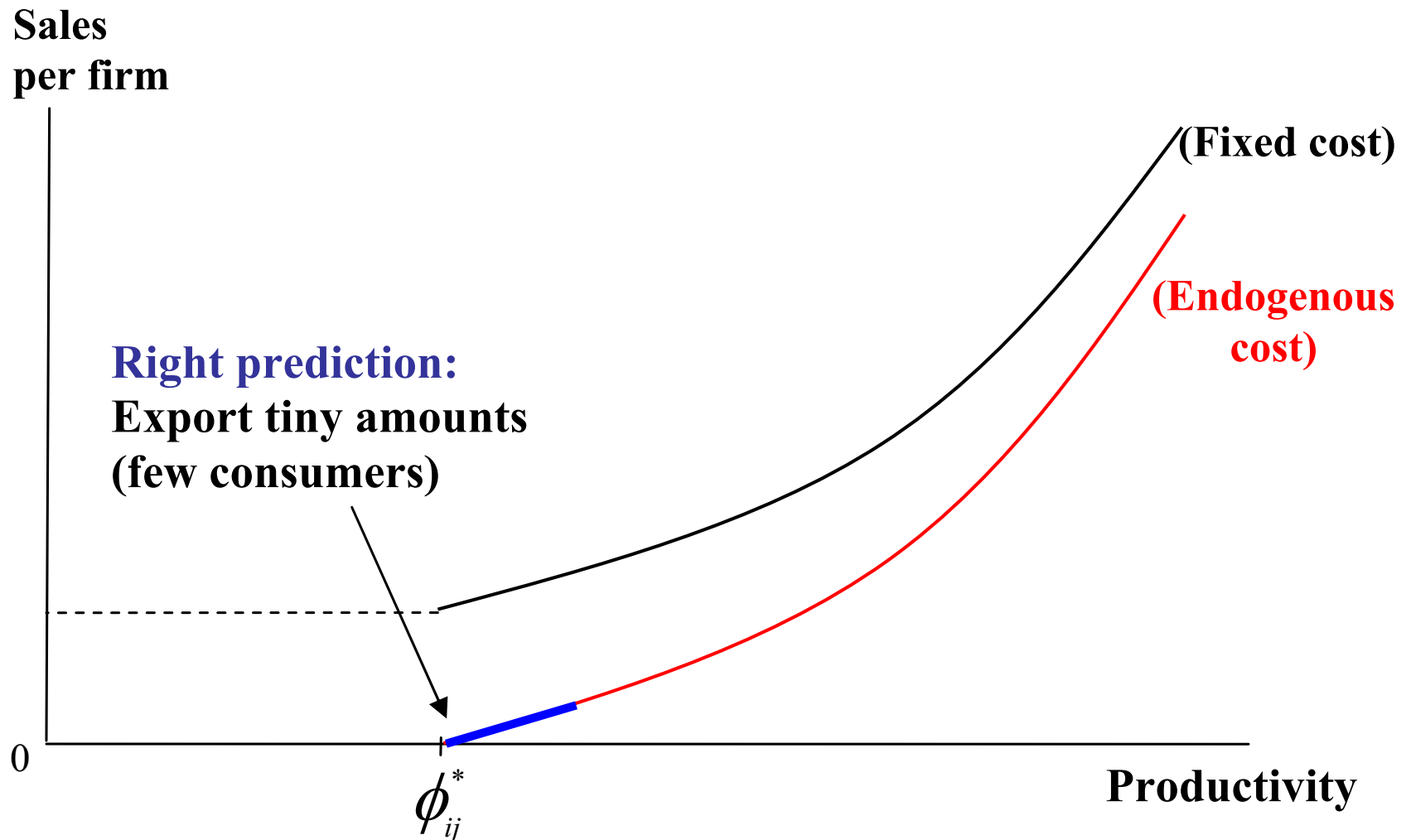
# Models' predictions on which firms export



# Models' predictions on how much firms export



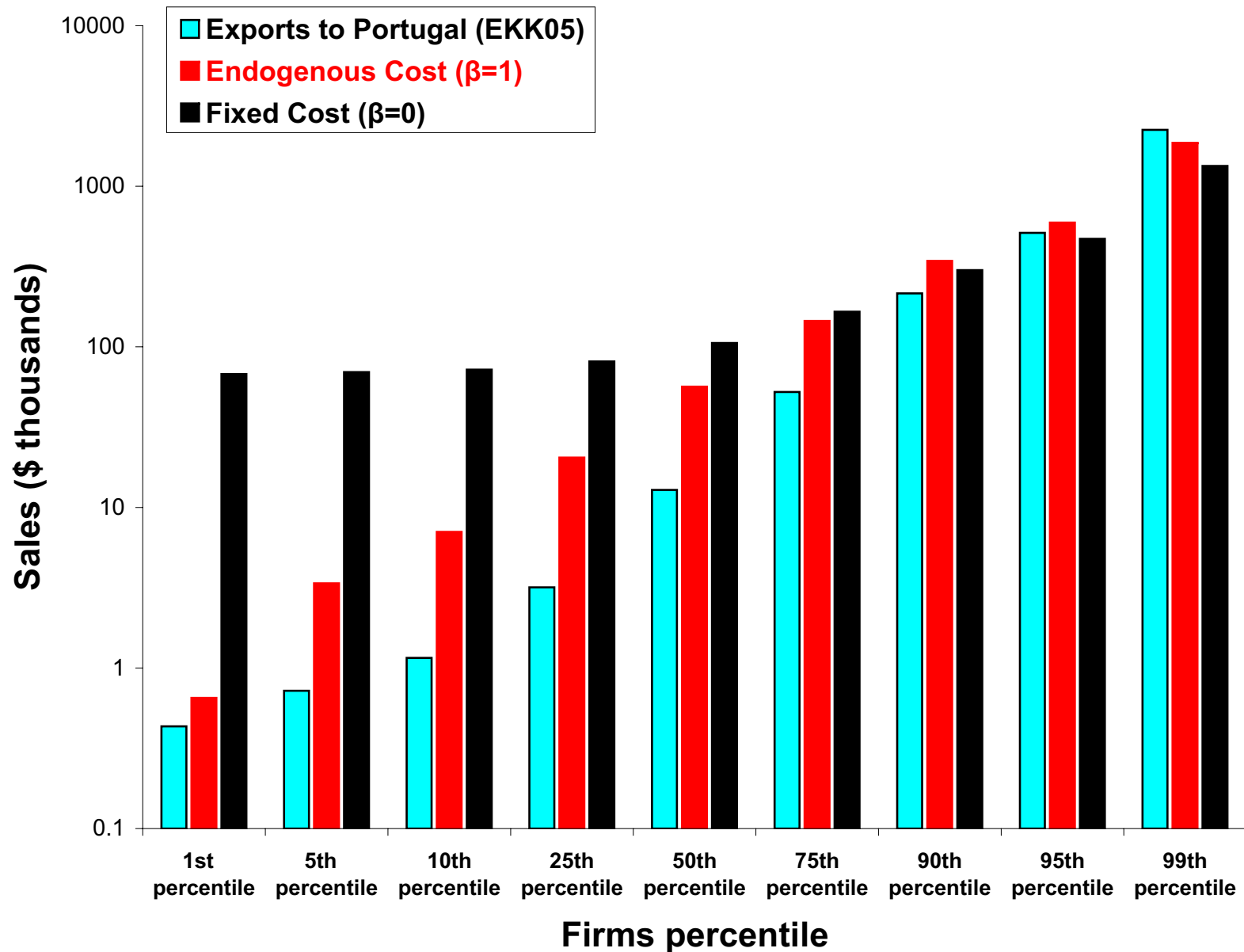
# Models' predictions on how much firms export



# 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

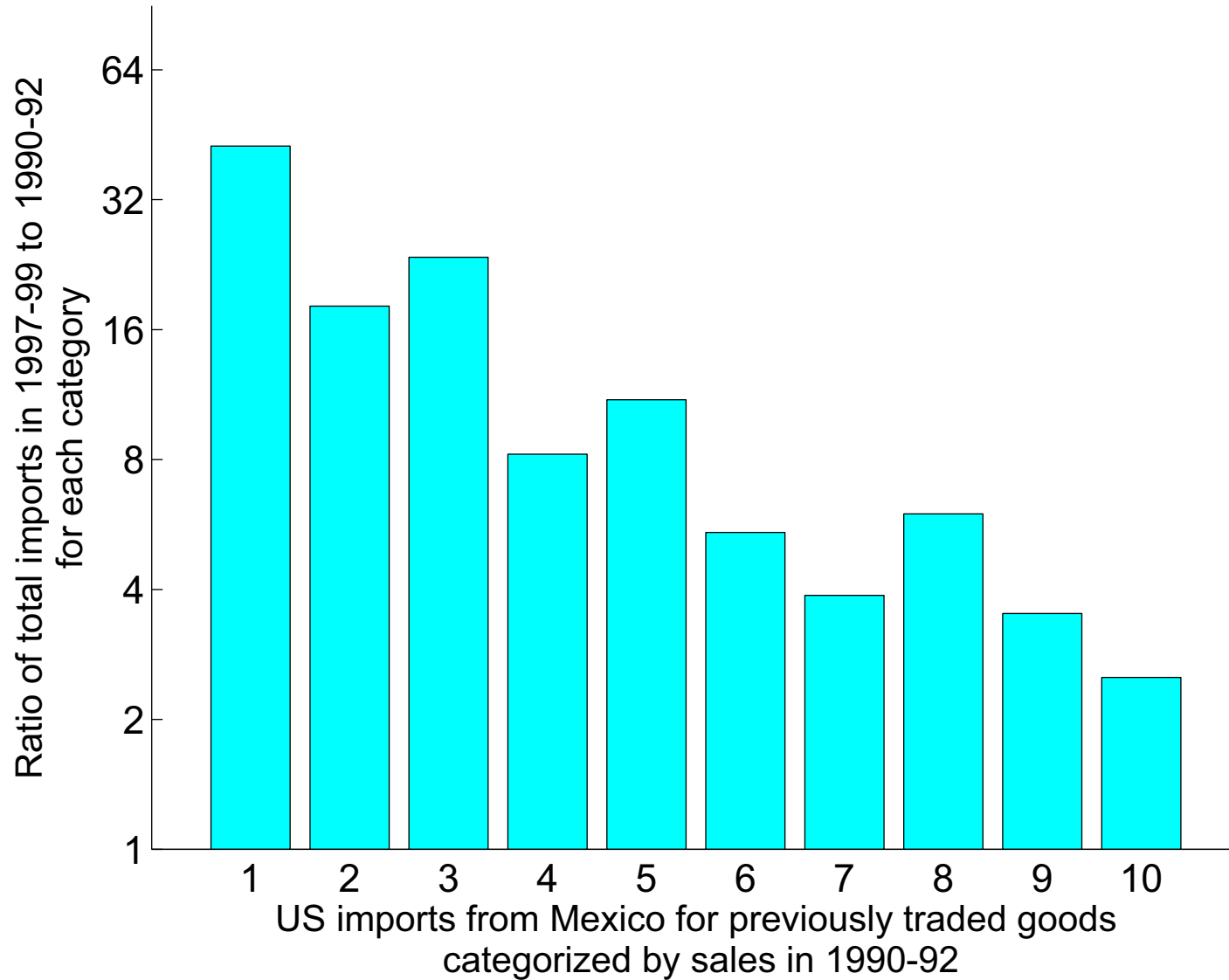


# Observation 2: Trading Decisions After Trade Liberalization

- **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



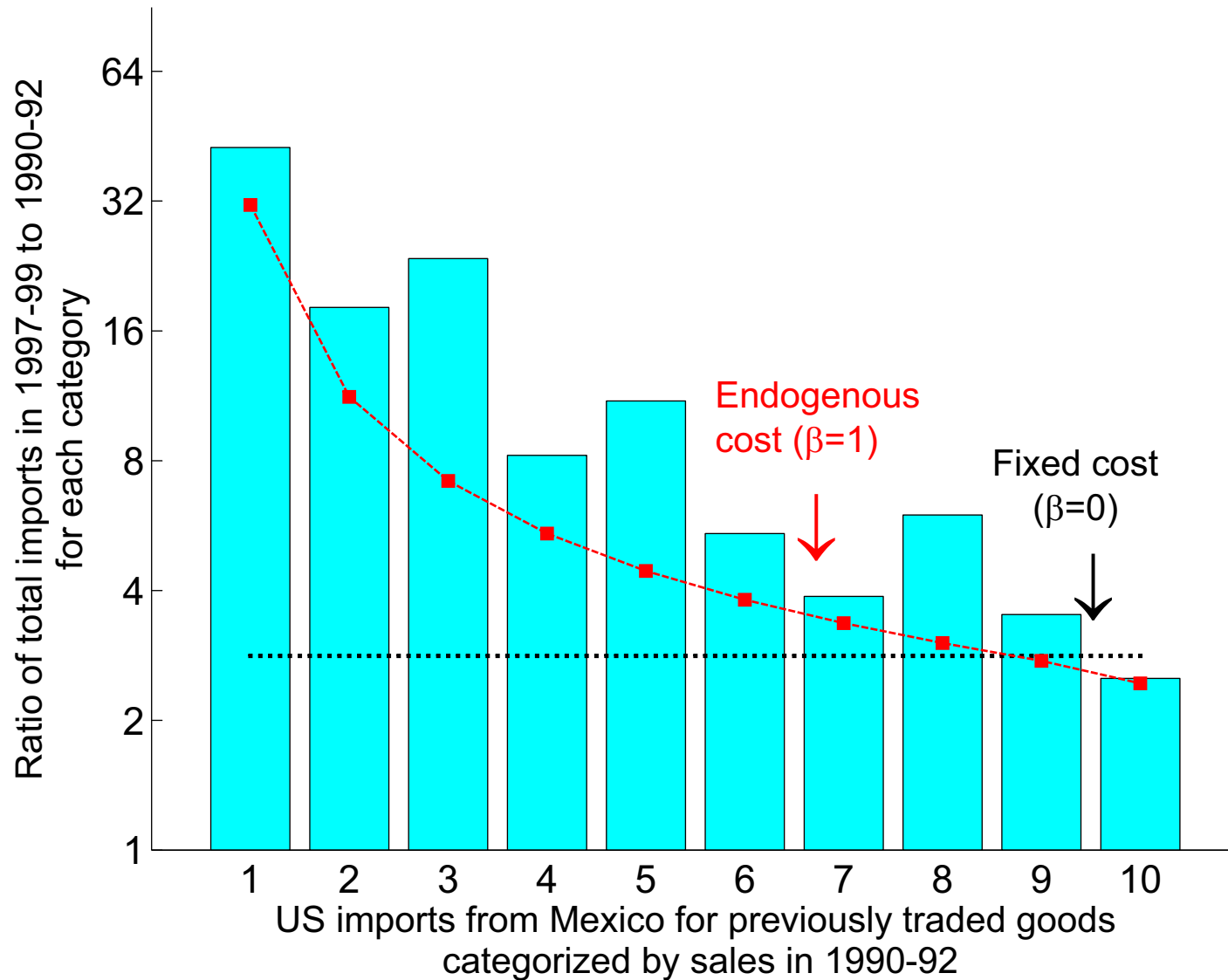
## Large increases in trade for least traded goods



# 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.  $\tau'_{ij} = 0.905\tau_{ij}$ )

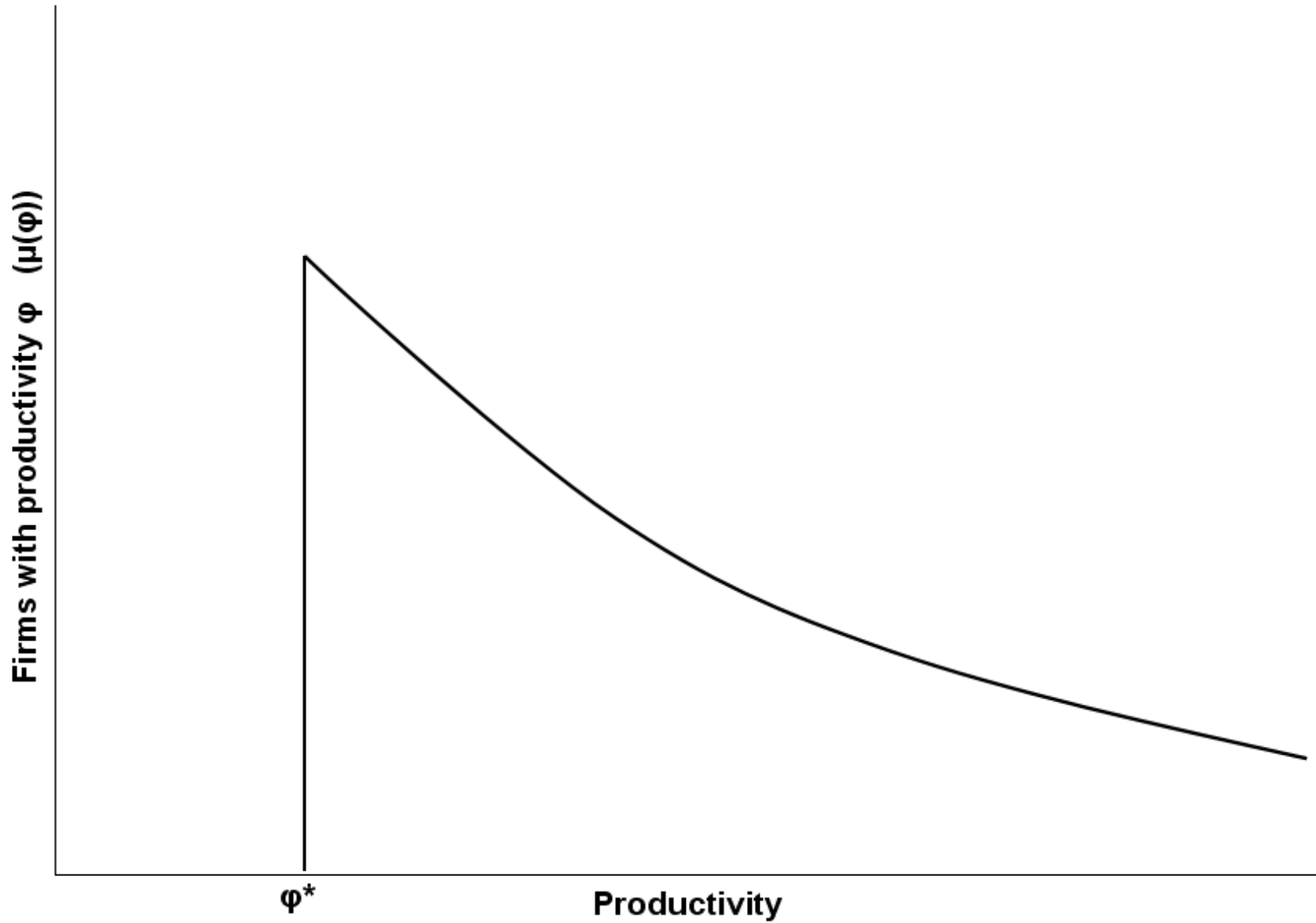
# Calibrated Endogenous Cost model predicts increases in trade for least traded goods



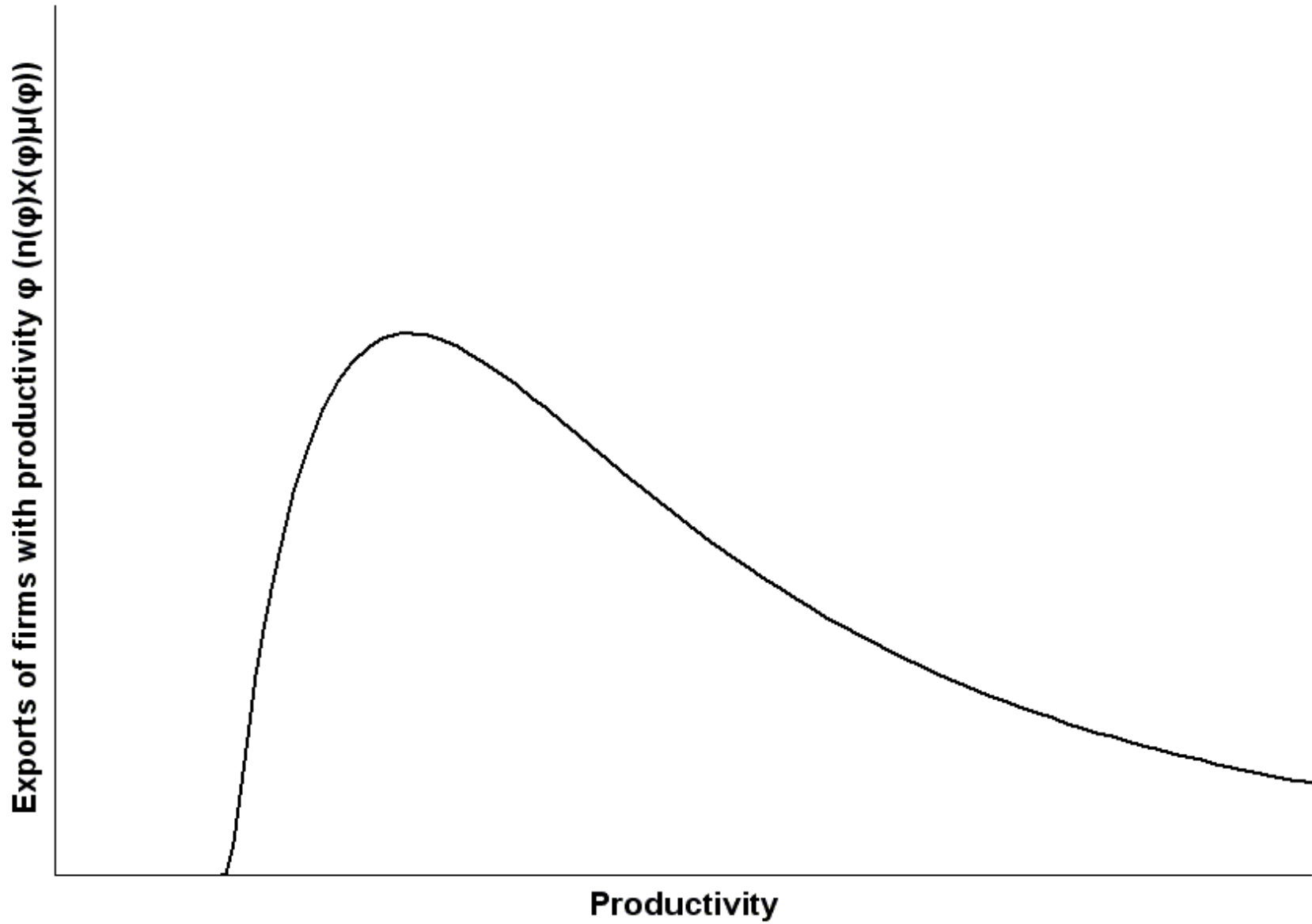
# New Consumers Margin and New Trade

- Recent theory emphasizes increase in trade due to **many** new firms (EK02, Chaney '06 à la Melitz '03)
- **Decompose contribution of the 3 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)

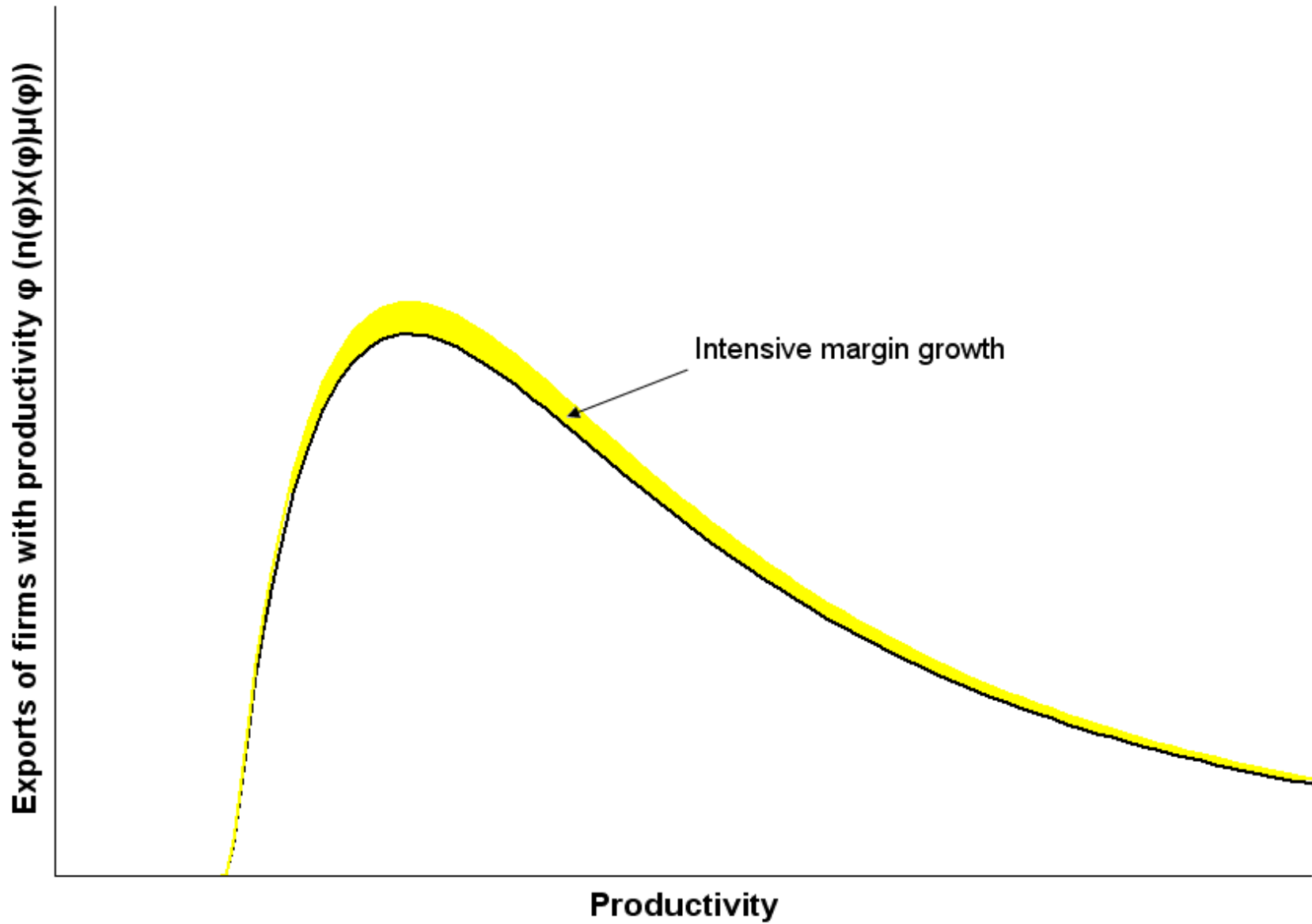
# Pareto Density and Number of Firms with Productivity $\phi$



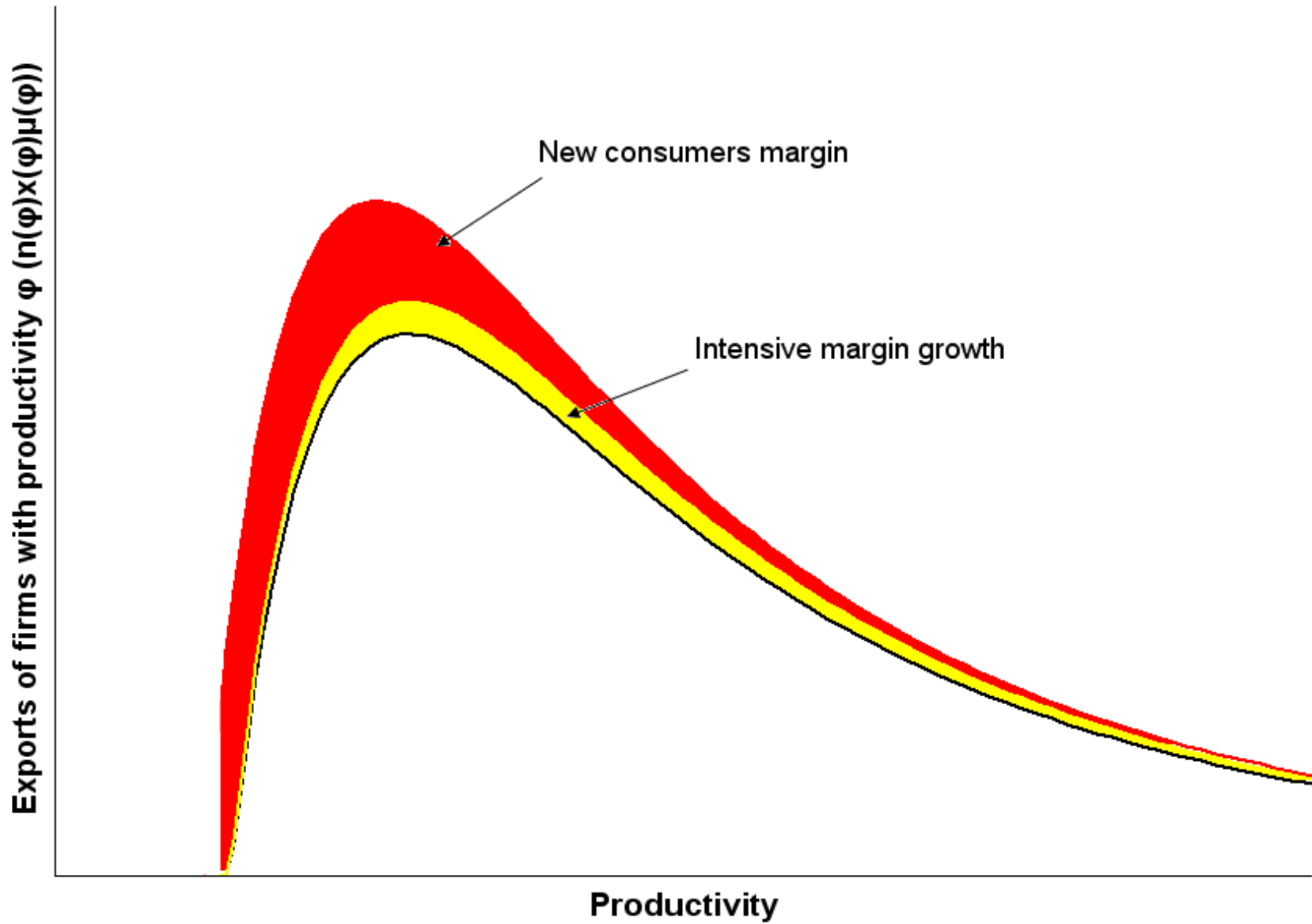
# Density of exports



## New Consumers Margin and new trade

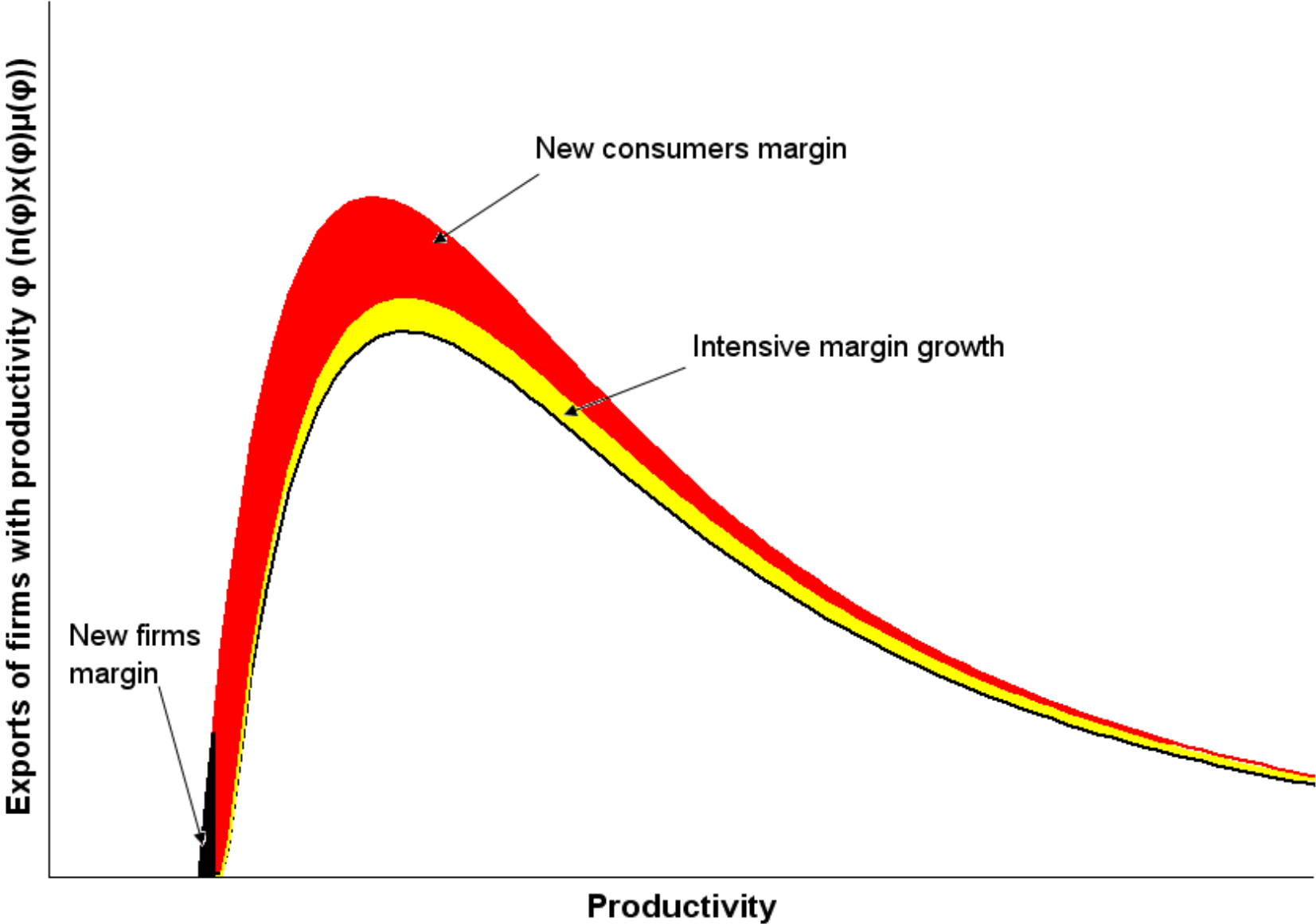


## New Consumers Margin and new trade

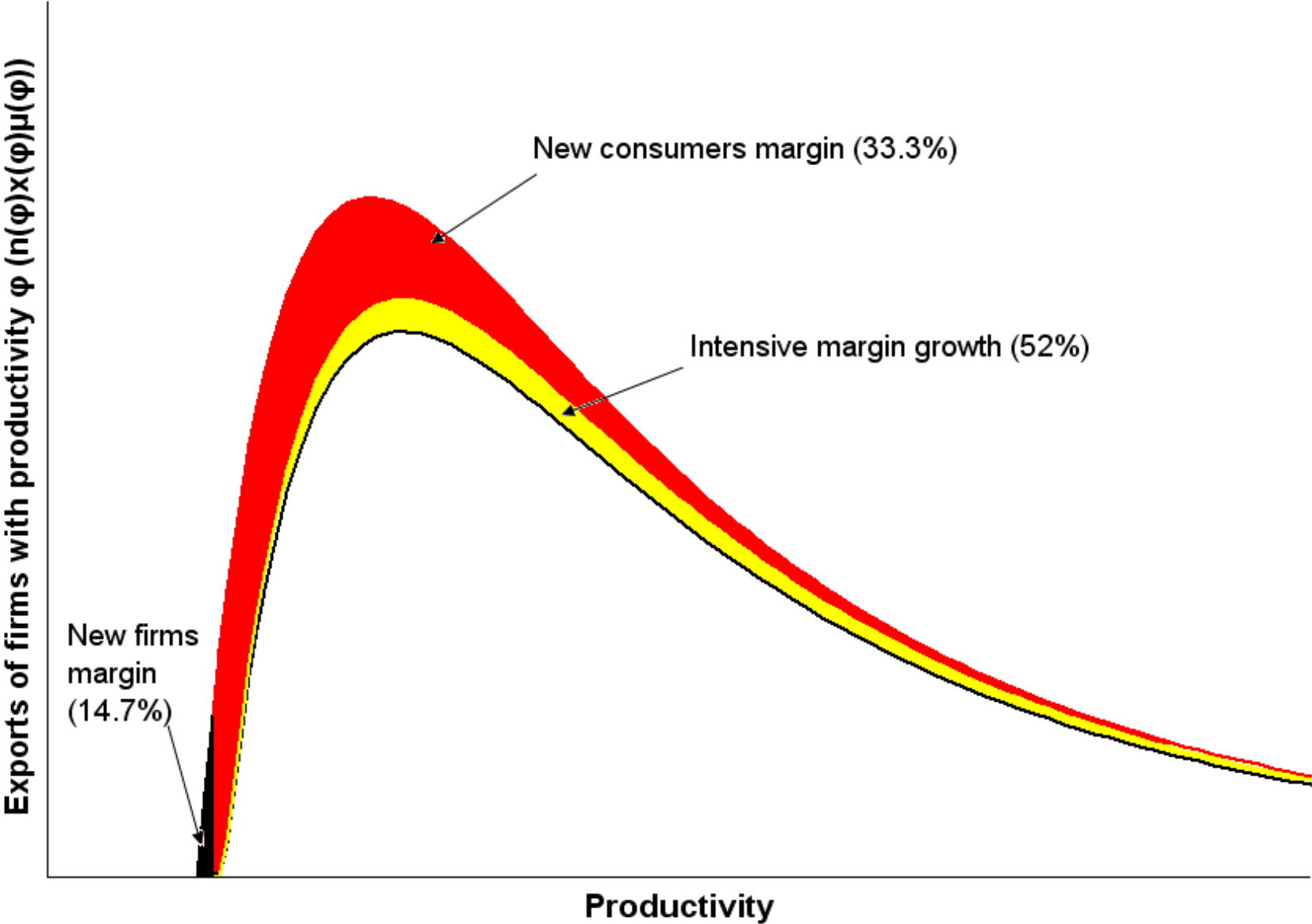




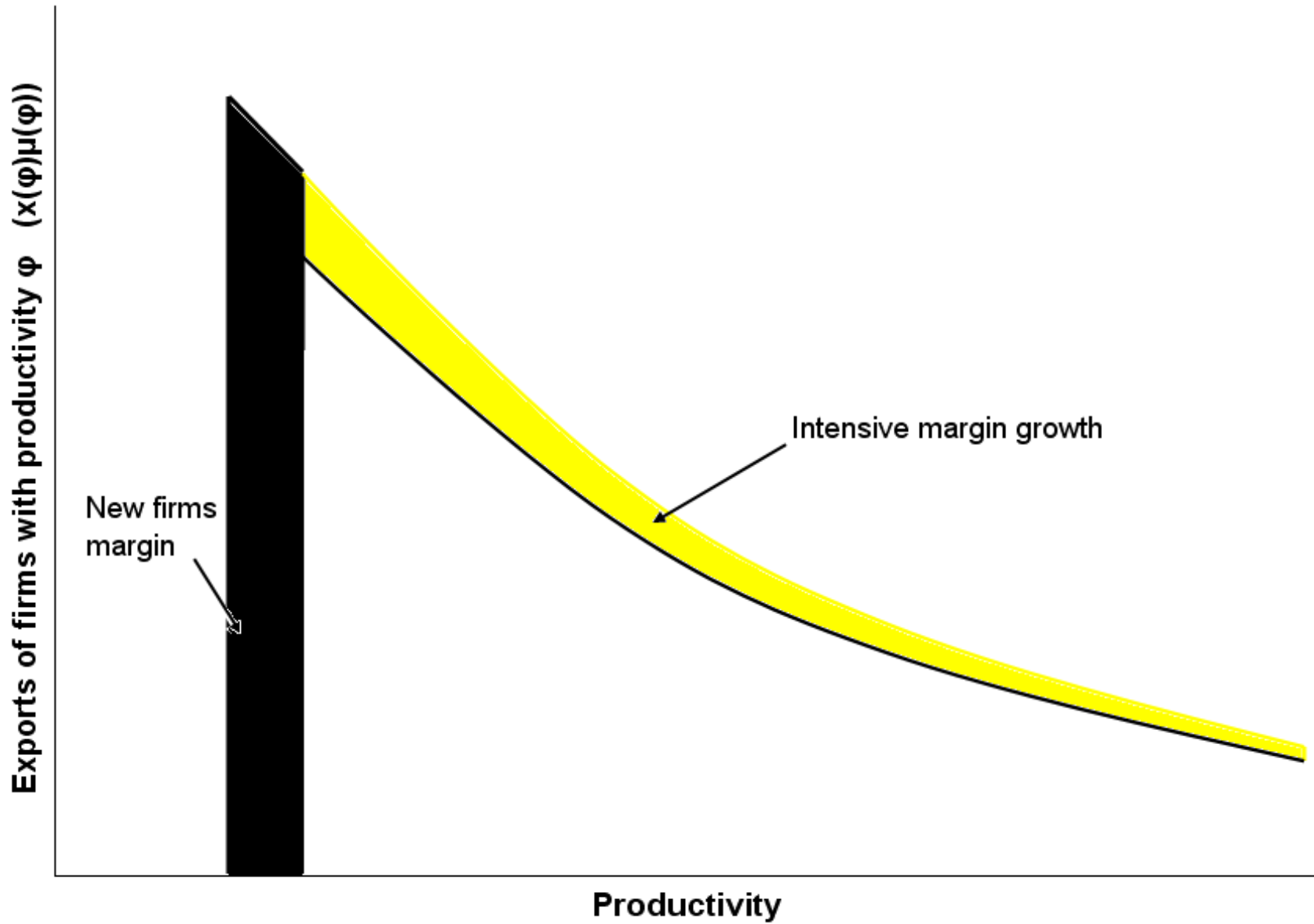
# New Consumers Margin and new trade



# New Consumers Margin and new trade



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



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

