**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

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

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

**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 $\delta$

## 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, $\chi_t^e$

**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 $\tau$

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 |

**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

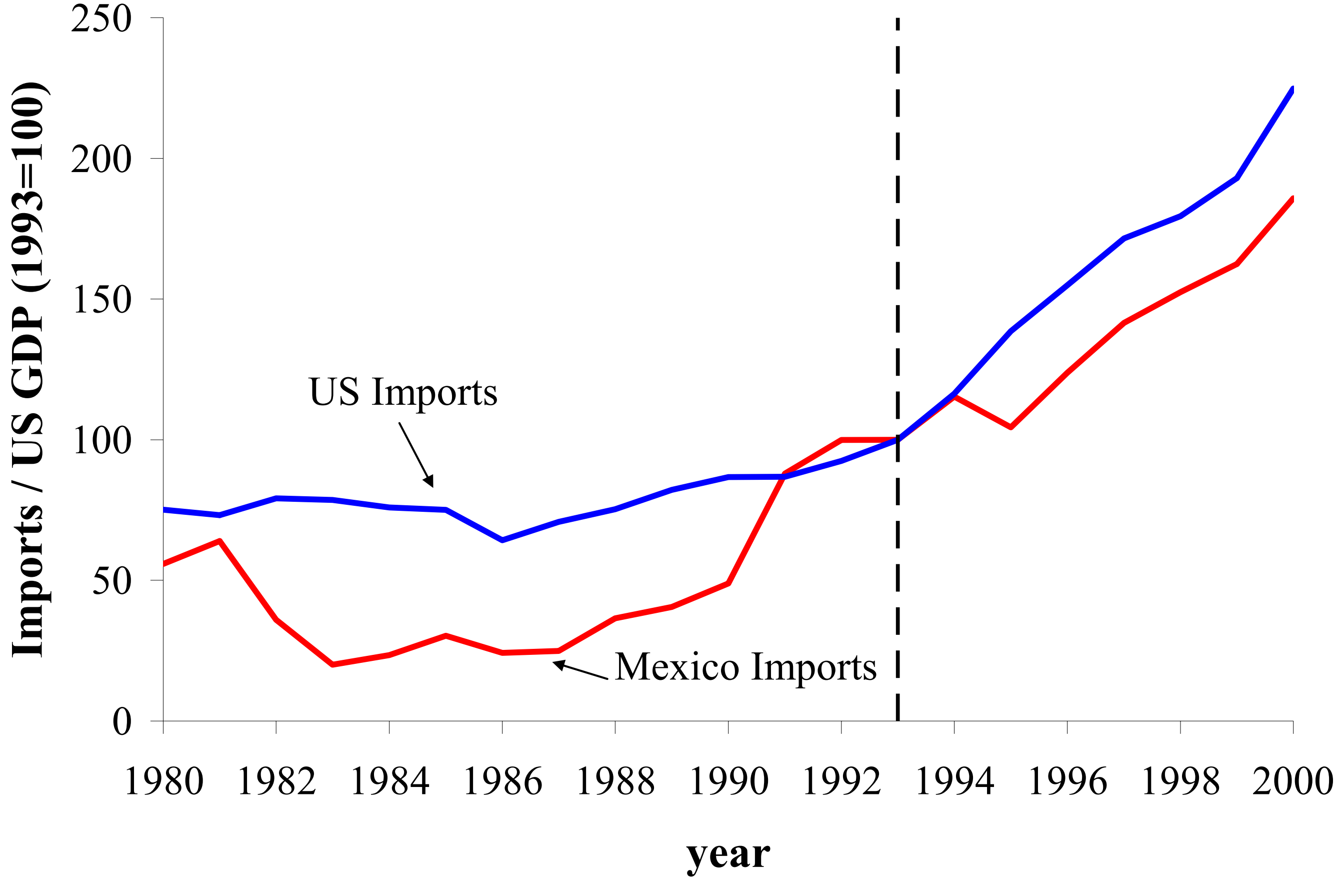
Low estimates from time-series data (< 2)

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 $t = 0, 1, 2, ...$

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:

$$C_{t}+\sum_{s_{t+1}}Q(s^{t},s_{t+1})B(s^{t},s_{t+1})\leq w_{t}N_{t}+B(s^{t})+\Pi_{t}+T_{t}$$

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

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

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

$\gamma$ : 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 $g$

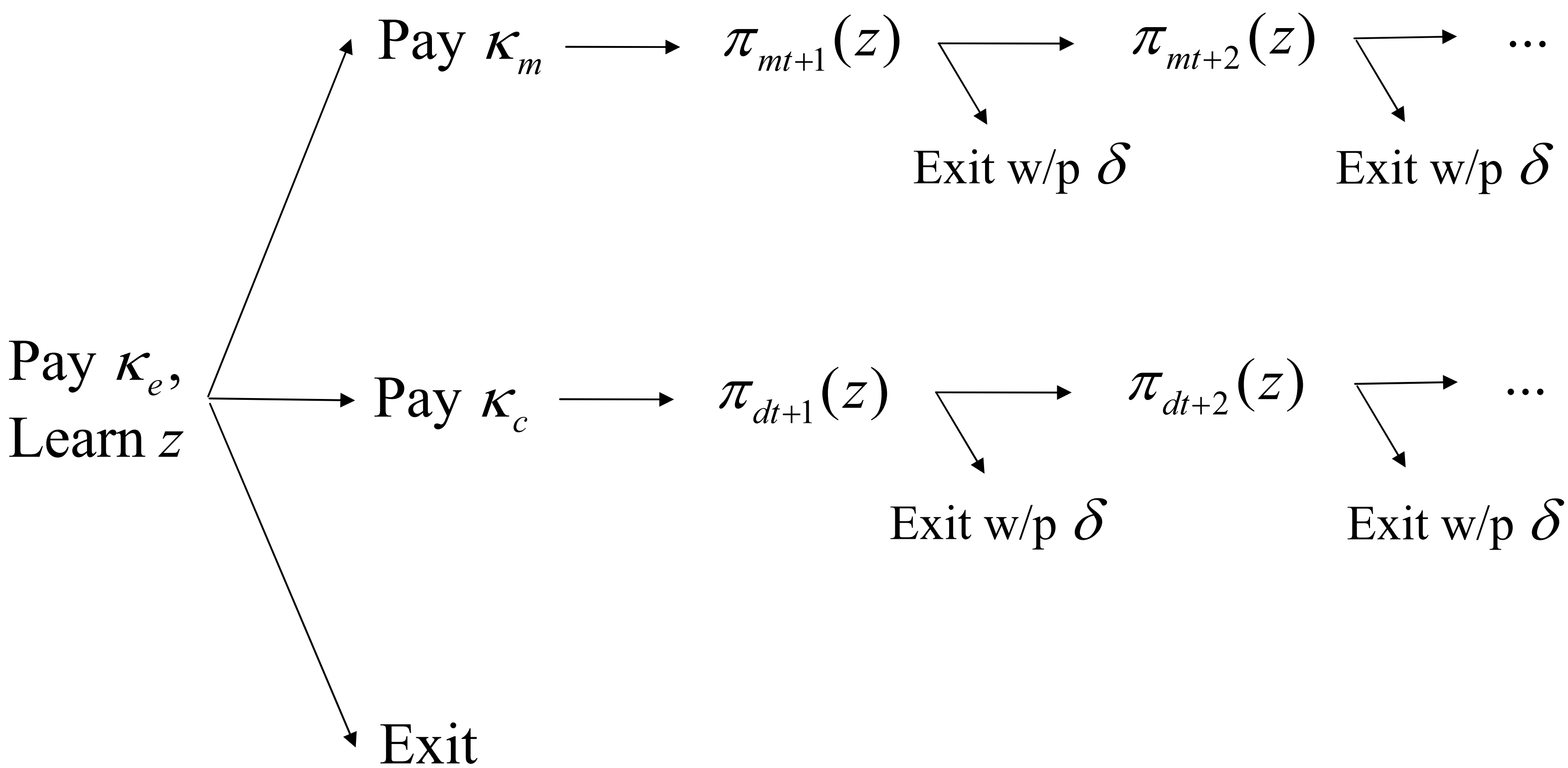
Decide whether to start producing or exit

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 $P_{t,t+k} = \beta^k \frac{U_{Ct+k}}{U_{Ct}}$ (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 $\hat{z}_{mt}$,

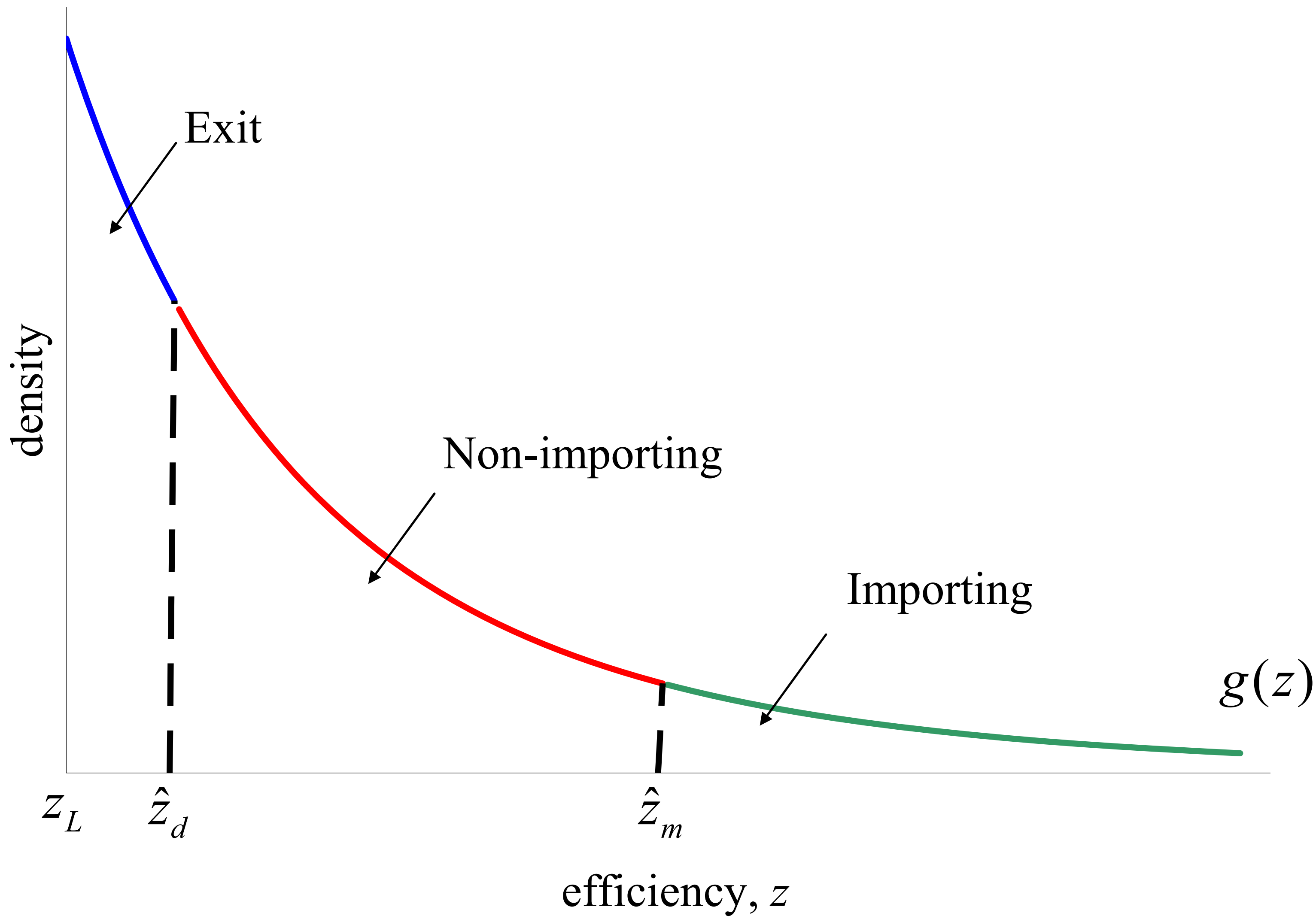
$$V_{dt}(\hat{z}_{dt})=\kappa_c$$
$$V_{mt}(\hat{z}_{mt})-V_{dt}(\hat{z}_{mt})=\kappa_m$$

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*,

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

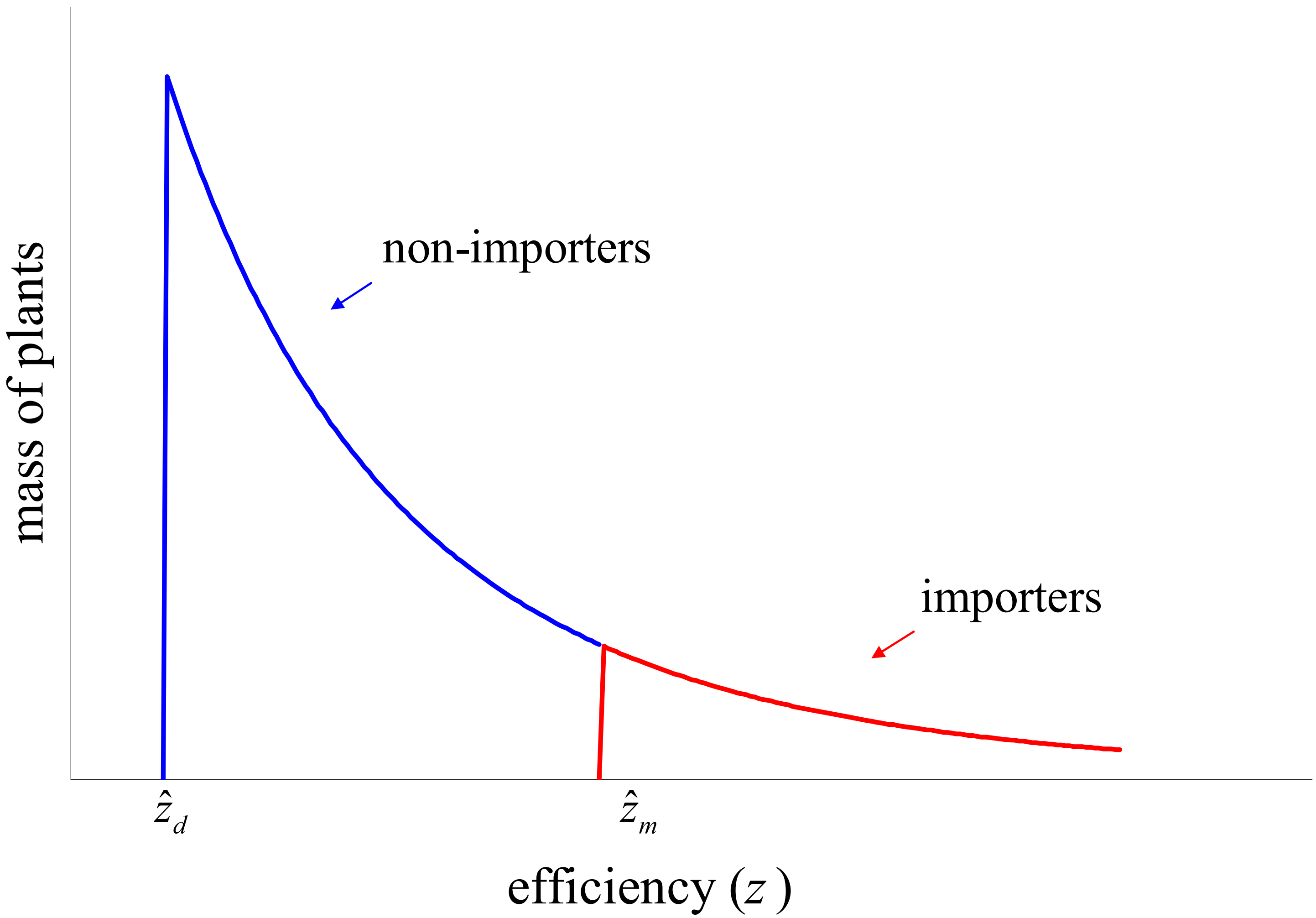
Decreasing in $(1+\tau)p_t$

Importing less profitable; fewer new plants choose importing.

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

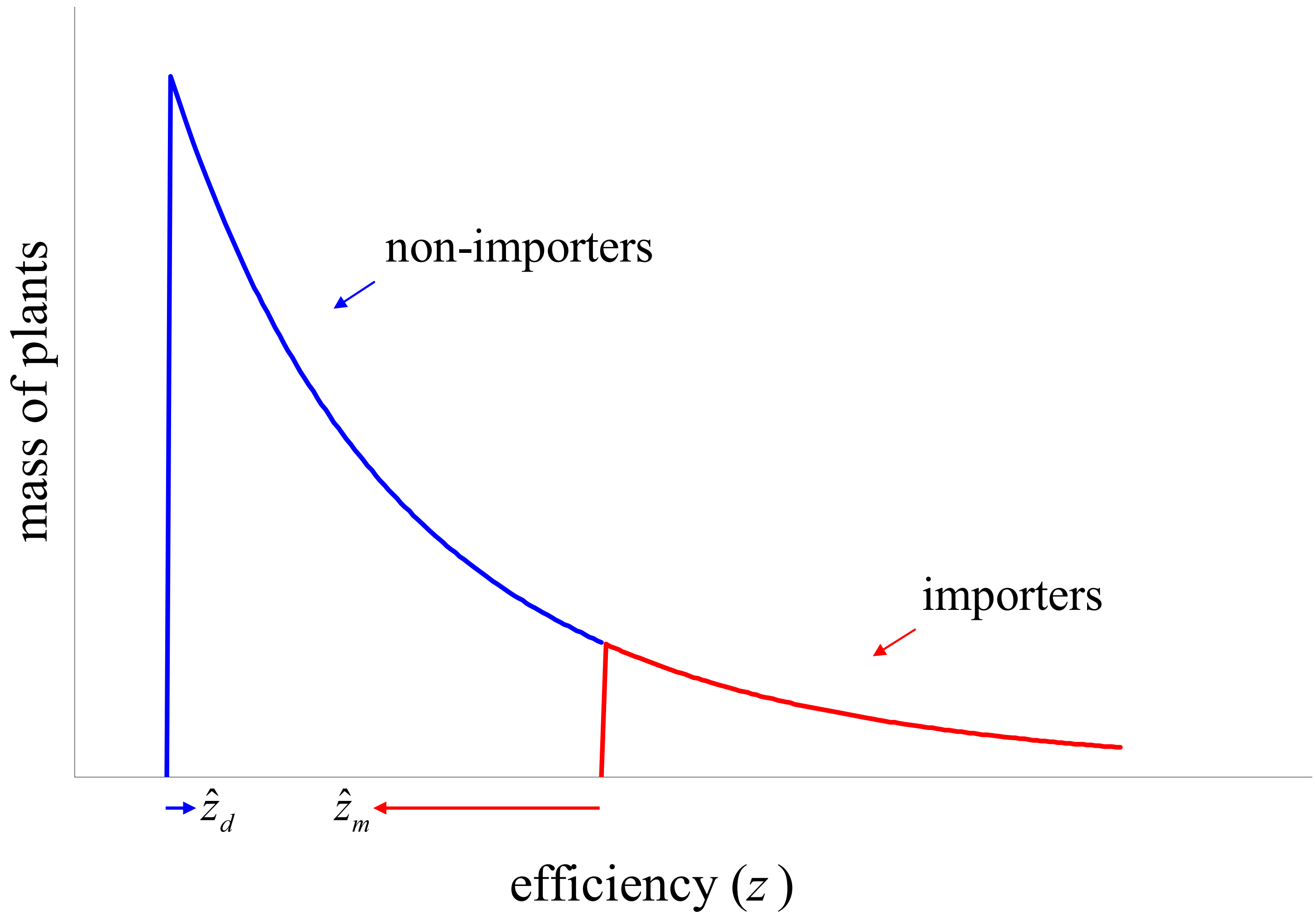
**Dynamic effect of increase in** $(1+\tau)p_t$

Distribution of Plants, $t$



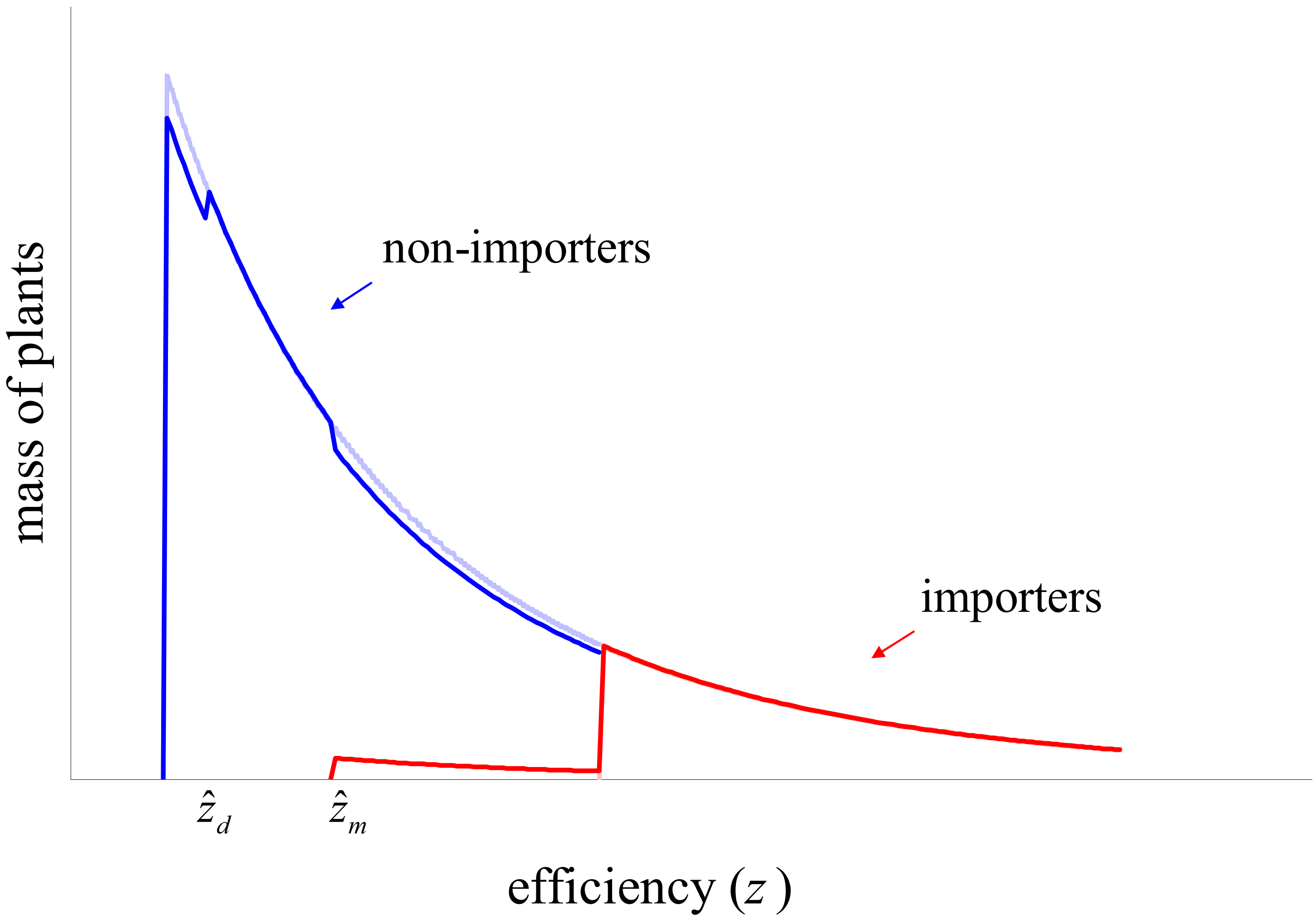
**Dynamic effect of increase in** $(1+\tau)p_t$

Distribution of Plants, $t$



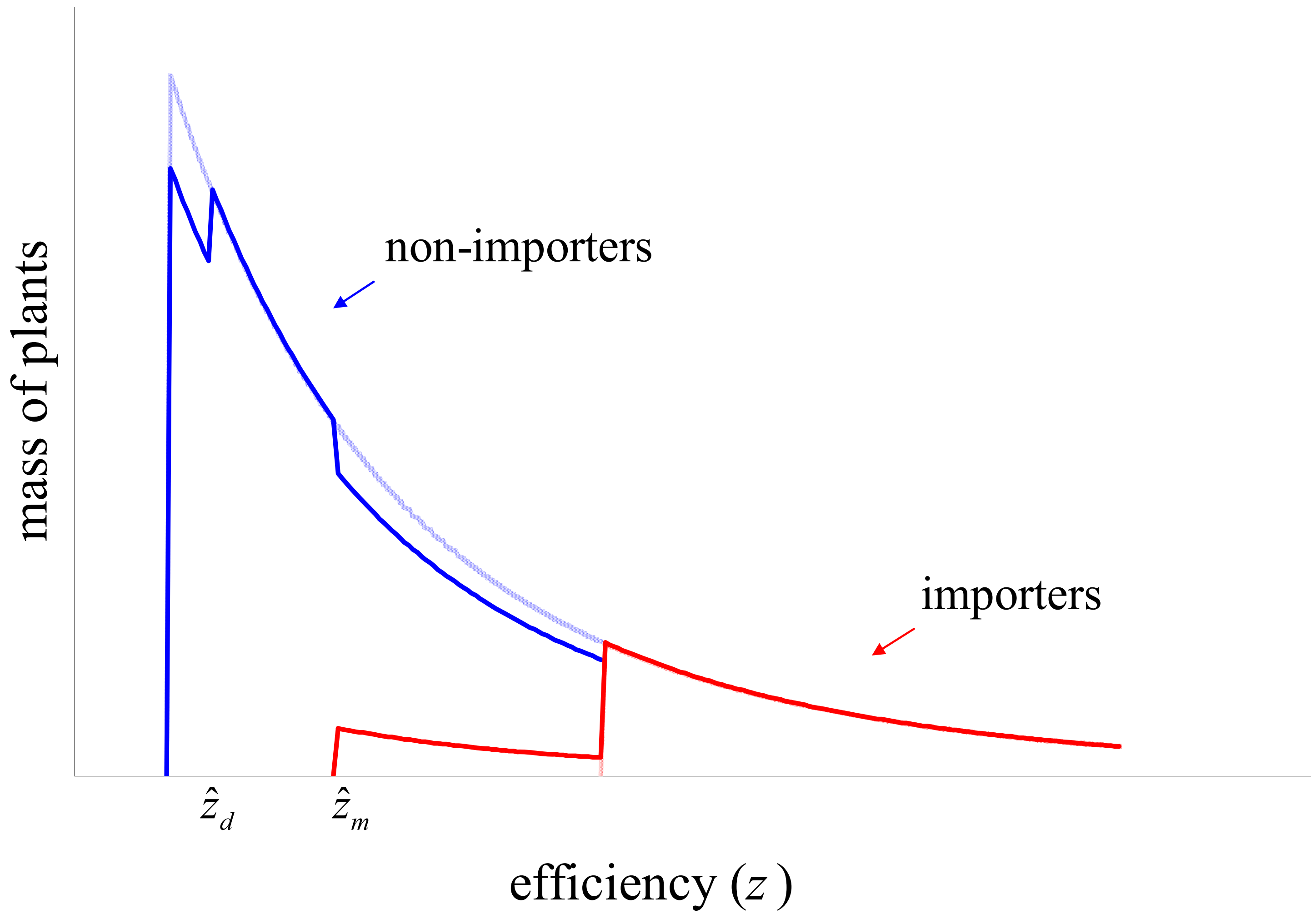
**Dynamic effect of increase in $(1+\tau)p_t$**

Distribution of Plants, *t+1*



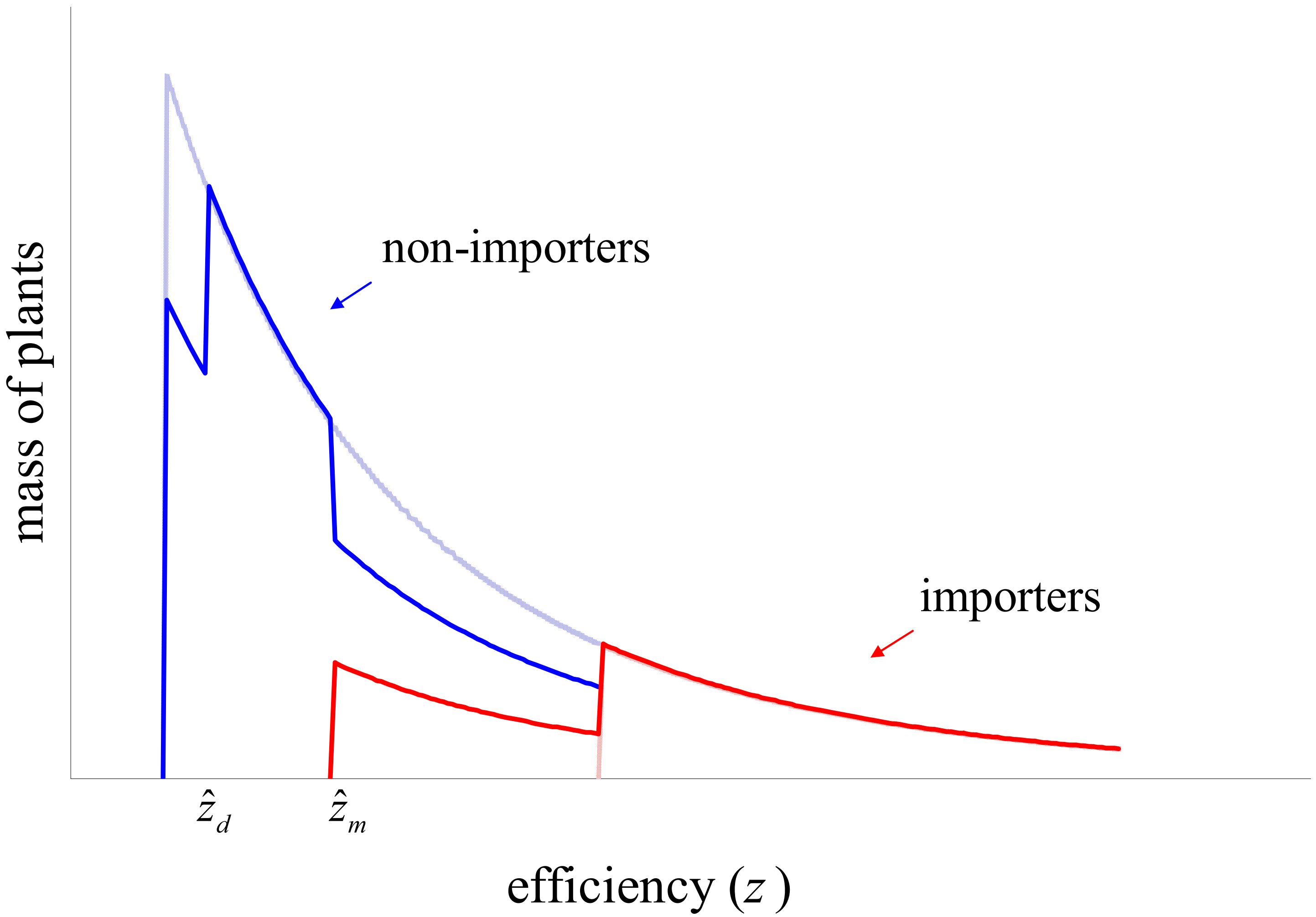
# **Dynamic effect of increase in** $(1+\tau)p_t$

## Distribution of Plants, *t+2*



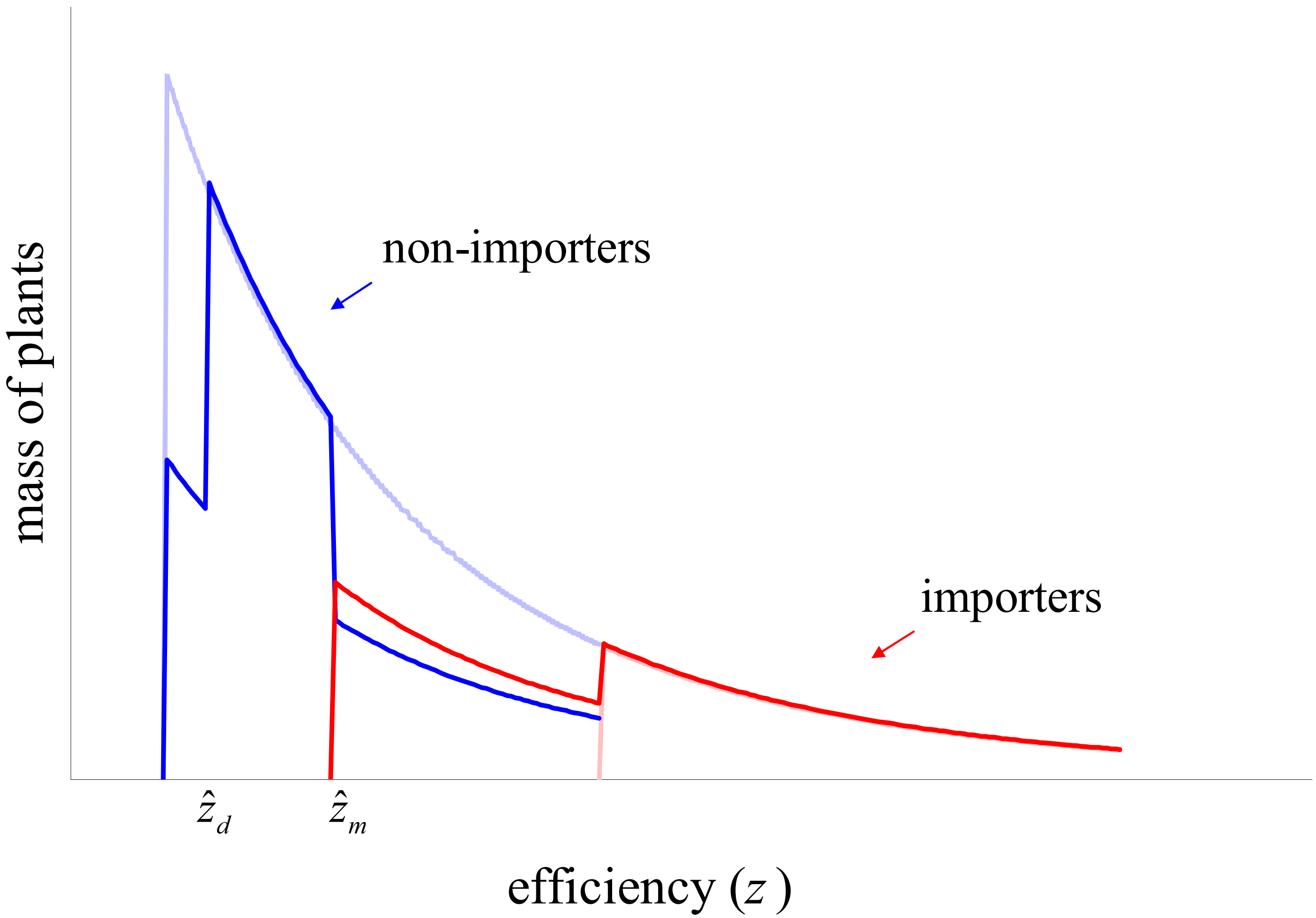
# **Dynamic effect of increase in** $(1+\tau)p_t$

Distribution of Plants, *t+5*



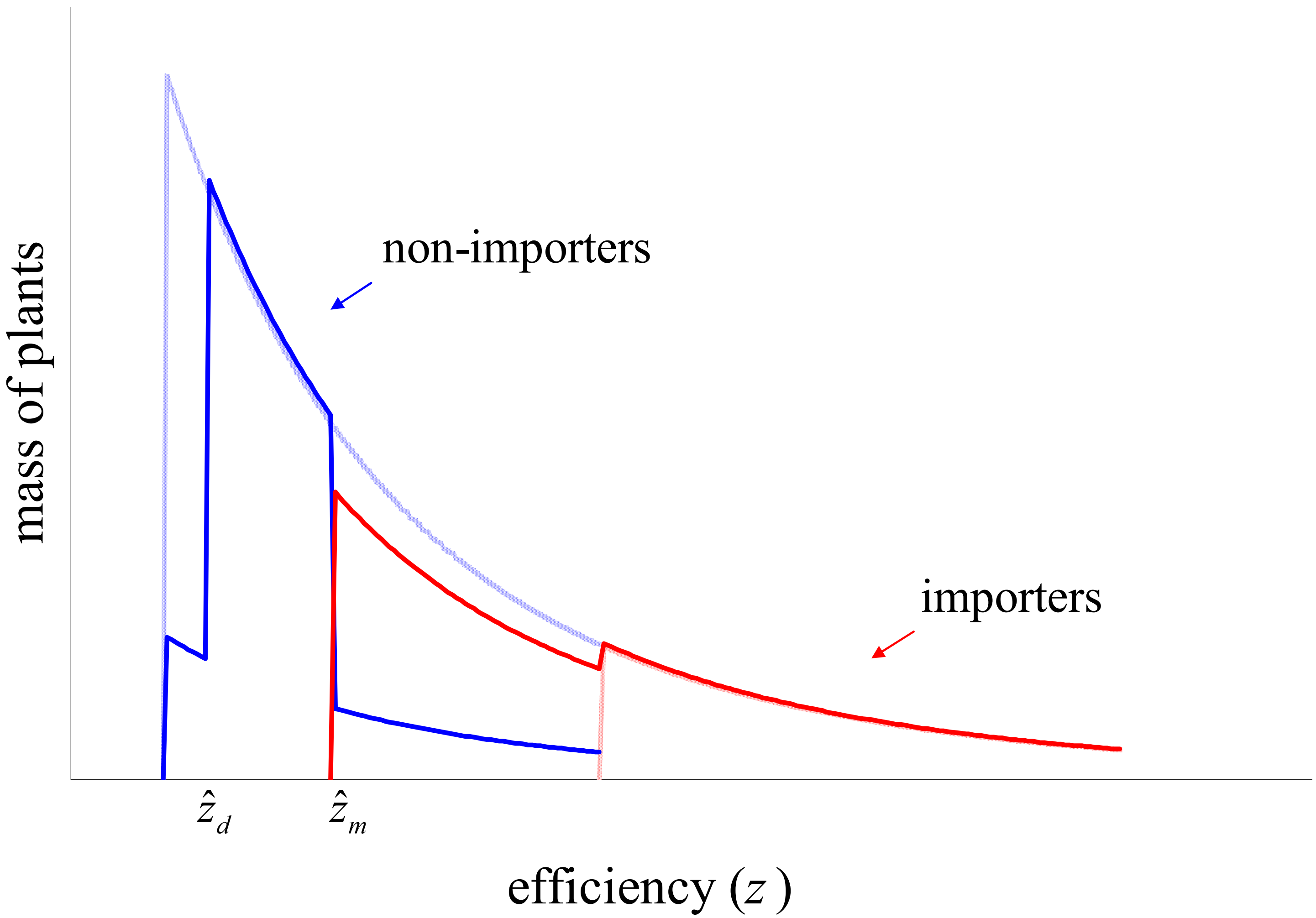
**Dynamic effect of increase in** $(1+\tau)p_t$

Distribution of Plants, *t+10*



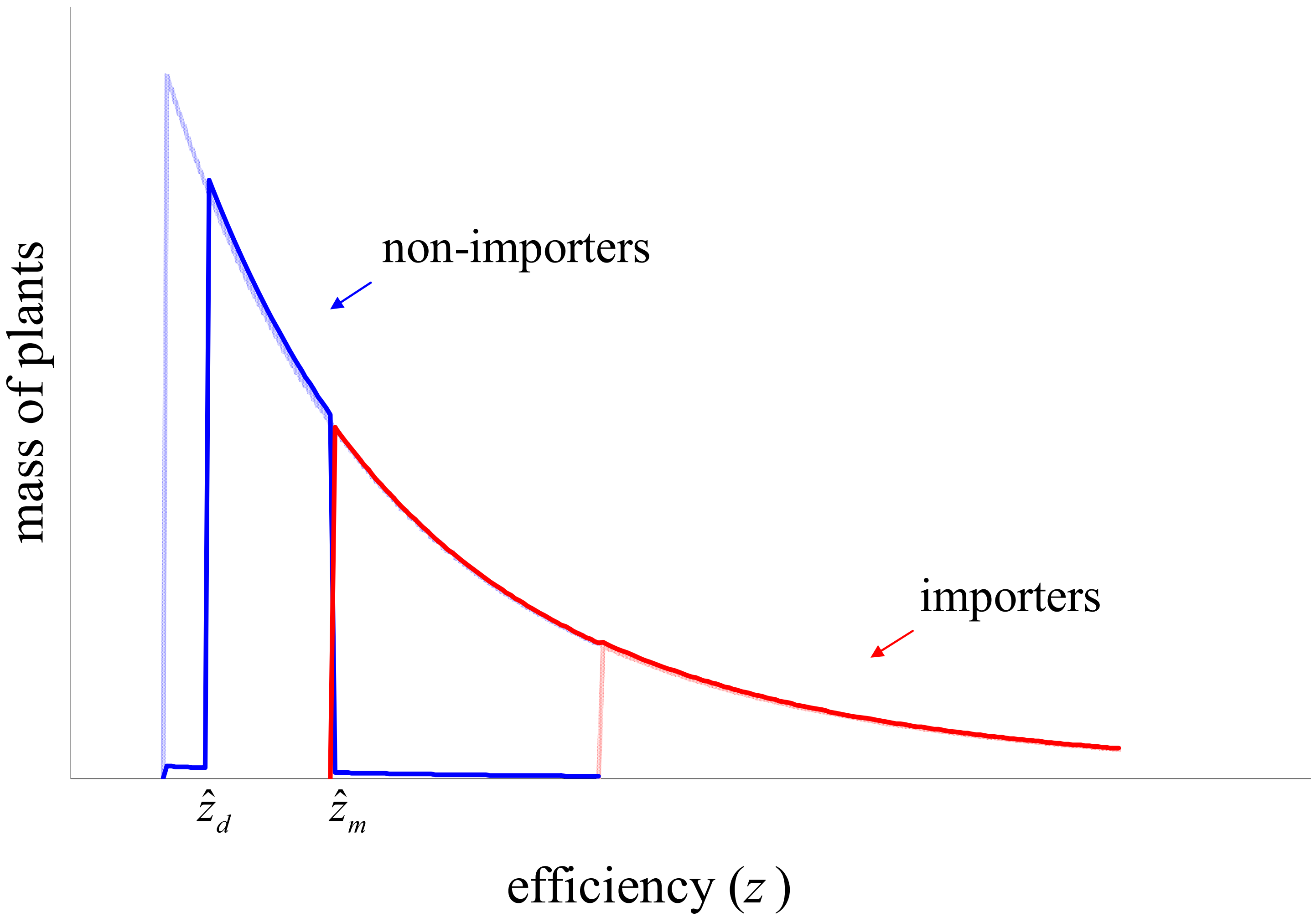
# **Dynamic effect of increase in** $(1+\tau)p_t$

Distribution of Plants, *t+20*



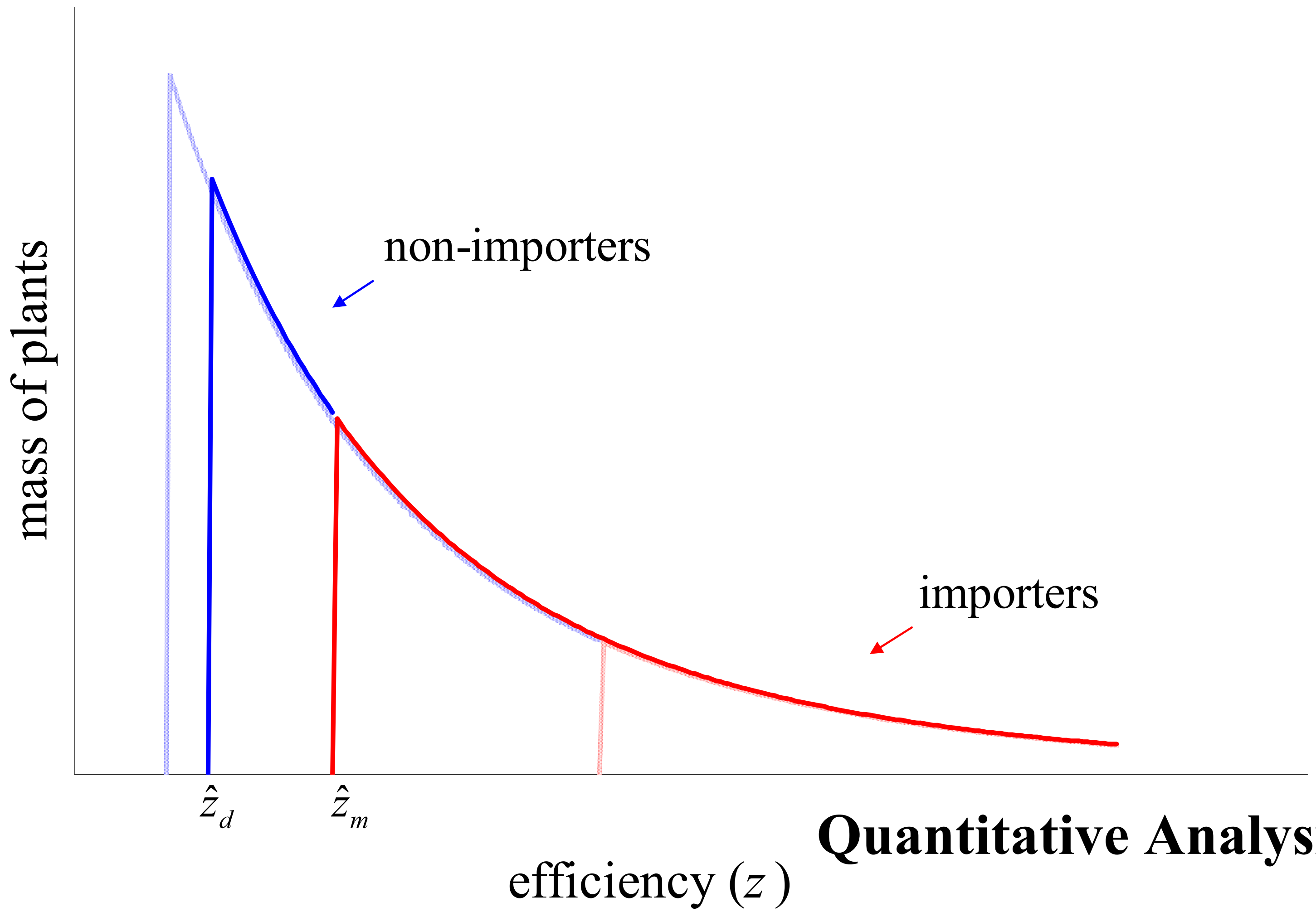
**Dynamic effect of increase in** $(1+\tau)p_t$

Distribution of Plants, *t+50*



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

Distribution of Plants, $t+\infty$




**Quantitative Analysis**

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

**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**

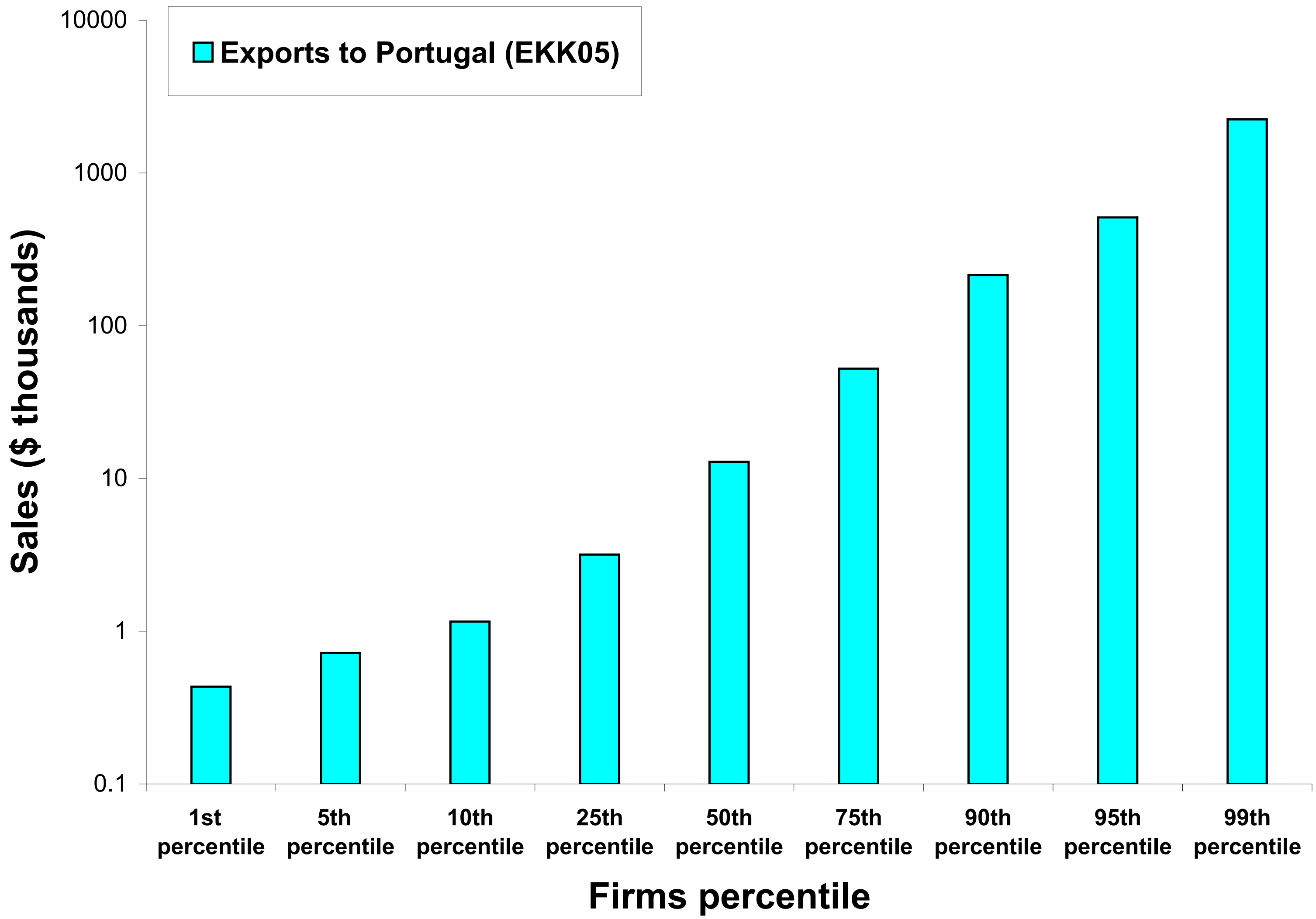
(Eaton Kortum and Kramarz '05)

- 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**

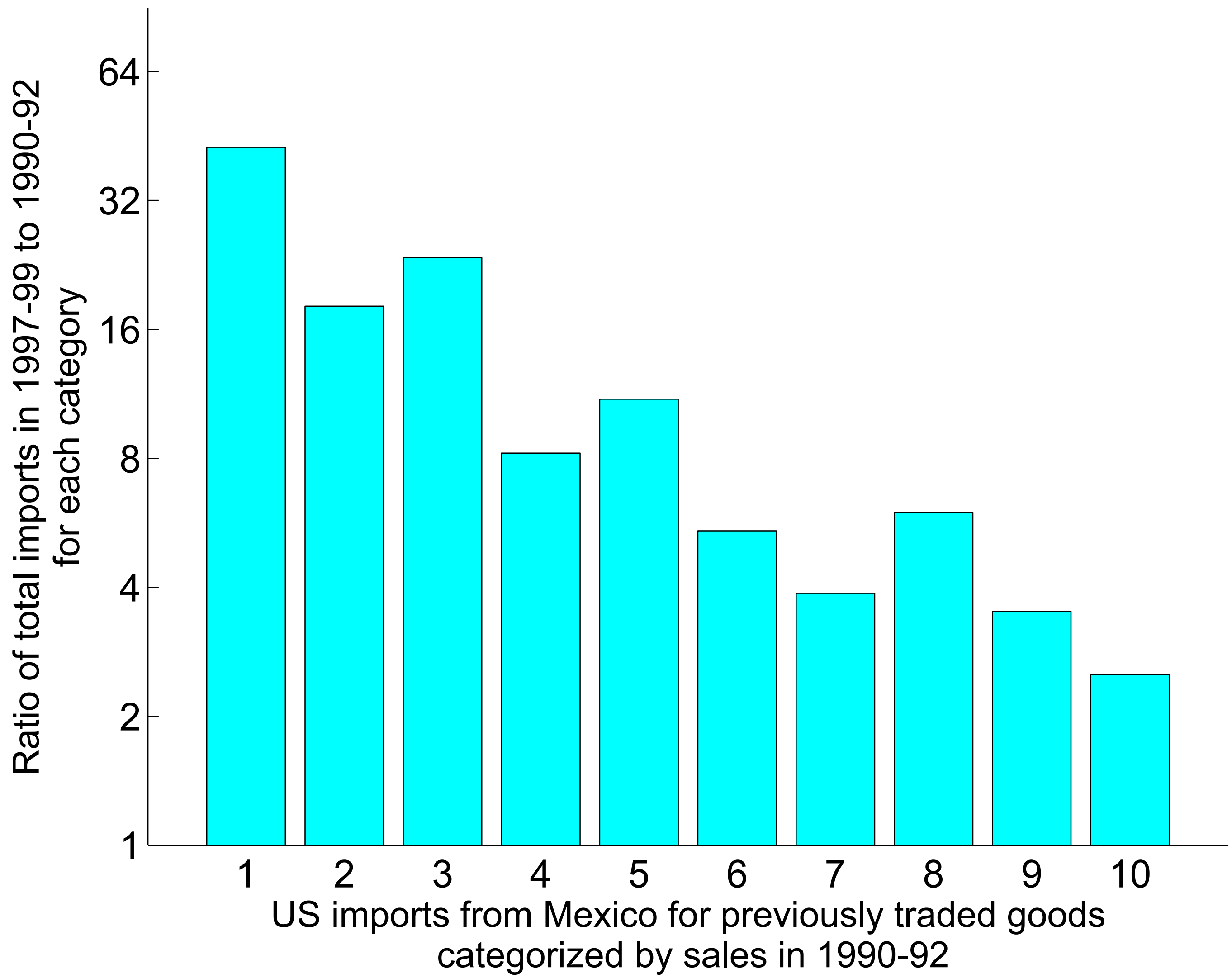
- Most firms do not export **and**
- Large fraction of firms exporting to each country sell tiny amounts there

**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 $\phi$ (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 $\phi$:

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

$p_{ij}(\phi)$ : 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 $j = 1, ..., N$

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

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

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

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

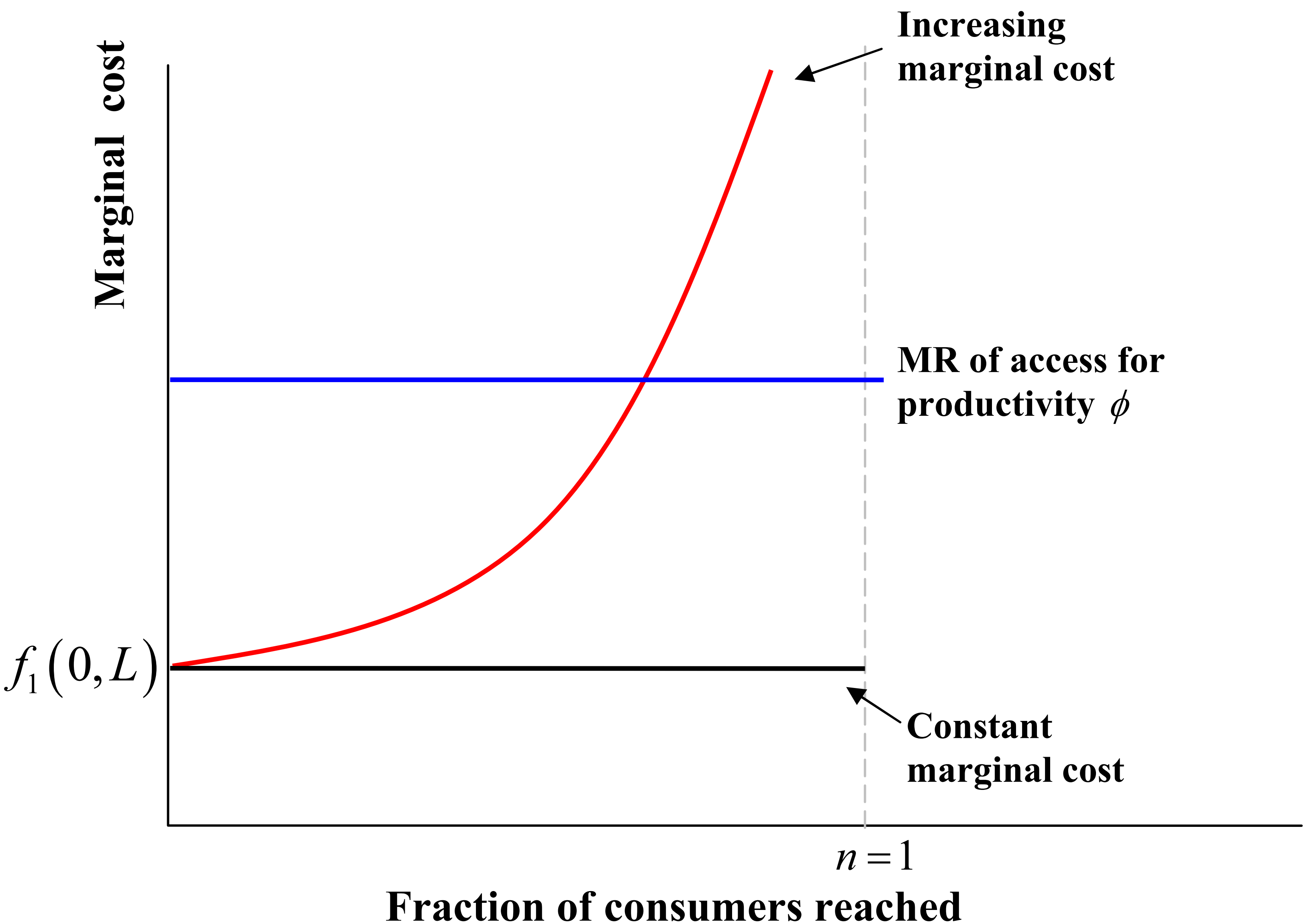
- Given price markup rule firm solves:

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

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

- Look at marginal decision of reaching additional fractions of consumers

## Marginal Revenue & Cost from Reaching Additional Consumers



# The Market Access Cost Function

- Solve the differential equation

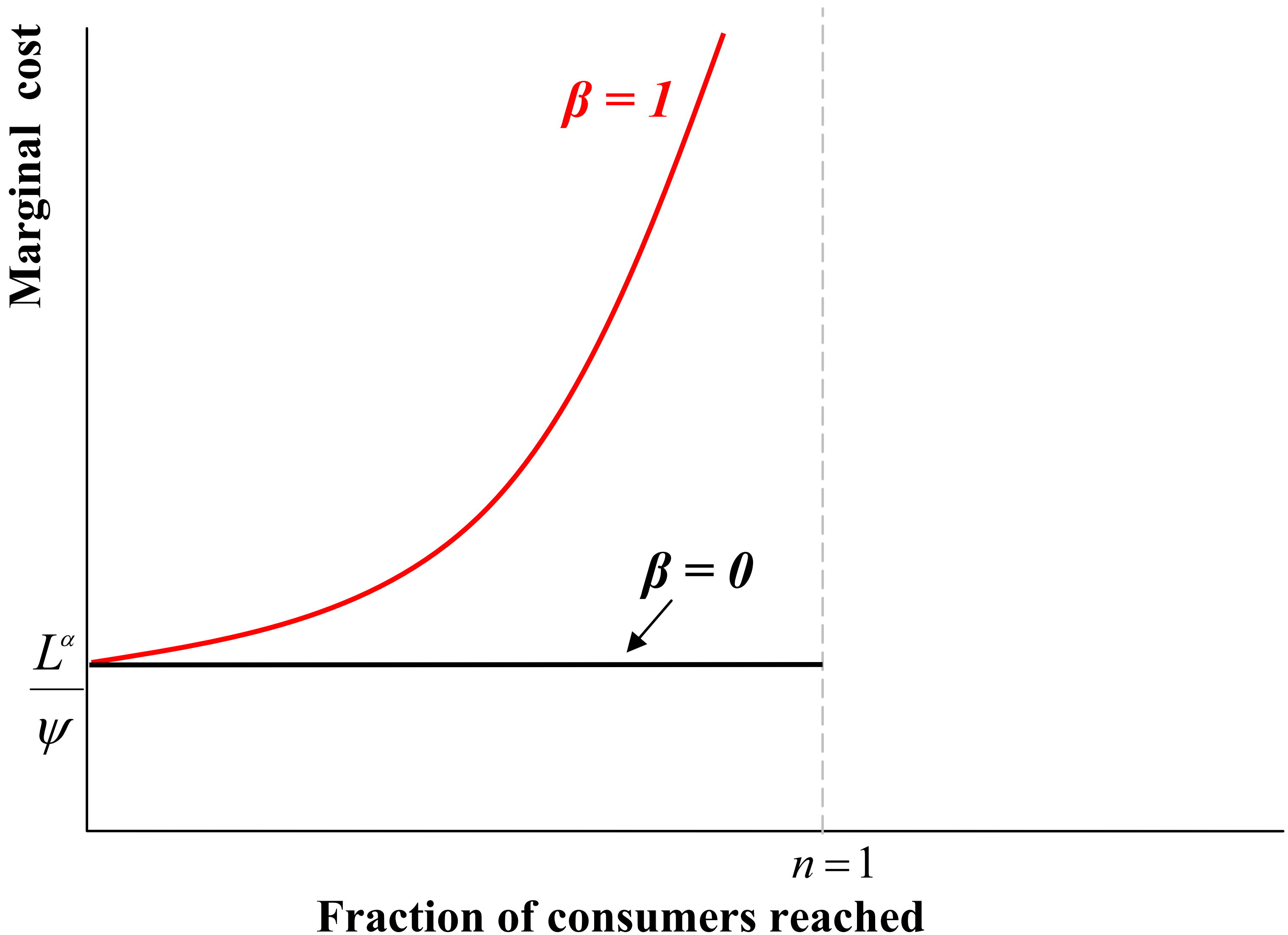
$$n'(S) = [1 - n(S)]^{\beta} \, L^{1-\alpha} \frac{1}{L}, \quad \text{s.t. } n(0) = 0$$

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

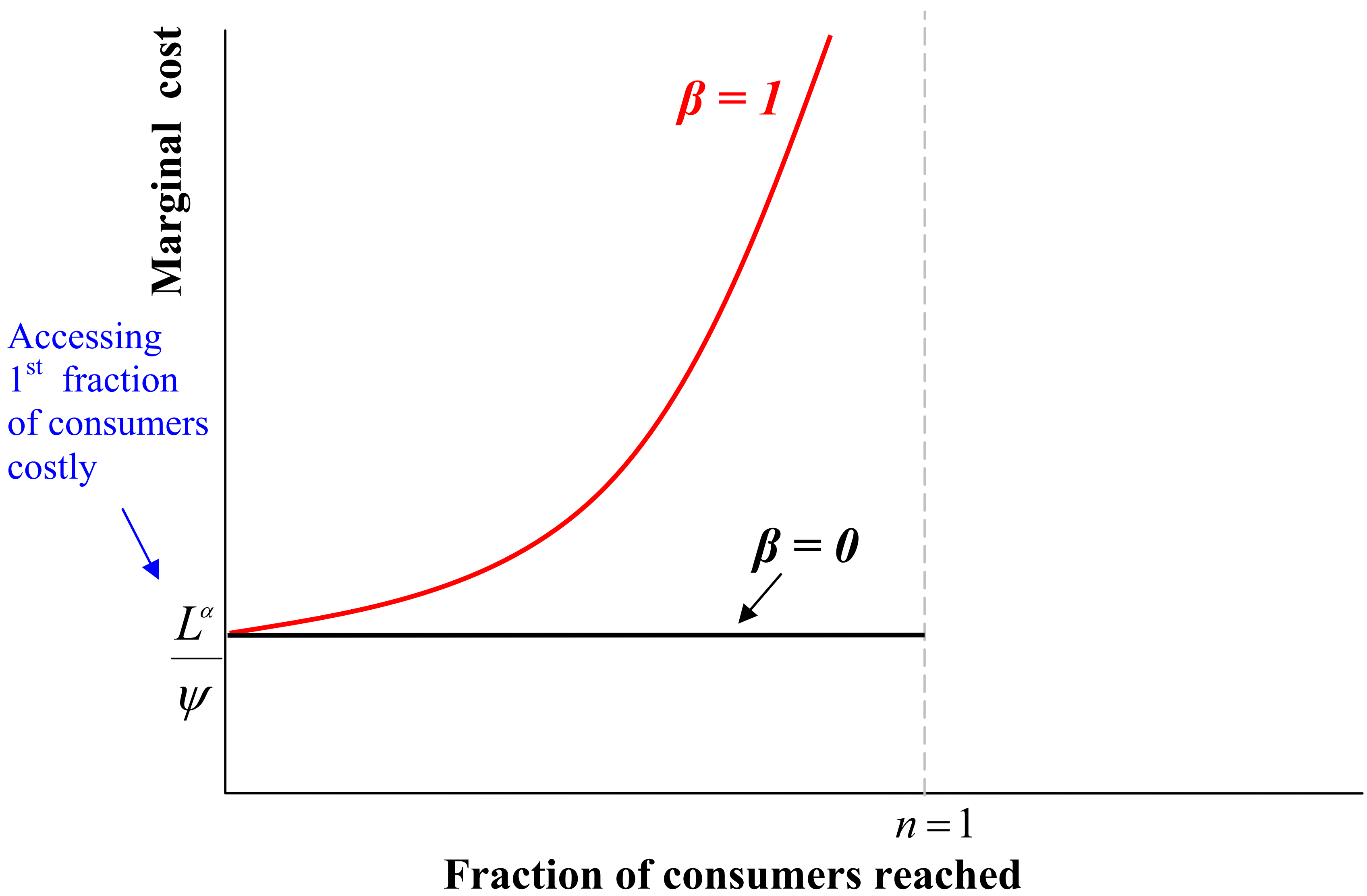
$$f(n, L) = \begin{cases} \frac{L^{\alpha}}{\psi} \frac{1-(1-n)^{-\beta+1}}{-\beta+1} & \text{if } \beta \in [0,1) \cup (1, +\infty) \\ \\ -\frac{L^{\alpha}}{\psi} log(1-n) & \text{if } \beta = 1 \end{cases}$$

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

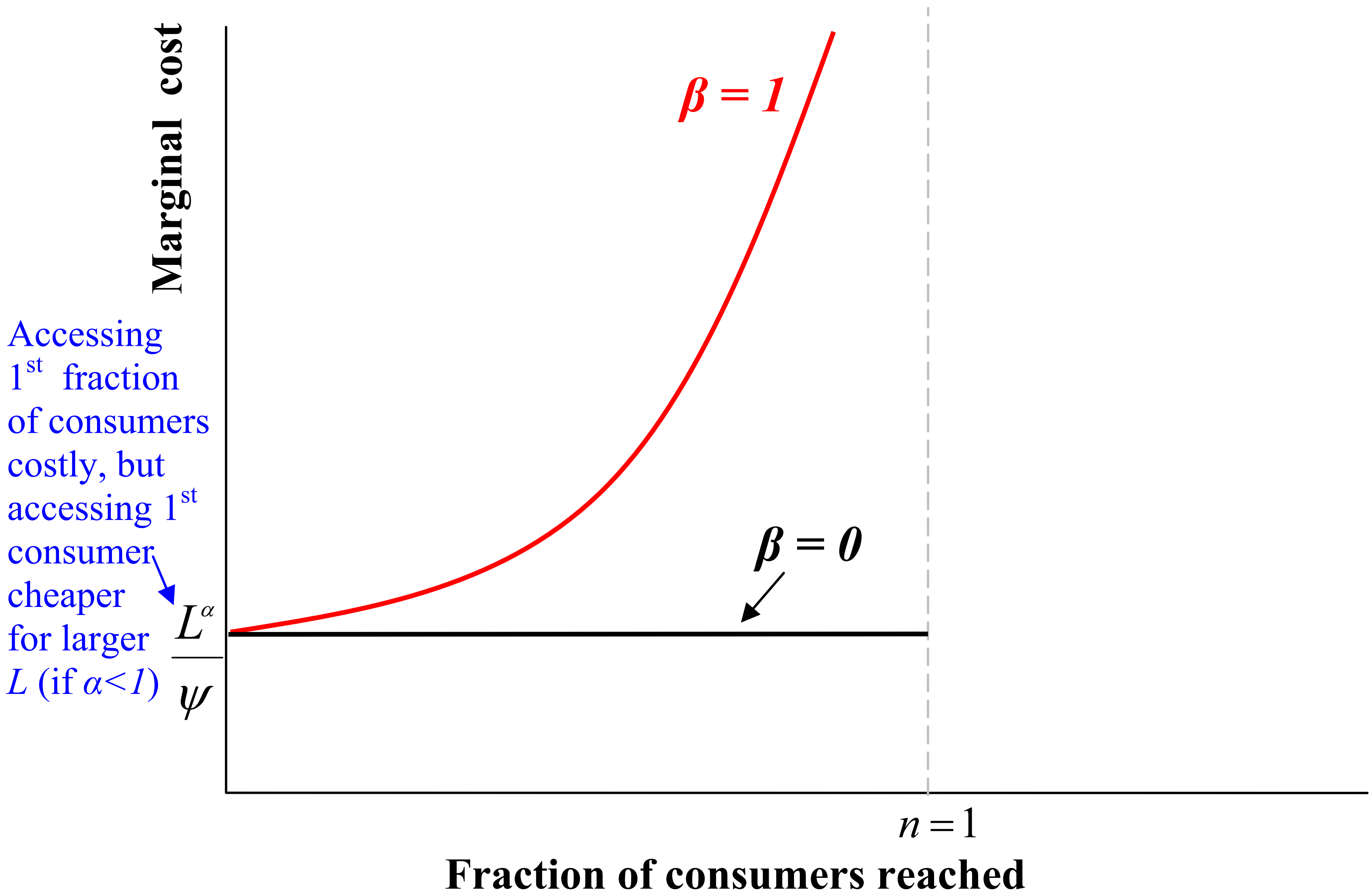
The properties of the Market Access Cost function



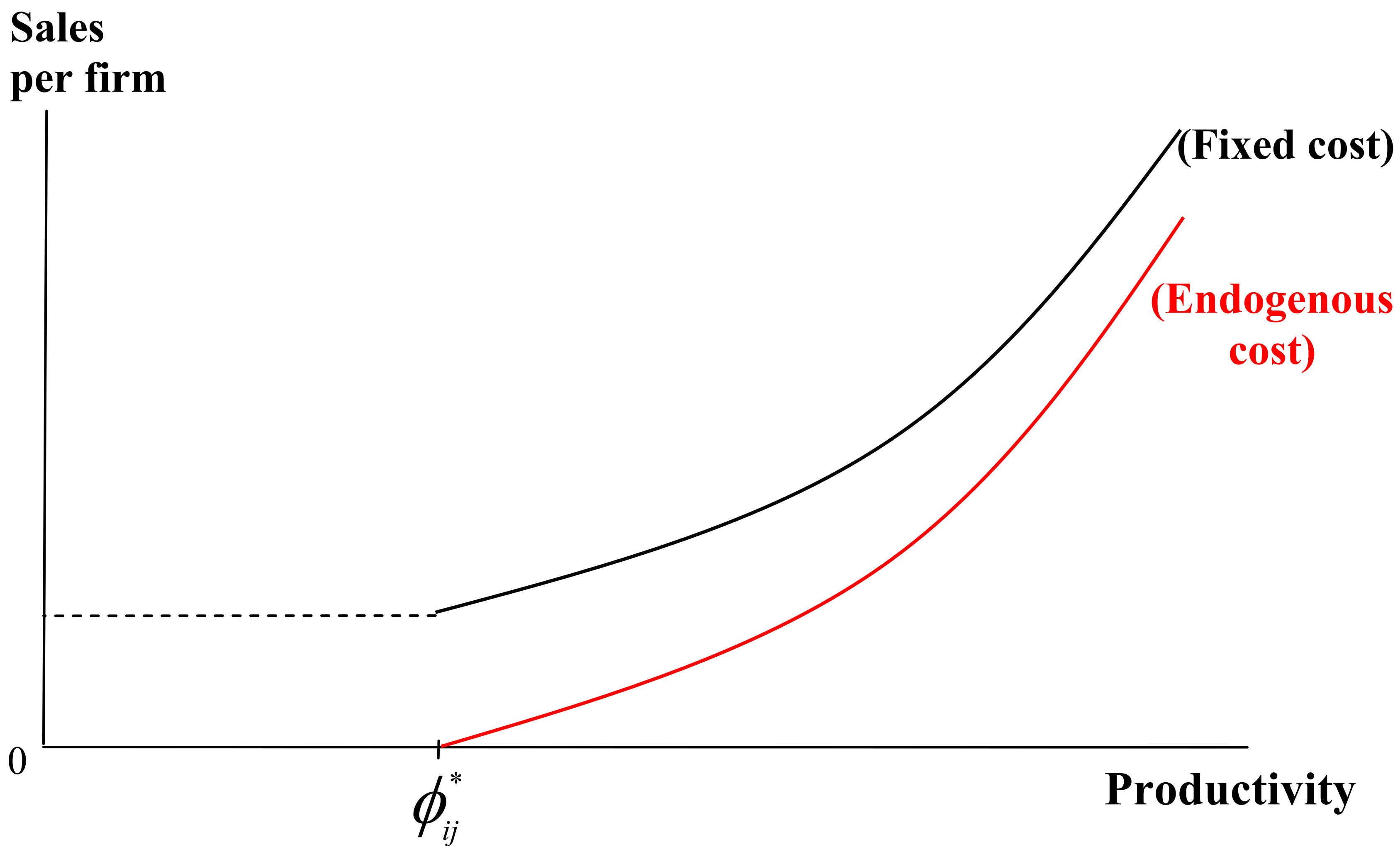
The properties of the Market Access Cost function



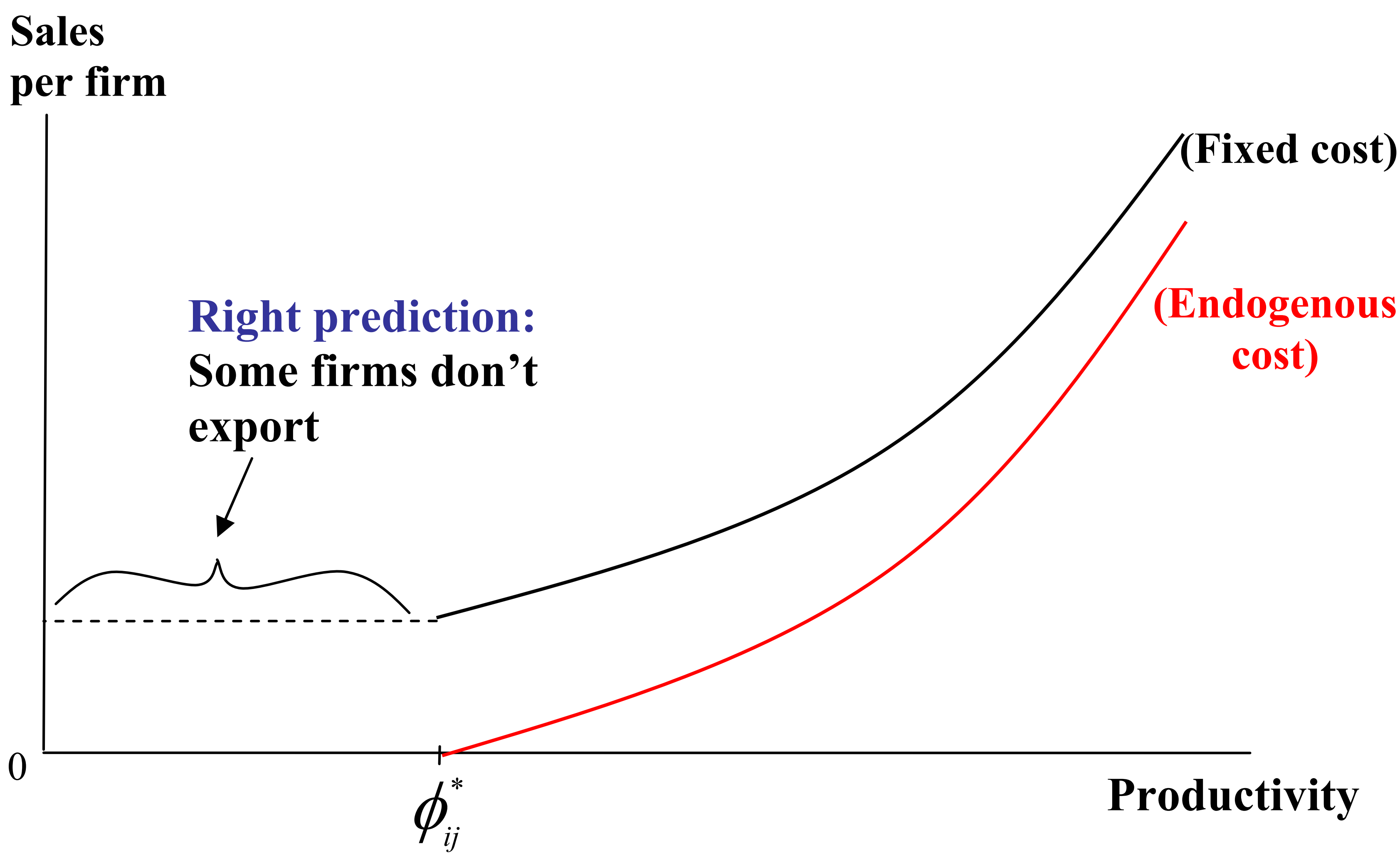
The properties of the Market Access Cost function



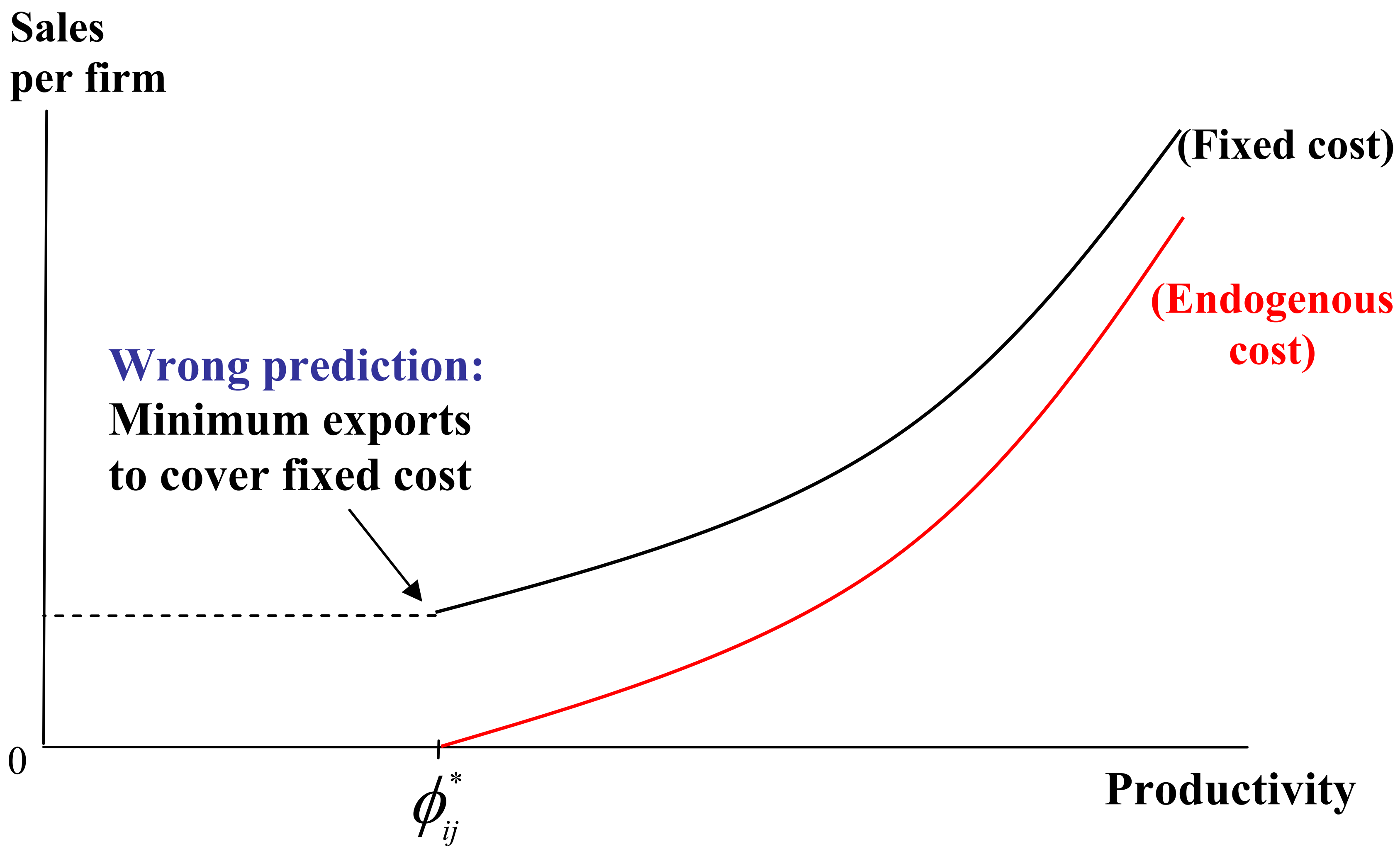
## The product of the two margins: total sales per firm



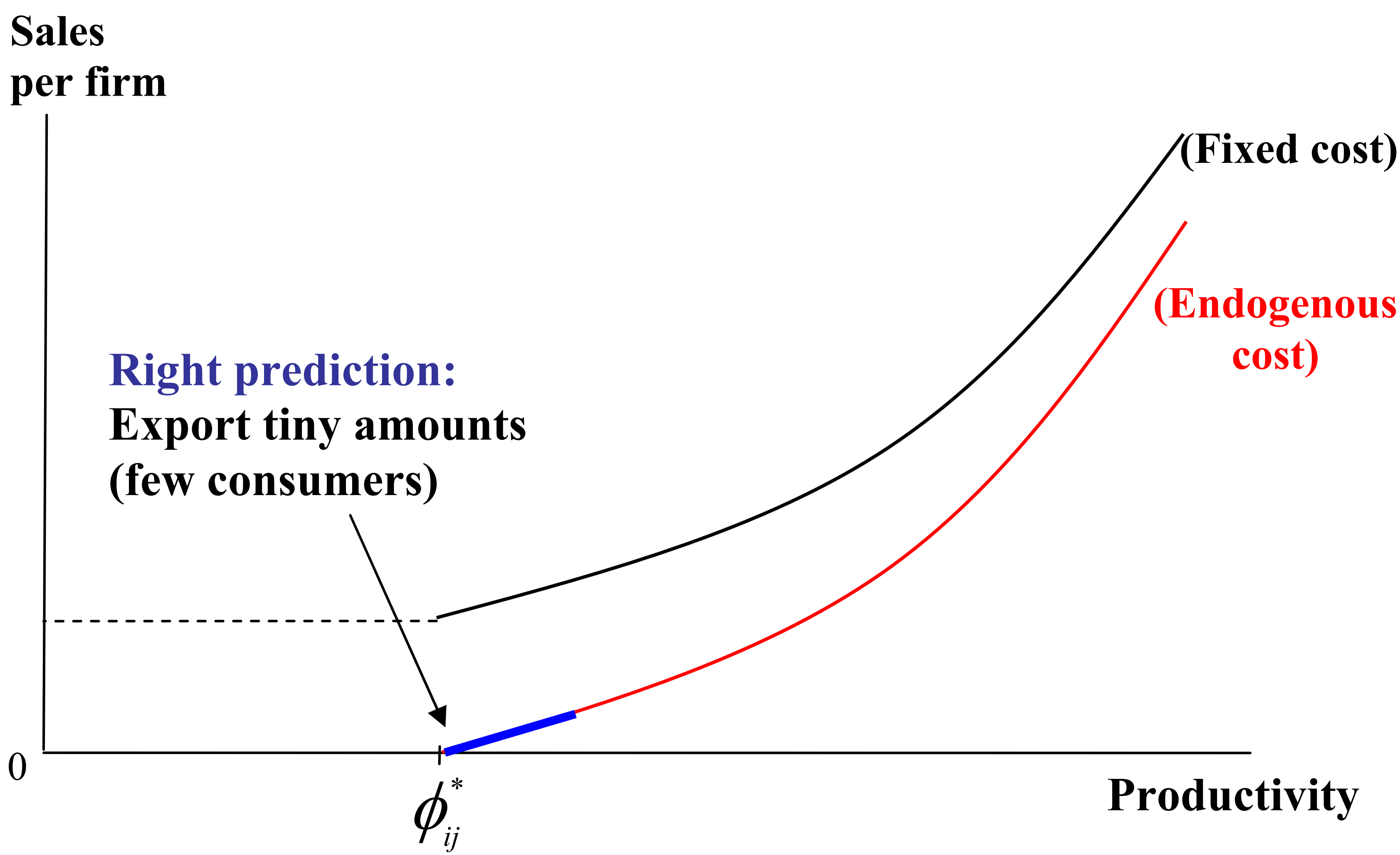
Models' predictions on which firms export



# Models' predictions on how much firms export



Models' predictions on how much firms export



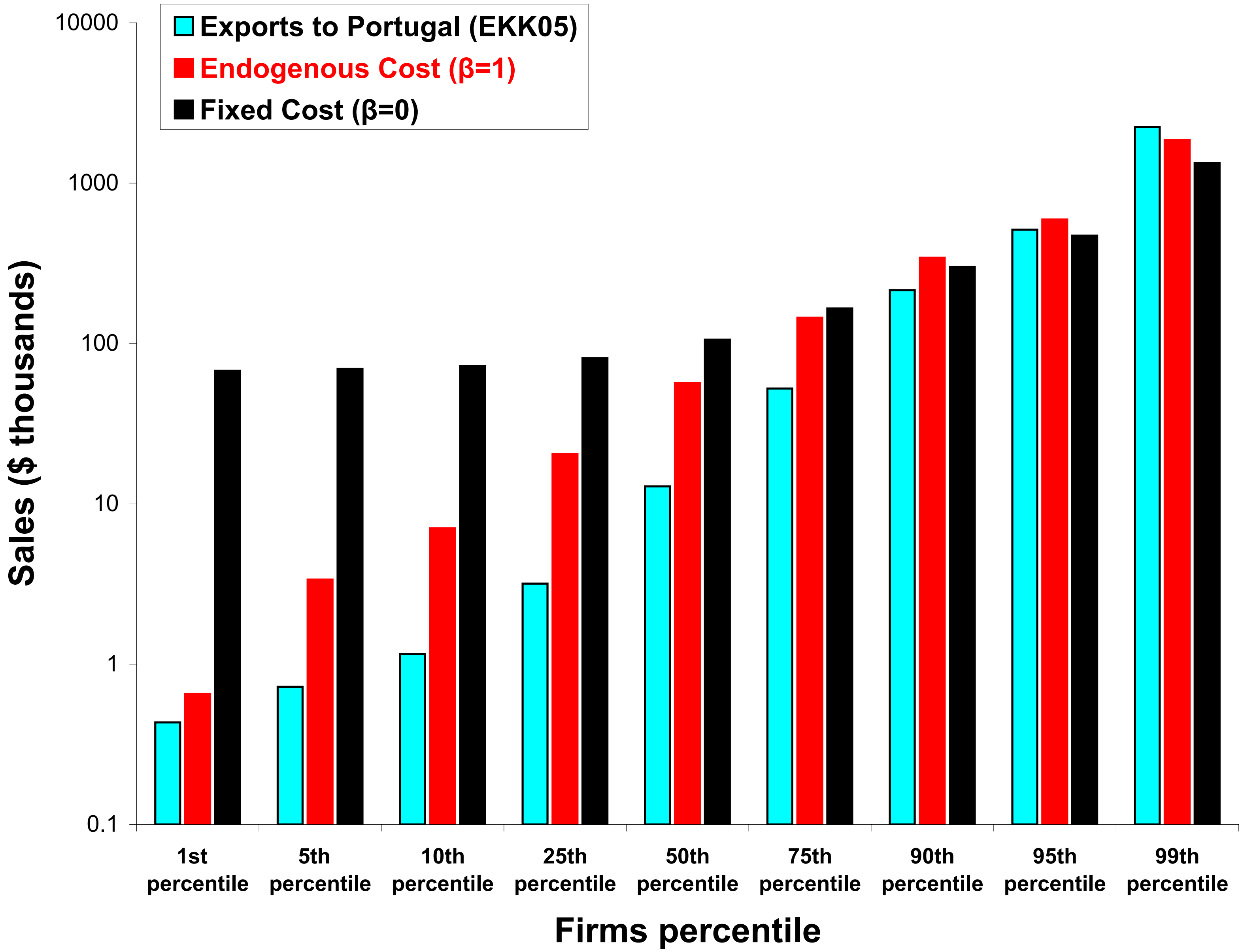
# Comparing the Calibrated Model to French Data

- 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

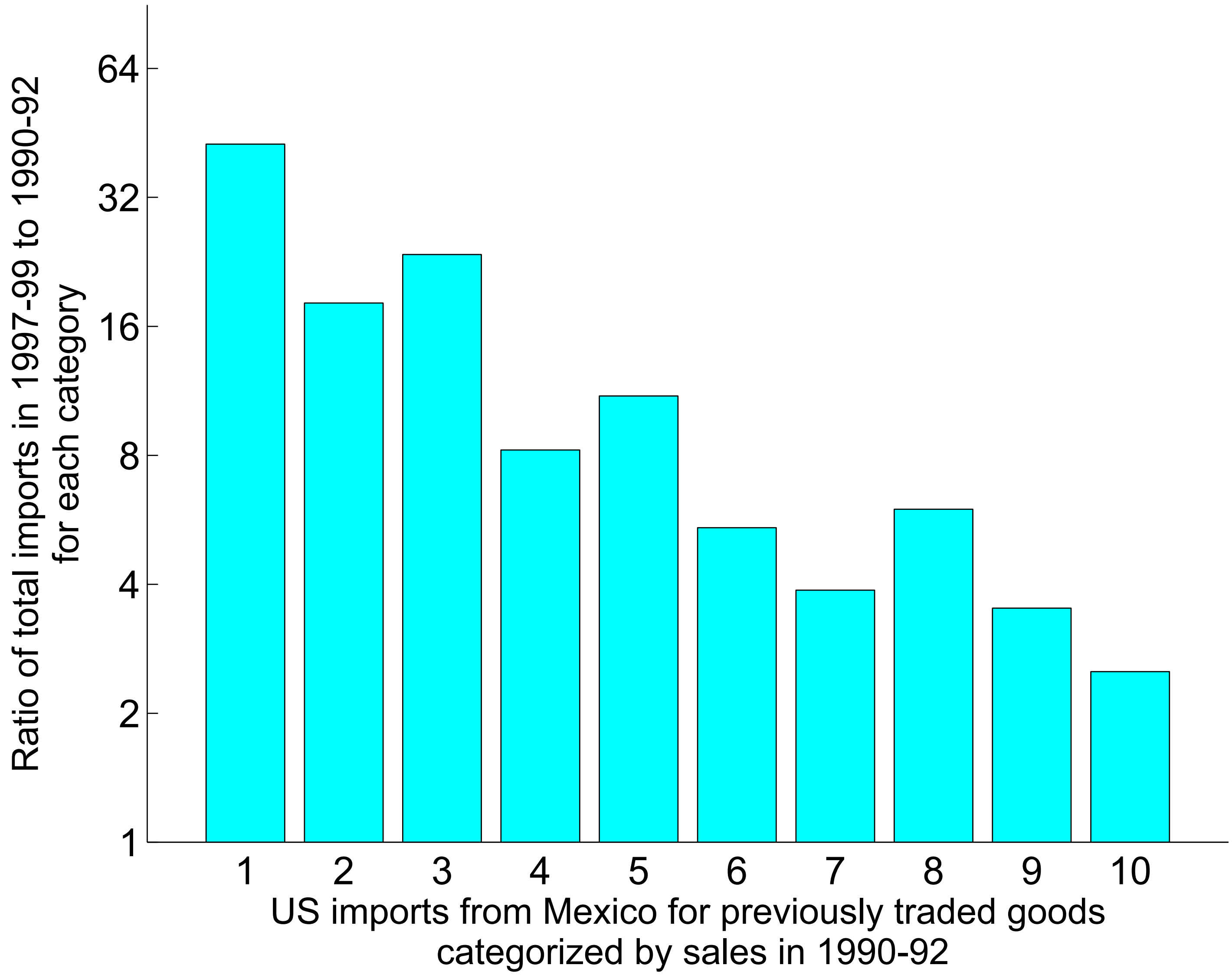
# Calibrated Endogenous Cost model accounts for large fraction of small exporters



# 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



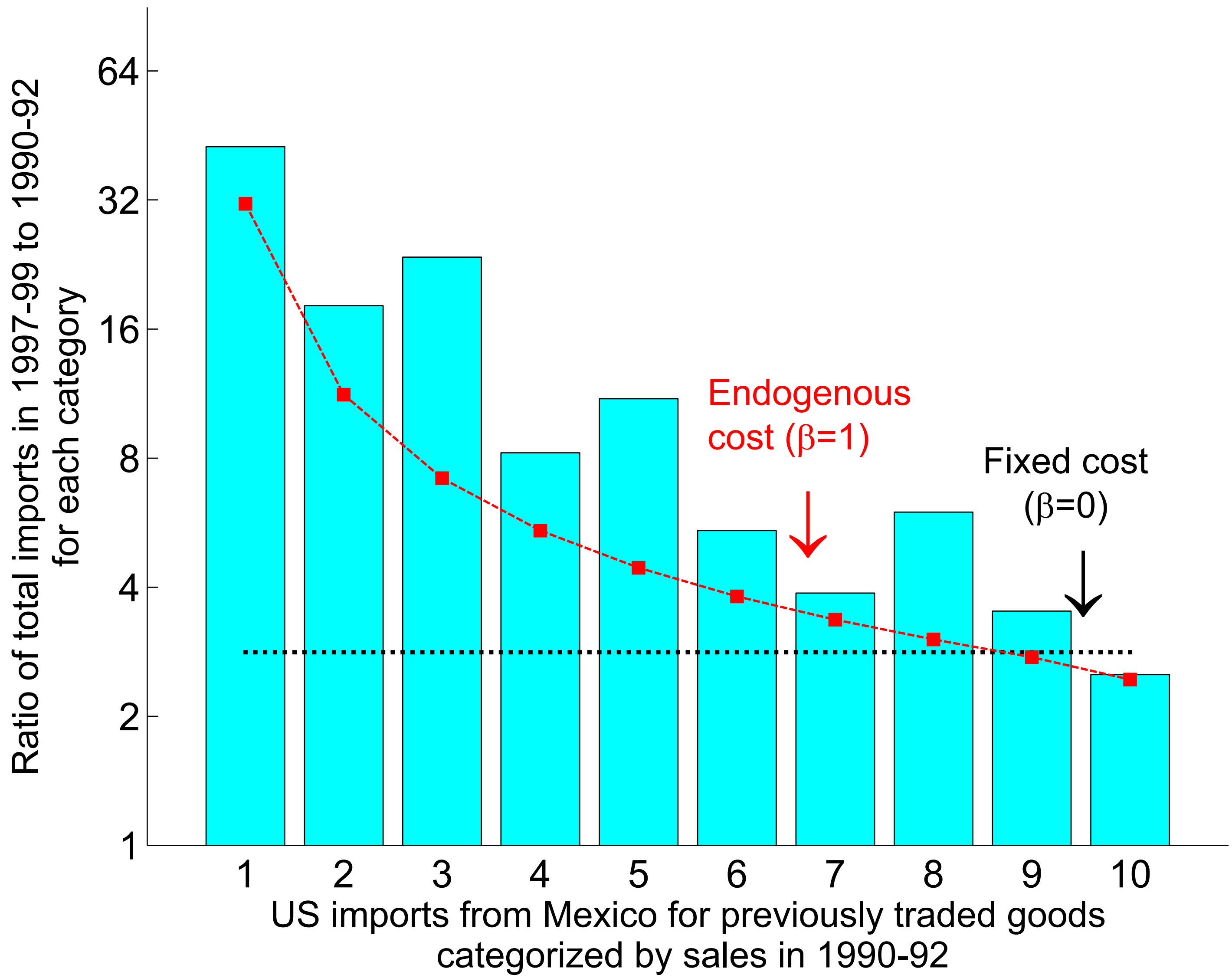
# Comparing Calibrated Model to Data from NAFTA Episode

- 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

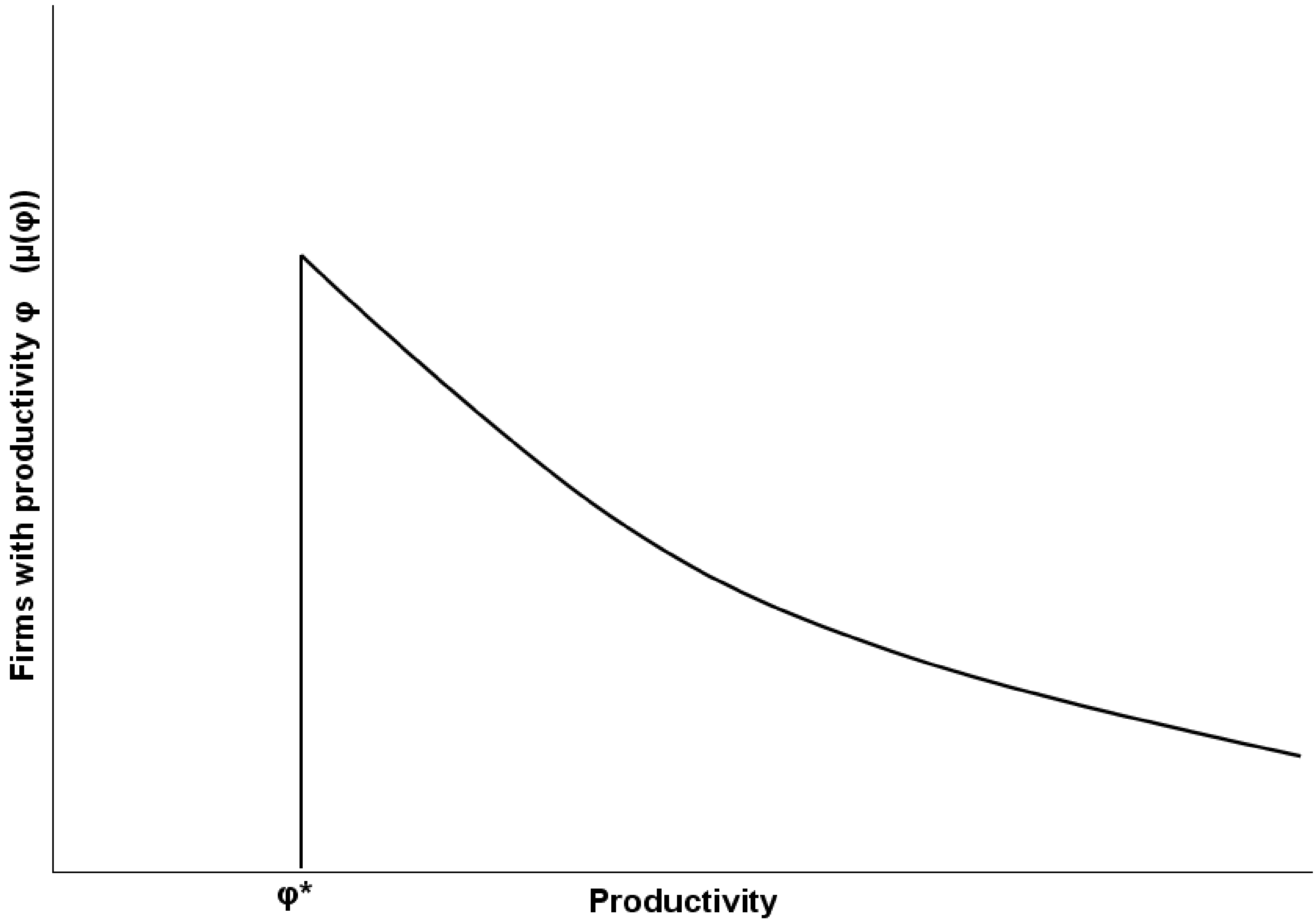


# New Consumers Margin and New Trade

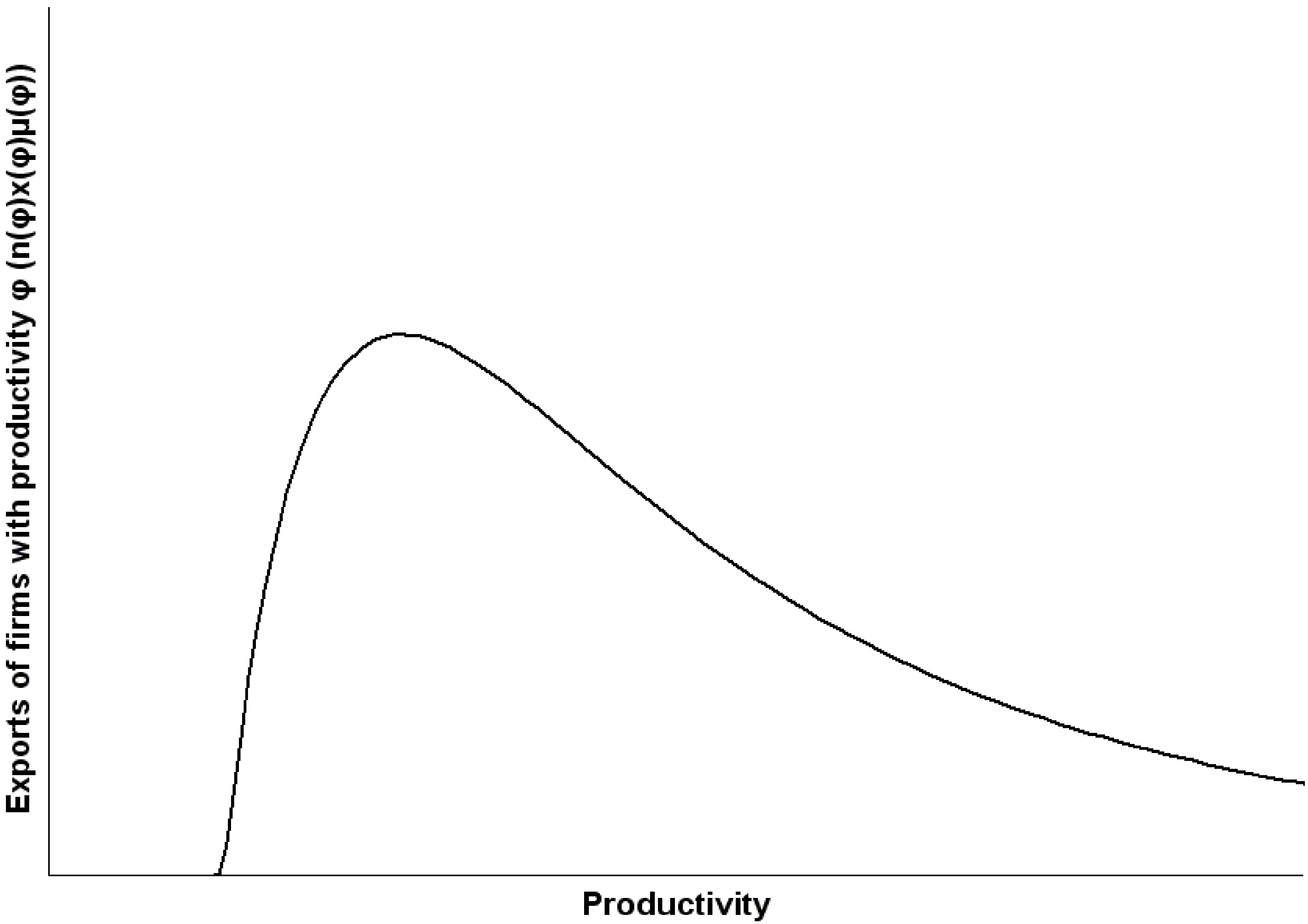
- Recent theory emphasizes increase in trade due to **many** new firms (EK02, Chaney '06 à la Melitz '03)

- **Decompose contribution of the 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)

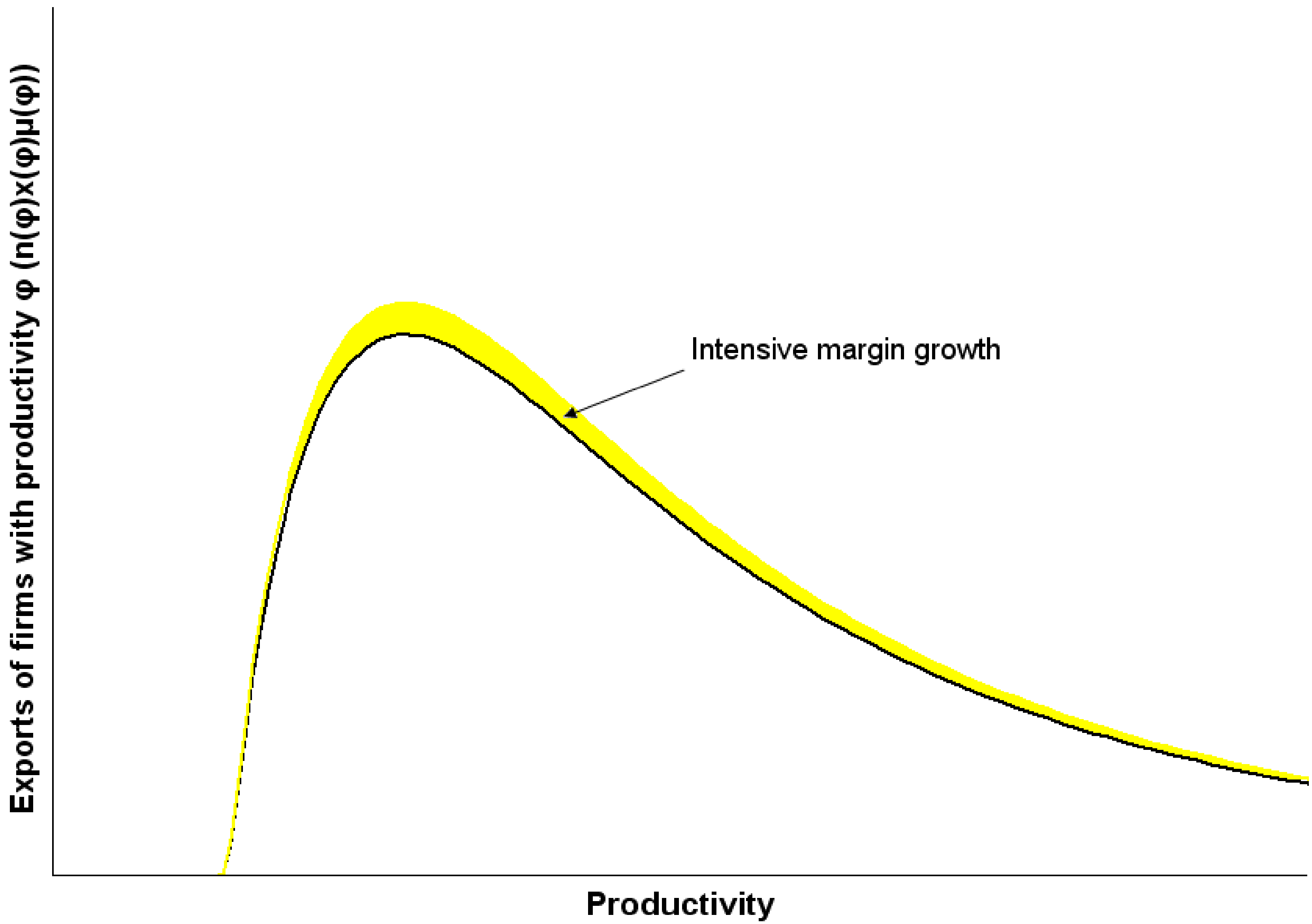
# Pareto Density and Number of Firms with Productivity $\phi$



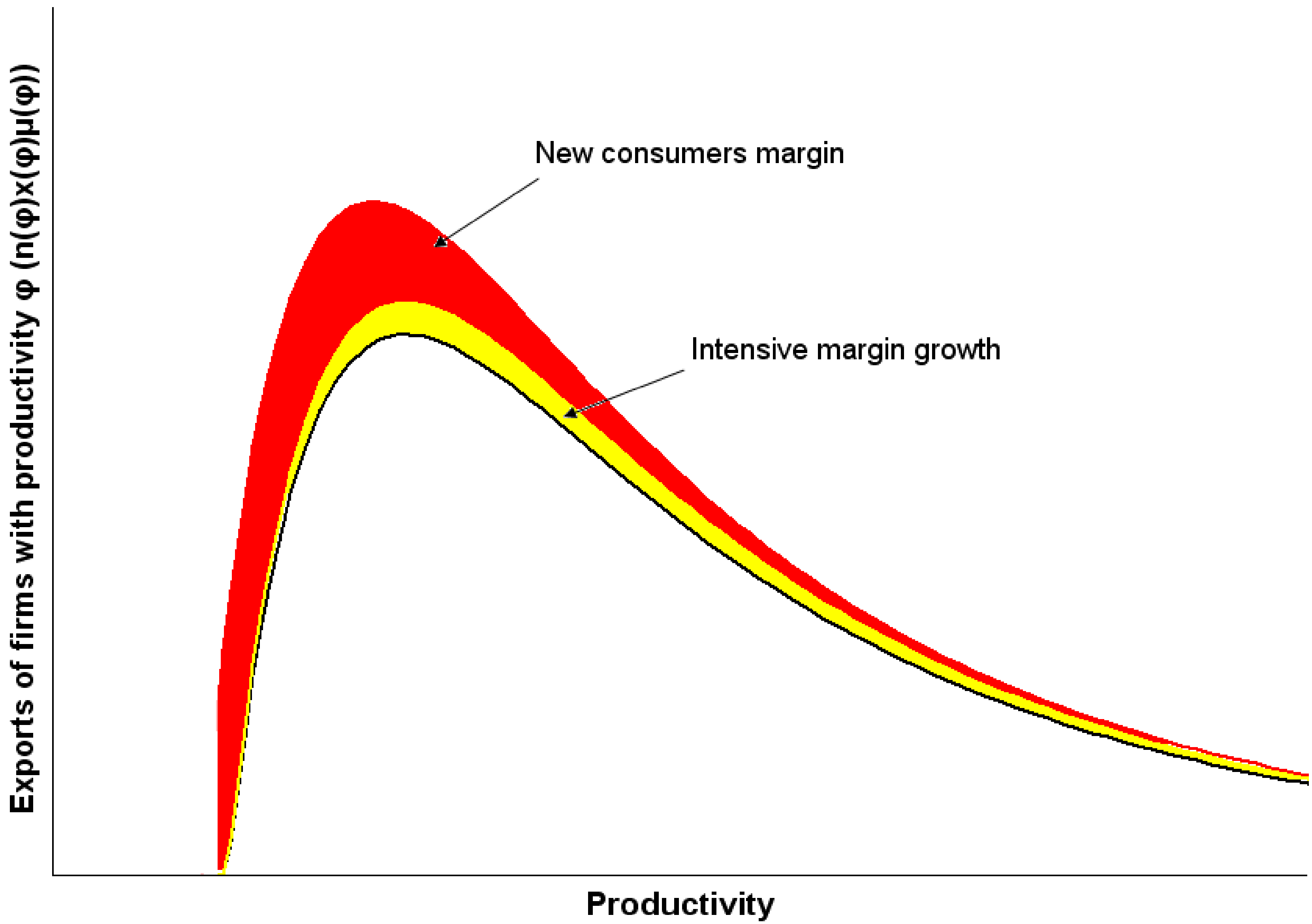
# Density of exports



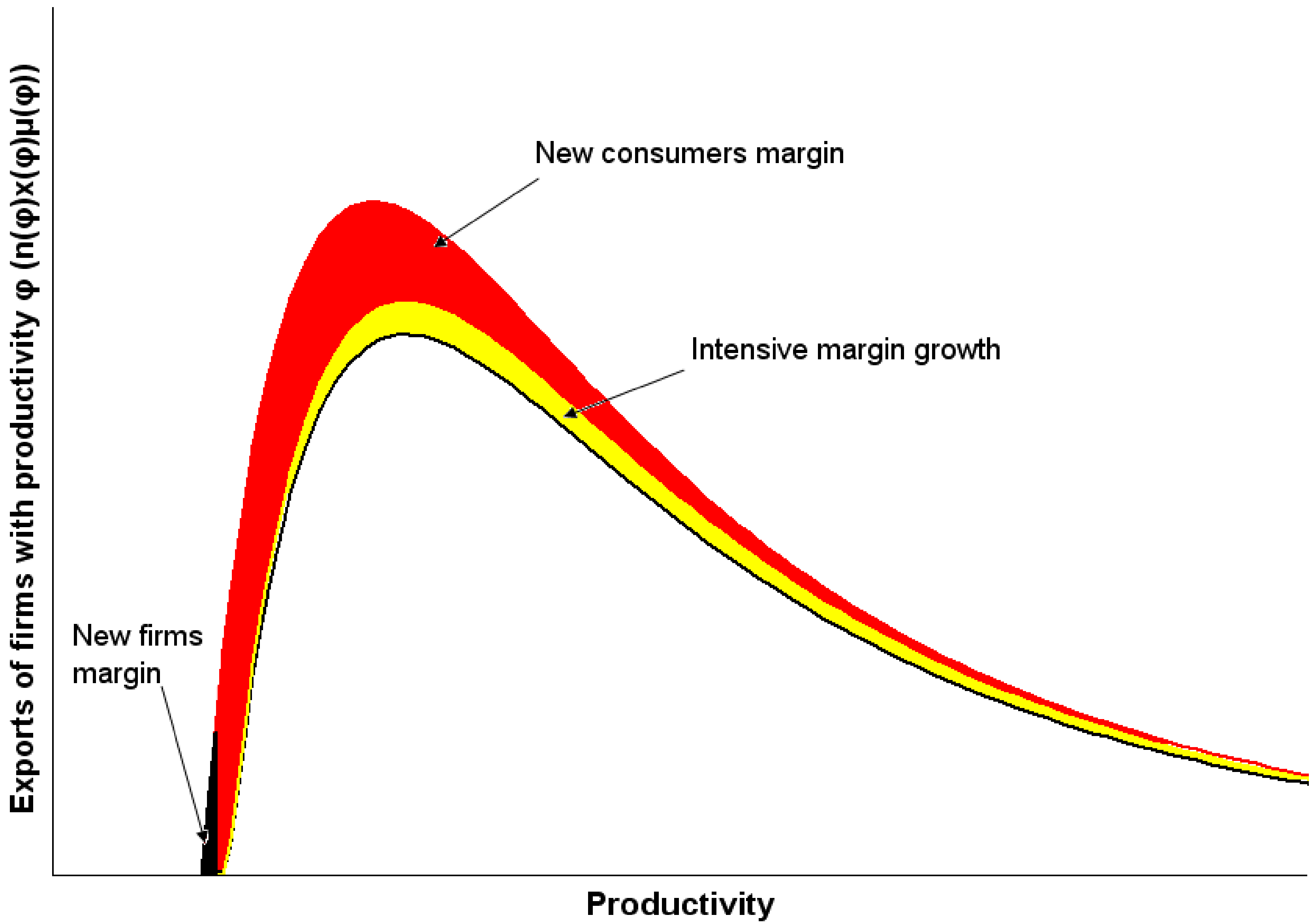
# New Consumers Margin and new trade



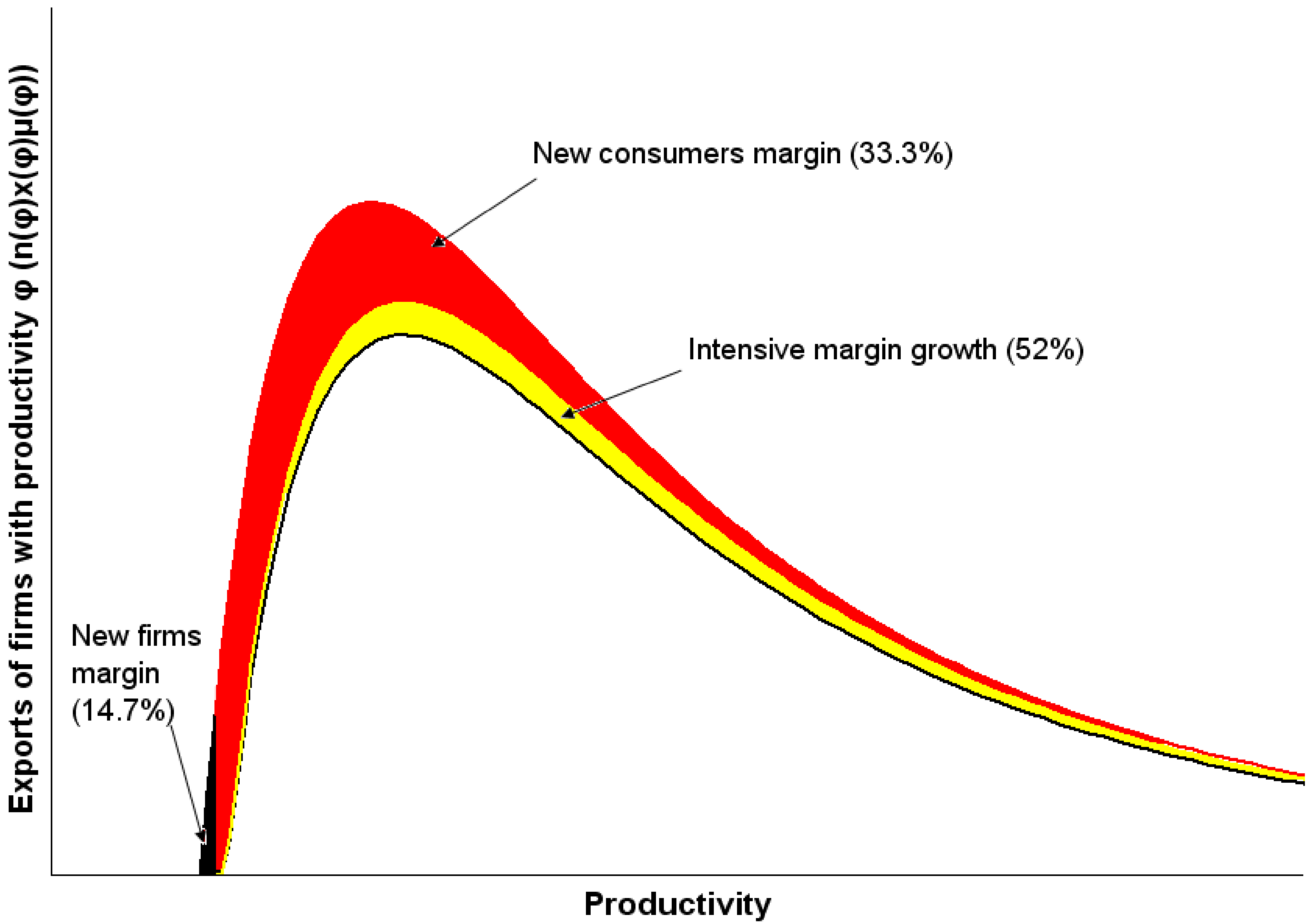
# New Consumers Margin and new trade



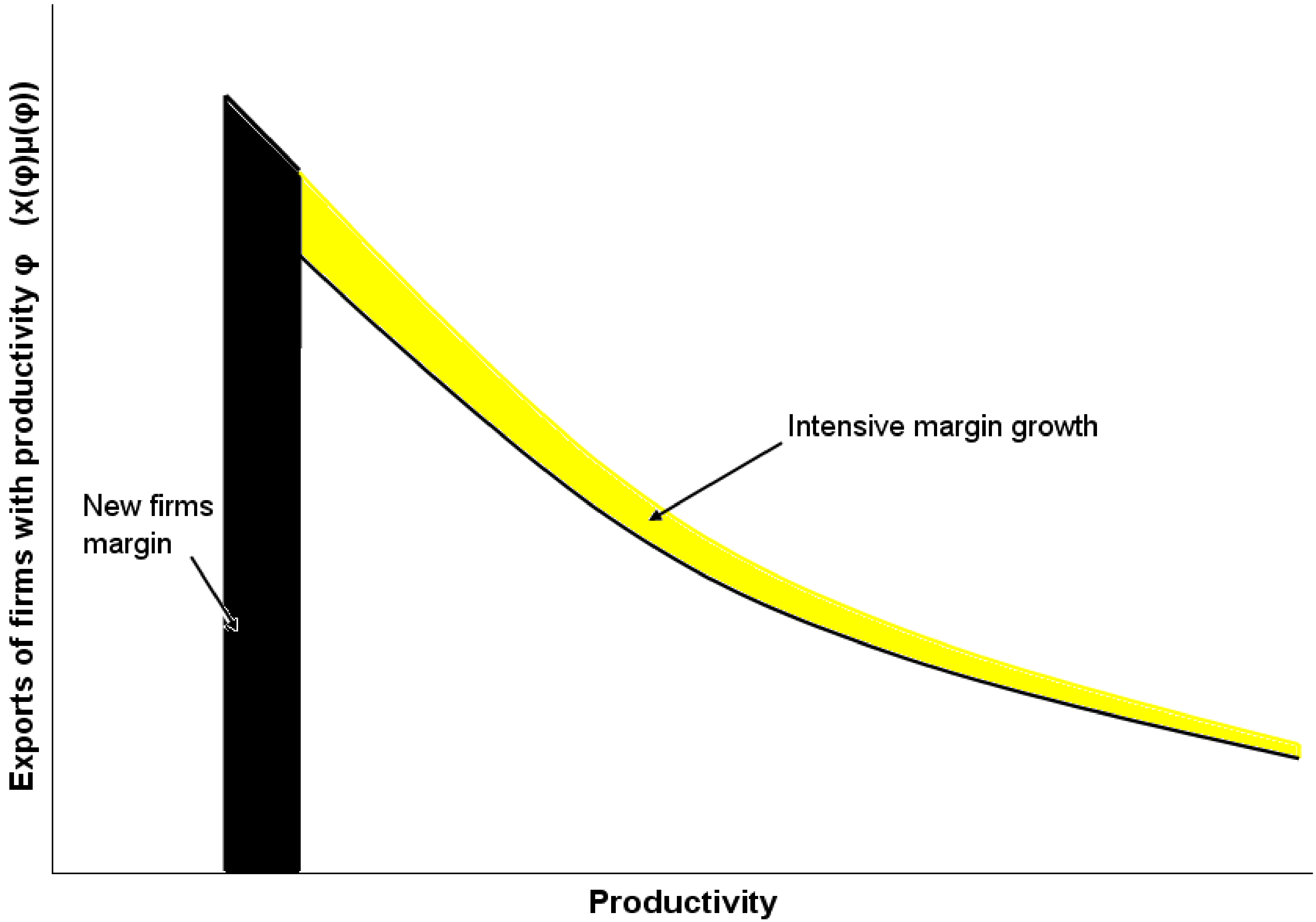
# New Consumers Margin and new trade



# New Consumers Margin and new trade



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



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