# Lecture 7: Trade with Heterogenous Firms (Theory)

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# Motivation

- The Helpman-Krugman model features universal exporting by firms in a differentiated product industry:
  - Every brand is produced by a single firm in just one country, which exports its output everywhere else in the world
- **Problem**: this does not provide a good description of firm-level data. In the data:
  1. Within a given industry, there is massive firm-level heterogeneity
  2. Fixed costs matter in export-related decisions
  3. Within a given industry, more productive firms are more likely to export
  4. Trade liberalization leads to intra-industry reallocation across firms
  5. These reallocations are correlated with productivity and export status

# Firm-level heterogeneity and trade

- Melitz (2003) will develop a model featuring facts 1 and 2 that can explain facts 3, 4, and 5
- This is by far the most influential trade paper in the last 10 years
- **Building blocks**:
  1. Krugman (1980): CES, IRS technology, monopolistic competition
  2. Hopenhayn (1992): equilibrium model of entry and exit
- From a normative point of view, Melitz (2003) may also provide new source of gains from trade if trade induces reallocation of labor from least to most productive firms

  $\rightarrow$ "New New" trade theory

# Today's lecture

Trade with heterogenous firms

- Firm-level stylized facts
- Melitz (2003)
  - Krugman (1980) meets Hopenhayn (1992)
  - Selection into Exports and the Impact of Trade

# Firm-level stylized facts

# Stylized fact #1

1 - Vast **heterogeneity** across plants / firms in productivity, capital and skill intensity

2 - Heterogeneity within industries is often as large as across industries

3 - Entry-exit, job creation-destruction in all industries

"Firm Heterogeneity and Massive Turnover''

# Stylized fact #1

## Productivity Dispersion

TABLE 2—PLANT-LEVEL PRODUCTIVITY FACTS

| Productivity measure (value added per worker) | Variability (standard deviation of log productivity) | Advantage of exporters (exporter less nonexporter average log productivity, percent) |
|---|---|---|
| Unconditional | 0.75 | 33 |
| Within 4-digit industries | 0.66 | 15 |
| Within capital-intensity bins | 0.67 | 20 |
| Within production labor-share bins | 0.73 | 25 |
| Within industries (capital bins) | 0.60 | 9 |
| Within industries (production labor bins) | 0.64 | 11 |

*Notes:* The statistics are calculated from all plants in the 1992 Census of Manufactures. The "within" measures subtract the mean value of log productivity for each category. There are 450 4-digit industries, 500 capital-intensity bins (based on total assets per worker), 500 production labor-share bins (based on payments to production workers as a share of total labor cost). When appearing within industries there are 10 capital-intensity bins or 10 production labor-share bins.

Source: Bernard, Eaton, Jensen and Kortum (2003) *AER*

# Stylized fact #1

## Firm Entry and Exit

**TABLE 2** **Entry and Exit Variables for the U.S. Manufacturing Sector (Averages over 387 Four-Digit SIC Industries)**

| | 1963–1967 | 1967–1972 | 1972–1977 | 1977–1982 |
|---|---|---|---|---|
| Entry Rate (*ER*): | | | | |
| All firms | .414 | .516 | .518 | .517 |
| Smallest firms deleted | .307 | .427 | .401 | .408 |
| Entrant Market Share (*ESH*): | | | | |
| All firms | .139 | .188 | .146 | .173 |
| Smallest firms deleted | .136 | .185 | .142 | .169 |
| Entrant Relative Size (*ERS*): | | | | |
| All firms | .271 | .286 | .205 | .228 |
| Smallest firms deleted | .369 | .359 | .280 | .324 |
| Exit Rate (*XR*): | | | | |
| All firms | .417 | .490 | .450 | .500 |
| Smallest firms deleted | .308 | .390 | .338 | .372 |
| Exiter Market Share (*XSH*): | | | | |
| All firms | .148 | .195 | .150 | .178 |
| Smallest firms deleted | .144 | .191 | .146 | .173 |
| Exiter Relative Size (*XRS*): | | | | |
| All firms | .247 | .271 | .221 | .226 |
| Smallest firms deleted | .367 | .367 | .310 | .344 |

Source: Dunne, Roberts and Samuelson (1988) *Rand Journal of Economics*

# Stylized fact #2

1 - Within an industry, only some firms export, many others do not

2 - Exporters are **larger**, **more productive**, **pay higher wages**

3 - Exports are **very** concentrated on very few big exporters

4 - **Difficult markets** are served by the best exporters

"Exporter Premia"

# Stylized fact #2

## Exporting is Rare

*Table 2*
**Exporting By U.S. Manufacturing Firms, 2002**

| *NAICS industry* | *Percent of firms* | *Percent of firms that export* | *Mean exports as a percent of total shipments* |
|---|---|---|---|
| 311 Food Manufacturing | 6.8 | 12 | 15 |
| 312 Beverage and Tobacco Product | 0.7 | 23 | 7 |
| 313 Textile Mills | 1.0 | 25 | 13 |
| 314 Textile Product Mills | 1.9 | 12 | 12 |
| 315 Apparel Manufacturing | 3.2 | 8 | 14 |
| 316 Leather and Allied Product | 0.4 | 24 | 13 |
| 321 Wood Product Manufacturing | 5.5 | 8 | 19 |
| 322 Paper Manufacturing | 1.4 | 24 | 9 |
| 323 Printing and Related Support | 11.9 | 5 | 14 |
| 324 Petroleum and Coal Products | 0.4 | 18 | 12 |
| 325 Chemical Manufacturing | 3.1 | 36 | 14 |
| 326 Plastics and Rubber Products | 4.4 | 28 | 10 |
| 327 Nonmetallic Mineral Product | 4.0 | 9 | 12 |
| 331 Primary Metal Manufacturing | 1.5 | 30 | 10 |
| 332 Fabricated Metal Product | 19.9 | 14 | 12 |
| 333 Machinery Manufacturing | 9.0 | 33 | 16 |
| 334 Computer and Electronic Product | 4.5 | 38 | 21 |
| 335 Electrical Equipment, Appliance | 1.7 | 38 | 13 |
| 336 Transportation Equipment | 3.4 | 28 | 13 |
| 337 Furniture and Related Product | 6.4 | 7 | 10 |
| 339 Miscellaneous Manufacturing | 9.1 | 2 | 15 |
| **Aggregate manufacturing** | **100** | **18** | **14** |

*Sources:* Data are from the 2002 U.S. Census of Manufactures.

Source: Bernard, Jensen, Redding and Schott (2007) *JEP*

# Stylized fact #2

## Performances

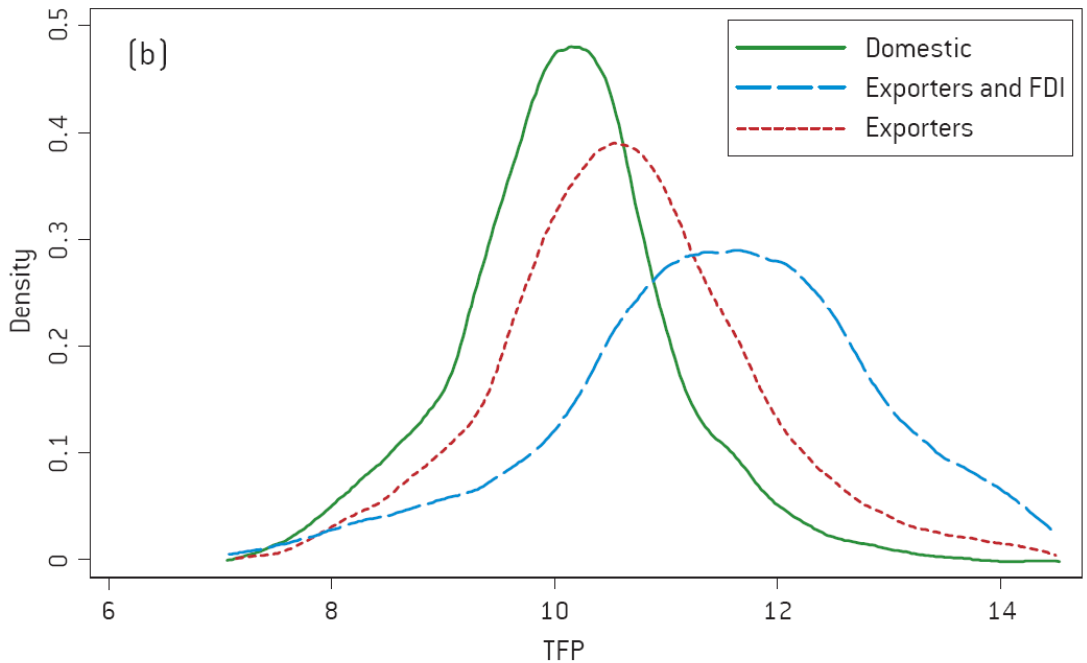
Table 4: Exporters and FDI-makers exhibit superior performance

| Country of origin | Employment premia | Value added premia | Wage premia | Capital intensity premia | Skill intensity premia |
|---|---|---|---|---|---|
| Exporters' premia | | | | | |
| Germany | 2.99 (4.39) | | 1.02 (0.06) | | |
| France | 2.24 (0.47) | 2.68 (0.84) | 1.09 (1.12) | 1.49 (5.6) | |
| United Kingdom | 1.01 (0.92) | 1.29 (1.53) | 1.15 (1.39) | | |
| Italy | 2.42 (2.06) | 2.14 (1.78) | 1.07 (1.06) | 1.01 (0.45) | 1.25 (1.04) |
| Hungary | 5.31 (2.95) | 13.53 (23.75) | 1.44 (1.63) | 0.79 (0.35) | |
| Belgium | 9.16 (13.42) | 14.8 (21.12) | 1.26 (1.15) | 1.04 (3.09) | |
| Norway | 6.11 (5.59) | 7.95 (7.48) | 1.08 (0.68 | 1.01 (0.23) | |
| FDI-makers' premia | | | | | |
| Germany | 13.19 (2.86) | | | | |
| France | 18.45 (7.14) | 22.68 (6.1) | 1.13 (0.9) | 1.52 (0.72) | |
| Belgium | 16.45 (6.82) | 24.65 (11.14) | 1.53 (1.2) | 1.03 (0.82) | |
| Norway | 8.28 (4.48) | 11 (5.41) | 1.34 (0.76) | 0.87 (0.13) | |

Source: EFIM. Note: The table shows premia of the considered variable as the ratio of exporters over non exporters (standard deviation ratio between brackets). France, Germany, Hungary, Italy and the United Kingdom have large firms only, Belgian and Norwegian data are exhaustive.

# Stylized fact #2

## TFP distributions




Source: EFIM. Note: Data for Belgium 2004.

# Stylized fact #2

## Skewness

Table 1: Share of exports for top exporters in 2003, total manufacturing

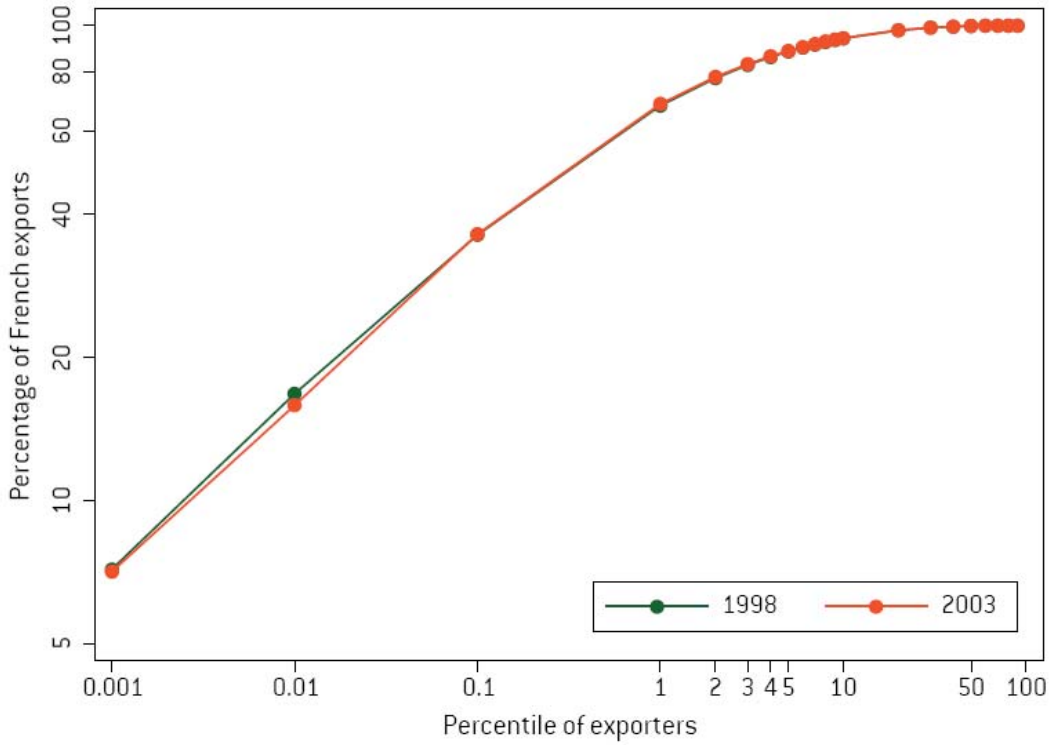
| Country of origin | Top one percent | Top five percent | Top 10 percent |
|---|---|---|---|
| Germany | 59 | 81 | 90 |
| France | 44 (68) | 73 (88) | 84 (94) |
| United Kingdom | 42 | 69 | 80 |
| Italy | 32 | 59 | 72 |
| Hungary | 77 | 91 | 96 |
| Belgium | 48 | 73 | 84 |
| Norway | 53 | 81 | 91 |

Source: EFIM. Note: France, Germany, Hungary, Italy and the UK have large firms only; Belgian and Norwegian data is exhaustive. Numbers in brackets for France are percentages from the exhaustive sample[5].

# Stylized fact #2

## Skewness

Figure 2: The superstar exporters phenomenon, logarithmic transformation (France, exhaustive sample)




Source: EFIM.

# Stylized fact #2

## Skewness

**Table 3: Distribution of French exporters over products and markets**[9]

*Share of French exporters in 2003 (total number exporters: 99259)*

| | Number of countries | | | |
|---|---|---|---|---|
| No. of products | 1 | 5 | 10+ | Total |
| 1 | 29.61 | 0.36 | 0.22 | 34.98 |
| 5 | 0.76 | 0.45 | 0.62 | 4.73 |
| 10+ | 0.95 | 0.89 | 10.72 | 18.57 |
| Total | 42.59 | 4.12 | 15.54 | 100 |

*Share of French exports in 2003 (total exports: 314.3 billion €)*

| | Number of countries | | | |
|---|---|---|---|---|
| No. of products | 1 | 5 | 10+ | Total |
| 1 | 0.7 | 0.08 | 0.38 | 1.86 |
| 5 | 0.3 | 0.08 | 1.06 | 1.97 |
| 10+ | 0.28 | 0.45 | 76.3 | 81.36 |
| Total | 2.85 | 1.55 | 85.44 | 100 |

Source: EFIM.

# Melitz (2003)

# Melitz (2003): basic framework

**On demand side: CES preferences**

$$\max_{q(\omega)} U \equiv \left( \int_{\Omega} q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

$$s.t. \int_{\Omega} p(\omega) q(\omega) d\omega = R, \tag{2}$$

where $\Omega$ is the set of available varieties, $\sigma > 1$ the elasticity of substitution, and R is the total spending.

# Melitz (2003): basic framework

This yields the usual **demand** for each variety:

$$q(\omega) = \frac{R}{P}\left[\frac{p(\omega)}{P}\right]^{-\sigma}, \tag{3}$$

where $P = \left(\int_{\Omega} p(\omega)^{1-\sigma} d\omega\right)^{\frac{1}{1-\sigma}}$ is the ideal price index.

**On the supply side:**

- Monopolistic competition; every variety is produced by a single firm and there is free entry into the industry.
- Production incurs a **fixed cost** $f$ (as in Krugman 80)
- New: marginal cost, $\frac{1}{\varphi}$, is **firm-specific**.

  i.e., the total cost (TC) of production, $TC(q, \varphi) = f + \frac{q(\varphi)}{\varphi}$.

# Melitz (2003): basic framework

Firms with higher $\varphi$ are more productive. Higher productivity firms charge lower prices, produce more output, and obtain higher revenues $r(\varphi)$ and higher profits $\pi(\varphi)$ :

$$p(\varphi) = \frac{\sigma}{\sigma - 1}\frac{1}{\varphi}; \quad q(\varphi) = RP^{\sigma-1}\left(\frac{\sigma - 1}{\sigma}\varphi\right)^{\sigma} \tag{4}$$

$$r(\varphi) = p(\varphi)q(\varphi) = \left(\frac{\sigma - 1}{\sigma}\varphi P\right)^{\sigma-1} R \tag{5}$$

$$\pi(\varphi) = \frac{r(\varphi)}{\sigma} - f \tag{6}$$

How to move from the firm to the aggregate level?

# Melitz (2003):Aggregation

Assume a mass $M$ of firms and a distribution $\mu(\varphi)$ over $\mathbb{R}^+$ for productivity. We can define an aggregate measure of productivity

$$\widetilde{\varphi} = \left( \int_{\mathbb{R}^+} \varphi^{\sigma-1} \mu(\varphi) d\varphi \right)^{\frac{1}{\sigma-1}},$$

which yields the following aggregate variables:

$$P = M^{\frac{1}{1-\sigma}} p(\widetilde{\varphi}) \quad ; \quad R = Mr(\widetilde{\varphi}) \quad ; \quad \Pi = M\pi(\widetilde{\varphi})$$

# Melitz (2003): Entry and Exit

- Prior to entry, firms face productivity uncertainty:
  - a firm pays a fixed cost of entry $f_e$ in units of labor;
  - a firm then draws its productivity $\varphi$ from a known distribution $G(\varphi)$ with density $g(\varphi) = G'(\varphi)$;
  - After observing $\varphi$, a producer decides whether to exit or produce.
- Every firm faces a probability $\delta$ of death per unit time.

- For the rest of the firms, what is the condition to produce?

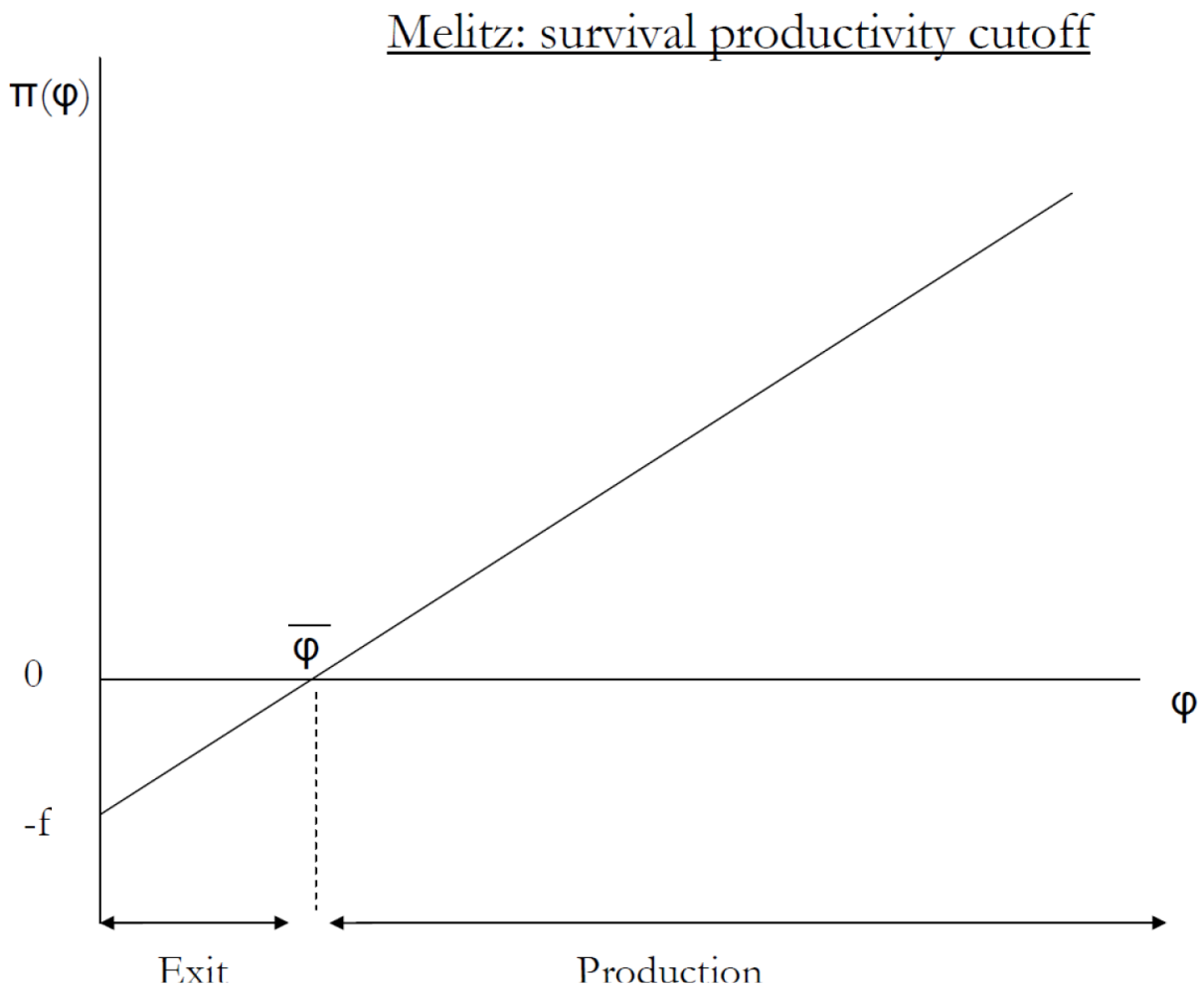
# Firm behavior

- Given stationarity, a firm with productivity $\varphi$ earns profits $\pi(\varphi)$ in every period, until it is hit by a shock. The expected value of the firm is:

$$v(\varphi) = max\left\{0, \sum_{t=0}^{\infty}(1-\delta)^t\pi(\varphi)\right\} = max\left\{0, \frac{1}{\delta}\pi(\varphi)\right\} \qquad (7)$$

- It is clear from (6) and (7) that there is a unique threshold productivity $\overline{\varphi}$ such that $v(\varphi) > 0$ if and only if $\varphi > \overline{\varphi}$.

# Melitz (2003)


Melitz: survival productivity cutoff
π(φ)
0
-f
φ
φ
Exit
Production

# Industry Equilibrium

- Free entry ensures that, in the industry equilibrium, the expected discounted value of profits for a potential entrant equal the fixed cost of entry, or

$$\int_{t=0}^{\infty} v(\varphi)g(\varphi)d\varphi = f_e \tag{8}$$

# Industry Equilibrium

- **Distribution of productivity in equilibrium**: (why?)

$$\begin{aligned} \mu(\varphi) &= \frac{g(\varphi)}{1 - G(\overline{\varphi})} \quad \textit{if} \quad \varphi > \overline{\varphi} \\ &= 0, \quad \textit{otherwise} \end{aligned} \tag{9}$$

- Aggregate productivity can be written as a function of $\overline{\varphi}$

$$\widetilde{\varphi} = \left( \frac{1}{1 - G(\overline{\varphi})} \int_{\overline{\varphi}}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi \right)^{\frac{1}{\sigma-1}}$$

# Industry Equilibrium

- Average revenues and profits are:

$$\bar{r} \equiv r(\tilde{\varphi}) = \left[\frac{\tilde{\varphi}(\overline{\varphi})}{\overline{\varphi}}\right]^{\sigma-1} r(\overline{\varphi})$$

$$\text{and } \bar{\pi} \equiv \pi(\tilde{\varphi}) = \left[\frac{\tilde{\varphi}(\overline{\varphi})}{\overline{\varphi}}\right]^{\sigma-1} \frac{r(\overline{\varphi})}{\sigma} - f \text{ with } \frac{r(\overline{\varphi})}{\sigma} = f \text{ (why?)}$$

- Now we can express the **zero cutoff profit (ZCP)** condition

$$\pi(\overline{\varphi}) = 0 \Longleftrightarrow \bar{\pi} = f\left[\left(\frac{\tilde{\varphi}(\overline{\varphi})}{\overline{\varphi}}\right)^{\sigma-1} - 1\right] \qquad \text{(ZCP)}$$

# Industry Equilibrium

- Before entry, all potential entrants consider their expected profit in case of entry and compare them with the cost of entry $f_e$
- The net value of entering today ($t = 0$) given the constant probability of dying each period is:

$$v^E = \frac{\overline{\pi}}{\delta}(1 - G(\overline{\varphi})) - f_e \tag{10}$$

- Firms will enter until the net value of entering is driven down to zero (i.e. expected profit for all potential entrants is zero)
- **Free entry (FE) condition**: $v^E = 0$
- As in Krugman: as more firms enter, market shares shrink.

# Industry Equilibrium

**Three conditions:**
(i) ZCP condition
(ii) FE condition
(iii) labor market clearing (total expenditure on differentiated goods must equal the total revenue of consumers)

$$\begin{cases} \pi(\bar{\varphi}) = 0 & \text{(Zero Cutoff Profits)} \\ v^E = 0 & \text{(Free Entry)} \\ R = L & \text{(Labor Market Clearing)} \end{cases} \Leftrightarrow \begin{cases} \bar{\pi} = f\left[\left(\frac{\tilde{\varphi}(\bar{\varphi})}{\bar{\varphi}}\right)^{\sigma-1} - 1\right] & (ZCP) \\ \bar{\pi} = \frac{\delta f^E}{1-G(\bar{\varphi})} & (FE) \\ M = \frac{L}{\sigma(\bar{\pi}+f)} & (LMC) \end{cases}$$

We can prove that ZCP and FE have respectively a positive and negative slope and intersest once

# Industry Equilibrium: Intuition

**ZCP**: average profit in the economy for a given $\overline{\varphi}$. When cutoff is higher, it's because it's harder to be profitable: average profit decrease with the cutoff

**FE**: traditional zero profit condition but for expected profit

- average profit for existing firms is positive, but expected profit of all firms is zero
- higher cutoff : $\rightarrow$ less firms, more productive one average: higher profit

# Industry Equilibrium

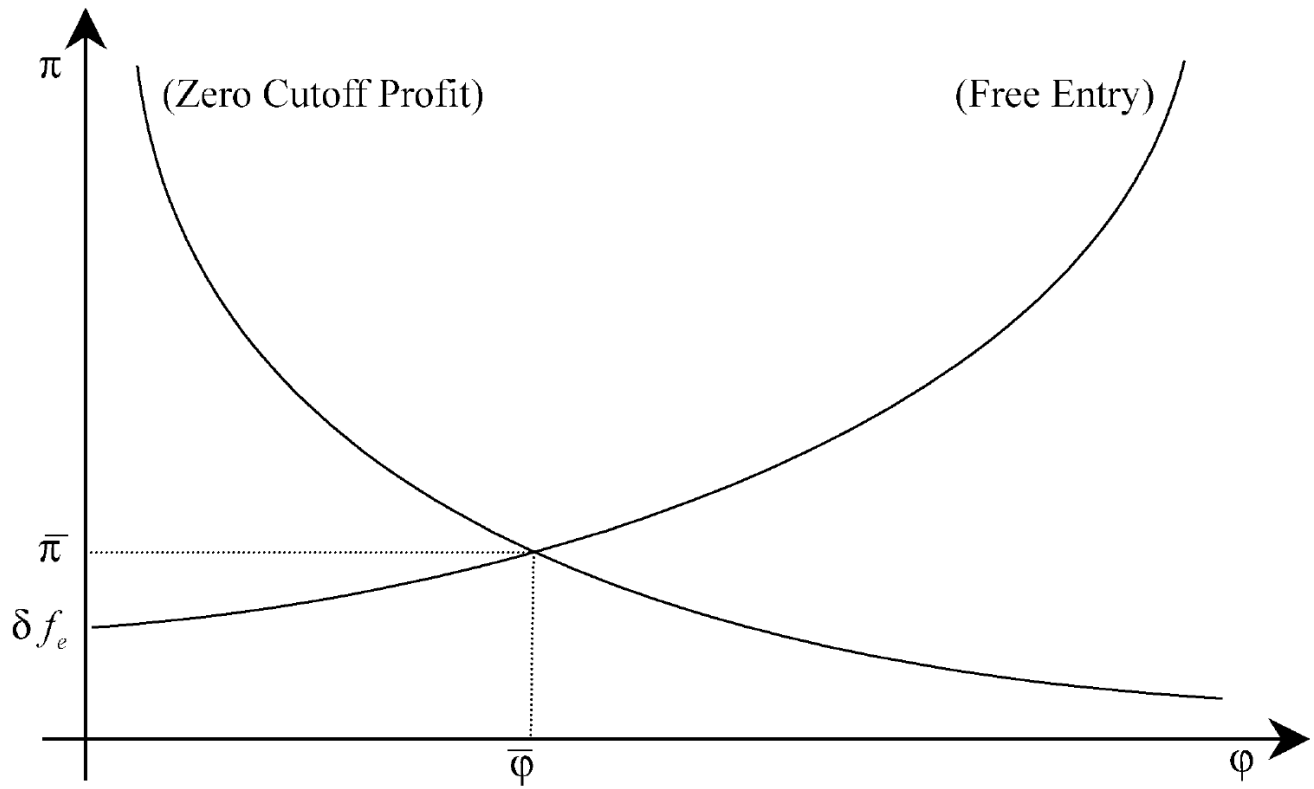



FIGURE 1.—Determination of the equilibrium cutoff $\bar{\varphi}$ and average profit $\bar{\pi}$.

# Melitz (2003): Trade equilibrium

**Consider 2 identical countries.**

Trade costs: (i) iceberg transport cost $\tau$; (ii) additional fixed cost (denominated in labor, with wages normalized to 1) $f^X$

More productive firms:

- charge lower price, capture a higher market share, and generate more profit on each market...

- *so are more likely to export*

# Melitz (2003): Trade equilibrium

**Formally**

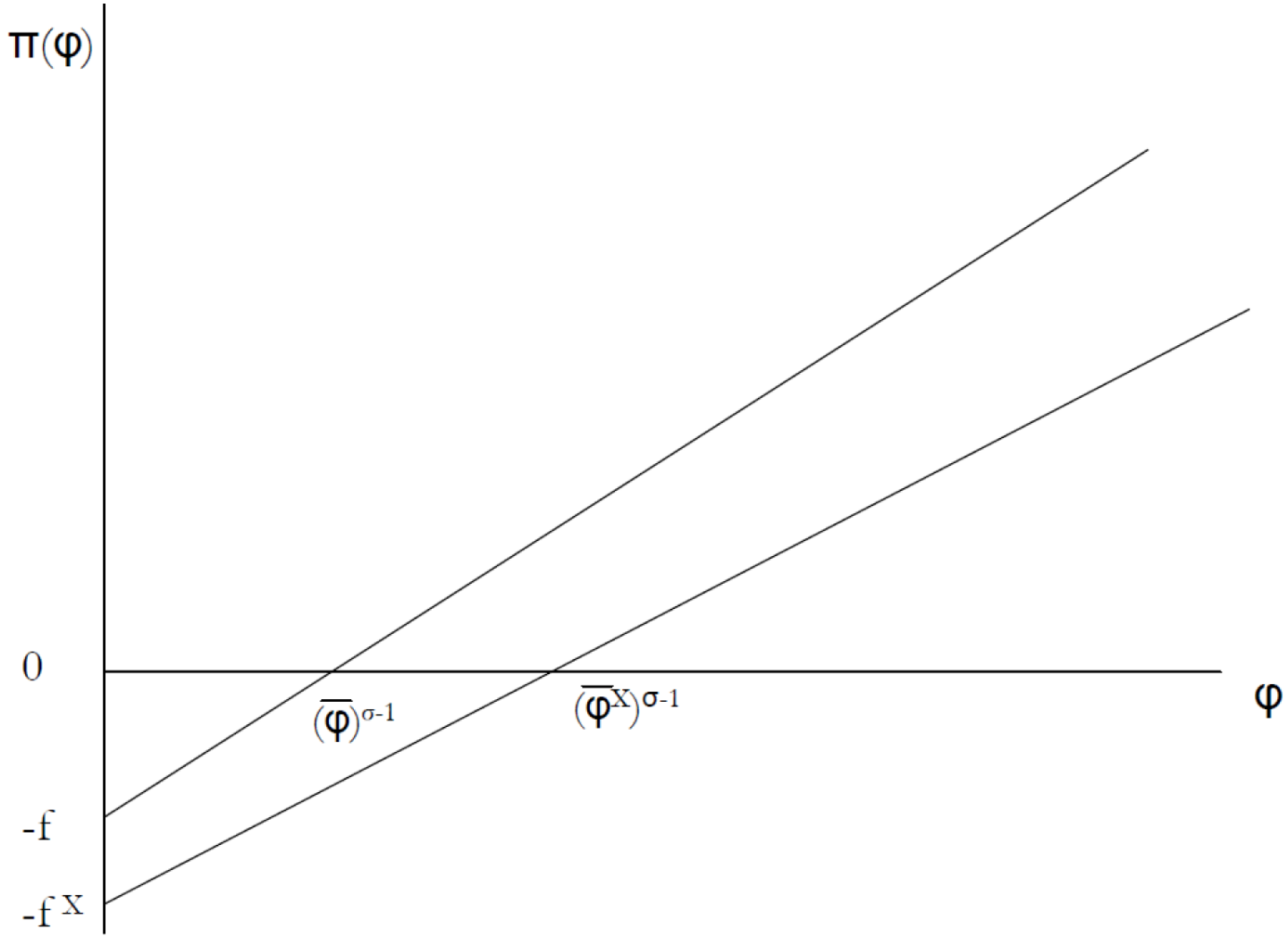
$p^X = \tau p$

$\pi^X(\varphi) = \left(\frac{\sigma-1}{\sigma}\frac{\varphi}{\tau}P\right)^{\sigma-1}\frac{R}{\sigma} - f^X$

and all firms with $\pi^X(\varphi) \geq 0$ export

$\rightarrow$ define the productivity cutoff for exporting $\overline{\varphi}^X$

# Melitz (2003): Trade equilibrium



# Melitz (2003): Trade equilibrium

**ZCP** for exports: $\pi^X(\overline{\varphi}^X) = 0 \Longleftrightarrow \overline{\varphi}^X = \tau \left(\frac{f^X}{f}\right)^{\frac{1}{\sigma-1}} \overline{\varphi}$

Average profit that a firm earns conditional on surviving:

$\overline{\pi} = \pi^D(\widetilde{\varphi}(\overline{\varphi})) + prob^X \pi^X(\widetilde{\varphi}(\overline{\varphi}^X))$

where $prob^X = \frac{1-G(\overline{\varphi}^X)}{1-G(\overline{\varphi})}$ is the probability of exporting conditional on survival

# Melitz (2003): Trade equilibrium

Labor market clearing and FE conditions are the same, but ZCP change.

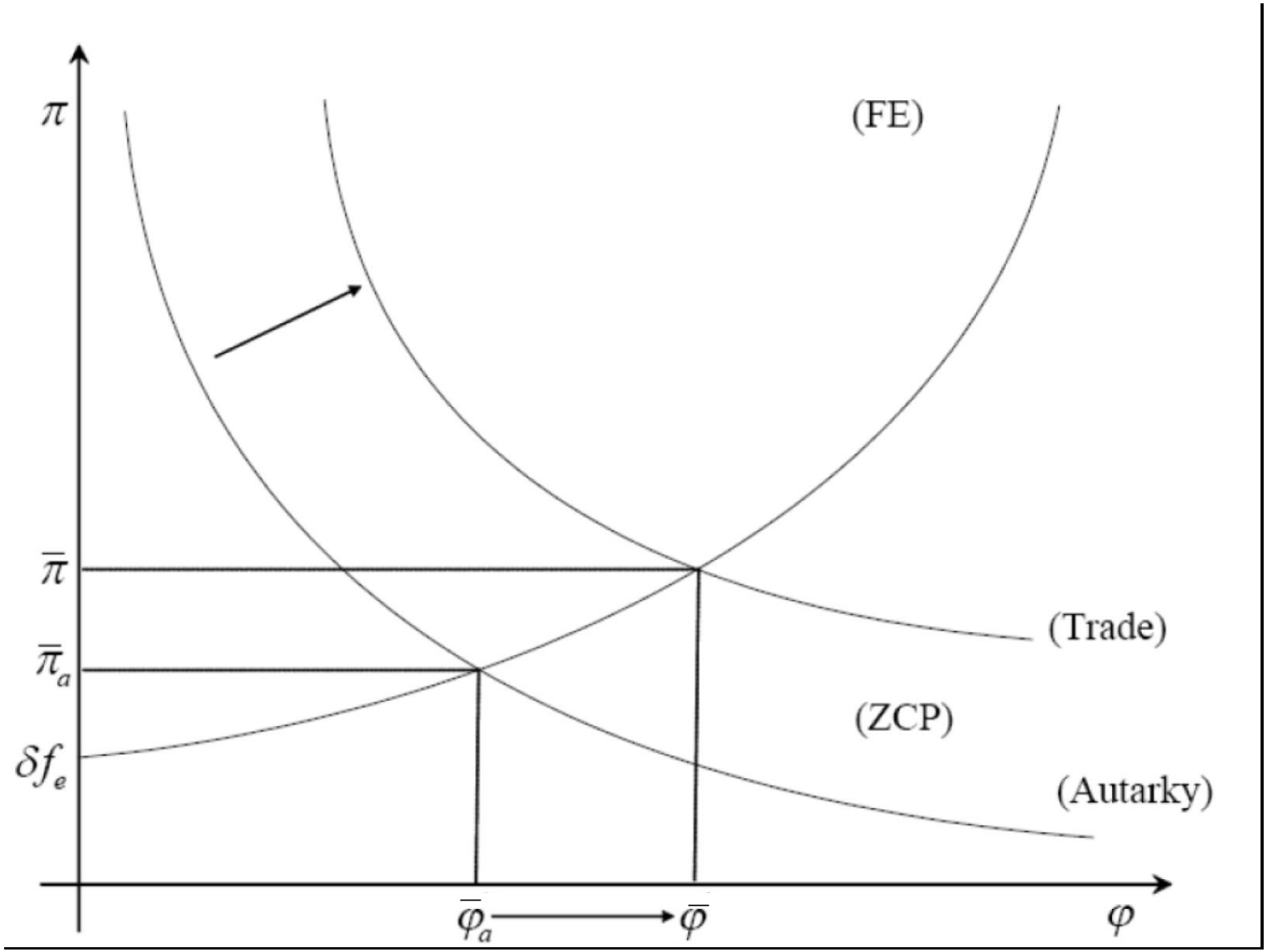
**Equilibrium is given by:**

$$\bar{\pi} = \pi^D\left(\tilde{\varphi}\right) + prob^X \pi^X\left(\tilde{\varphi}^X\right)$$

$$\text{where } prob^X = \frac{1 - G\left(\bar{\varphi}^X\right)}{1 - G\left(\bar{\varphi}\right)}$$

$$\begin{cases} \bar{\varphi}^X = \tau\left(\frac{f^X}{f}\right)^{\frac{1}{\sigma-1}}\bar{\varphi} & (ZCP^X) \\ \bar{\pi} = f\left(\left[\frac{\tilde{\varphi}(\bar{\varphi})}{\bar{\varphi}}\right]^{\sigma-1} - 1\right) + prob^X f^X\left(\left[\frac{\tilde{\varphi}(\bar{\varphi}^X)}{\bar{\varphi}}\right]^{\sigma-1} - 1\right) & (ZCP) \\ \bar{\pi} = \frac{\delta f^E}{1-G(\bar{\varphi})} & (FE) \\ M = \frac{L}{\sigma(\bar{\pi}+f+prob^X f^X)} & (LMC) \end{cases}$$

# Melitz (2003): Trade equilibrium



# Melitz (2003): Trade equilibrium

- FE condition relates average profit to the cutoff: unchanged under trade
- ZCP now contains a new term: shifts upward

  $\rightarrow$ the cutoff rises: less productive firms are wiped out

  $\rightarrow$ average profit increases

What is the intuition behind this result?

# Melitz (2003): Intuition

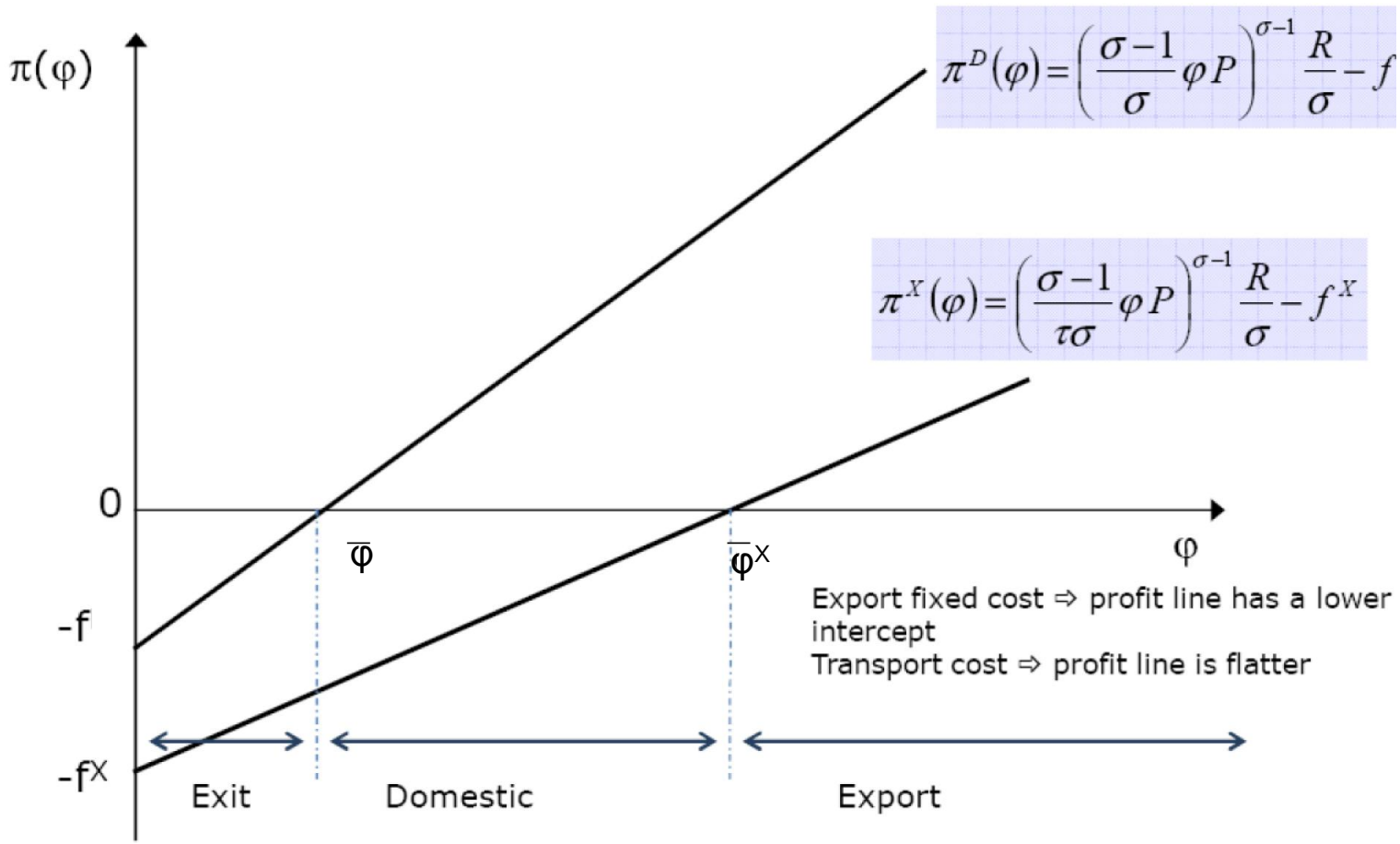
1. Domestic firms have to face the "competition" from the best foreign firms that export
   - Adjustment in the price index: more firms, lower price index, lower demand addressed to each all firms
   - Reduces market shares and profits for all firms (in a proportional way due to the CES assumption)
   - The smaller firms are not profitable enough anymore and exit

2. Not a standard competition effect: markups are constant (CES utility)

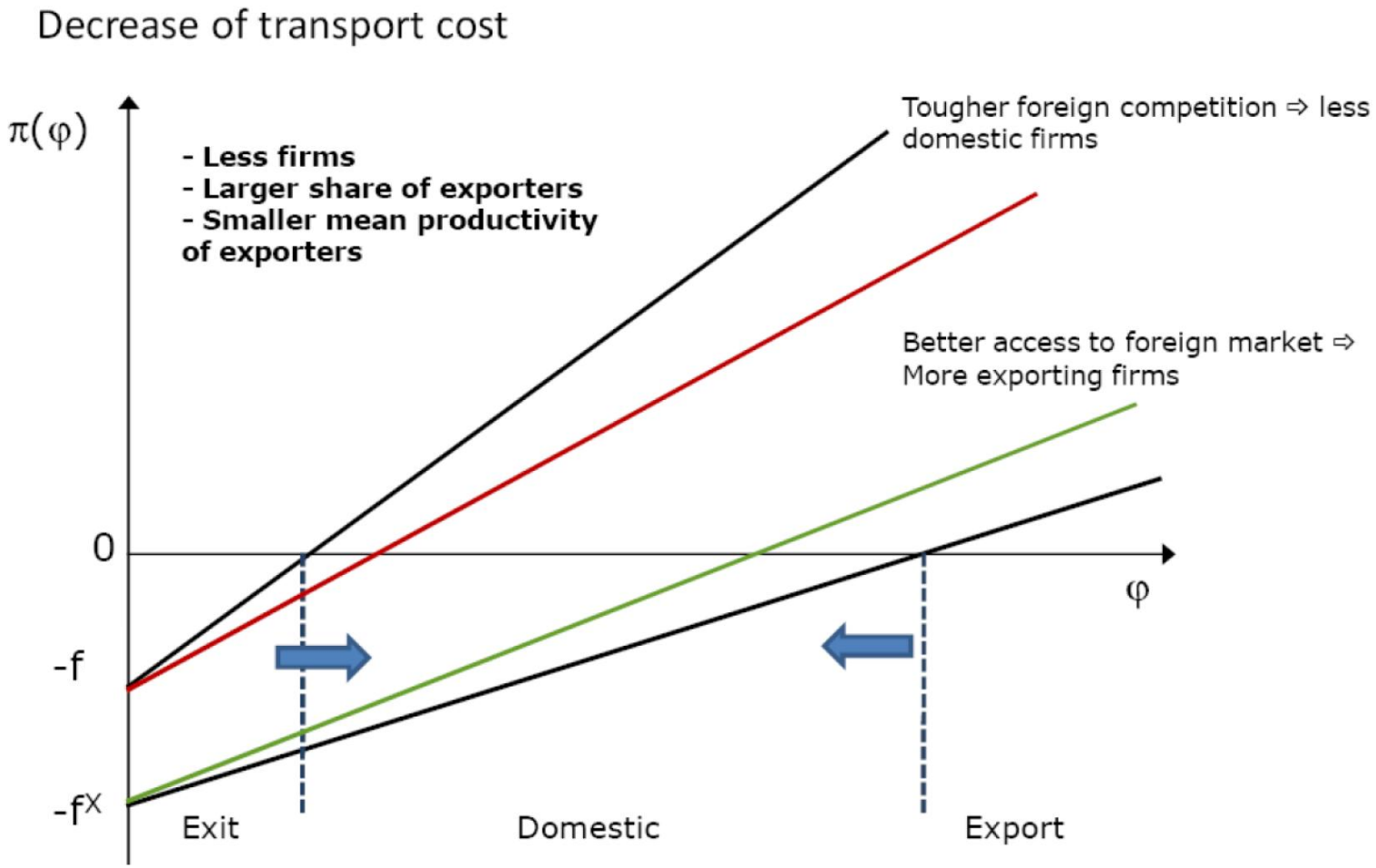
3. Melitz interprets this as labor market competition (even if wages are fixed), as real wage increases
   - Intuition: the most productive firms can trade. They expand their production, hire more workers, which pushes up wages and make the least productive firms become unprofitable

# Melitz (2003): Trade equilibrium

Let's decompose the effect of trade



# Melitz (2003): Trade equilibrium



# Melitz (2003): Summary

**Take-away**

1. Explain empirical regularities: most firms do not export, exporters are bigger / more productive

2. Shows multiple gains from trade in a GE model

3. Needs to assume an explicit distribution of $\varphi$ to have prediction on aggregate trade flows

# Acknowledgment

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