Recent advances in the field of Trade Theory

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Session 2:
The heterogeneous firms model of international trade

The heterogeneous firm model of international trade

- Motivations
- The Melitz (2003) model
  - Assumptions
  - Equilibrium in closed economy
  - Open economy results
  - Testable implications
- Empirical evidence

The heterogeneous firm model of international trade

Motivations

- Until the 1980s, the "old" trade theory did not consider intra-industry trade for simplicity, but strong empirical evidence showed that a big share of world trade is intra-industry (Grubel and Lloyd 1975)

- The "new" trade theory, by including imperfect competition and increasing return to scale, predicts intra-industry trade (Krugman 1979)

- But the "new" trade models do not consider firms differences within sectors that we showed in the former lecture to be large

- Melitz (2003) is the first attempt to consider firms differences (in productivity levels) in a model of international trade. This new class of models add:
  - Heterogeneity with respect to firm's marginal costs
  - Fixed entry costs for each market (to be added to the fixed cost for developing a new variety)

The heterogeneous firm model of international trade

Motivations

- The Melitz model is a dynamic model with heterogeneous firms where opening to trade leads to:
  - Reallocation of resources within an industry
  - Low productivity firms exit
  - High productivity firms expand so there is a change in industry composition
  - High productivity firms enter the export market
  - No change in firm productivity

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Melitz (2003): assumptions

- Single factor: labor with wage normalized to one
- Factor price equalization works in equalizing w and w* → w=w*=1 → firms heterogeneity is given by unit labor requirement (α)
- Firms enter the foreign market by paying sunk entry cost (f_x)
- Firms enter the domestic market by paying sunk cost (f_d)
- Firms produce horizontally differentiated varieties with a fixed cost of production (f_I)
- Firms observe their productivity (φ) from a distribution $G(\varphi)$ with support $0 \leq \varphi \leq \varphi_0$
- All firms face the same fixed costs but have different productivity levels

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Melitz (2003): demand side

- Consumer side of the economy follows the traditional Dixit-Stiglitz structure
- Preferences $$Q = \left[\int_{k \in \Omega} q(k)^{\frac{\sigma-1}{\sigma}} dk \right]^{\frac{\sigma}{\sigma-1}}$$
- Where q(k) is the quantity consumed of variety k and σ>1 is the elasticity of substitution among varieties (people love varieties)
- Price Index $$P = \left[\int_{k \in \Omega} p(k)^{1-\sigma} dk \right]^{\frac{1}{1-\sigma}}$$ where p(k) is the price of variety k
- ***Consumers love varieties which have a certain degree of substitutability among themselves***

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Melitz (2003): supply side

- Continuum of firms producing a different variety k (monopolistic competition)

- Total cost of production (i.e. total labor requirement) is given by the fixed cost for producing a certain variety (f_I) plus the labor requirement for each product multiplied by the total production level (q(k)):

$$L = f_I + \frac{q(k)}{\varphi(k)}$$

- Pricing rule: $p(\varphi) = \frac{mc}{\rho\varphi}$

- Where 1/ρ=σ/σ-1 is the mark-up; notice that having normalized wages to one, marginal costs *mc* will also be equal to one

Melitz (2003): supply side

- Thus the profit maximization function is:

$$\pi(\varphi) = \max_{q(\varphi)} \left\{ p(\varphi)q(\varphi) - f_I - \frac{q(\varphi)}{\varphi} \right\} \Rightarrow \frac{r(\varphi)}{\sigma} - f_I$$

- Where r(φ) is the revenue function

- ***The intuition:*** *firms differ only in terms of their revealed productivity level that determines how many workers the firm needs to produce one unit of final good ➔ firm's profit function is increasing with its productivity level (which is exogenously drawn)*

Melitz (2003): aggregation

- At the equilibrium there will be M firms (and hence M varieties)
- Thus all firms can be aggregated taking into account the distribution of productivities across firms (as it is the only source of heterogeneity) and creating a weighted average of firm productivity levels:

$$\tilde{\varphi} = \left[\int_{k \in \Omega} \varphi^{1-\sigma} \mu(\varphi) d\varphi \right]^{\frac{1}{1-\sigma}}$$

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Melitz (2003): firm entry and exit

- Prior to entry firms are identical
- In order to enter, firms must pay a fixed cost f_d (in units of labor)
- Then firms draw their productivity parameter φ from the distribution G(φ)
- Given the "revealed" productivity level, firms can exit (if profits are negative) or stay in (positive profits)
- Thus the cut-off productivity level is given by: π(φ*)=0
- Since all firms with φ<φ* exit the market, the aggregate productivity level is now function of the cut-off level

$$\tilde{\varphi}(\varphi^*) = \left[\frac{1}{1-G(\varphi^*)} \int_{\varphi^*}^{\infty} \varphi^{1-\sigma} g(\varphi) d\varphi \right]^{\frac{1}{1-\sigma}}$$

Melitz (2003): zero cut-off profit condition

- At the cut-off level profits are zero, so revenues equal average costs r(φ*)=σf, so the average profits are

$$\bar{\pi} = \left(\frac{\tilde{\varphi}(\varphi^*)}{\varphi^*}\right)^{\sigma-1} \frac{r(\varphi^*)}{\sigma} - f = \left(\frac{\tilde{\varphi}(\varphi^*)}{\varphi^*}\right)^{\sigma-1} \frac{\sigma f}{\sigma} - f = fk(\varphi^*)$$

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Melitz (2003): free entry condition

- All incumbent firms earn positive profits
- Present value of the average profits flows is $v = \sum_t (1-\delta)^t \bar{\pi}$
- Average value of firms conditional on successful entry is: $\bar{v} = \int_{\varphi^*}^{\infty} v(\varphi)\mu(\varphi)d\varphi$
- So the net value of entry is $V = P\bar{v} - f = \frac{1-G(\varphi^*)}{\delta}\bar{\pi} - f$ where P is the probability to be in the market and δ is the firm-death probability
- The net value of entry has to be zero under free entry condition

$$\bar{\pi} = \frac{\delta}{1-G(\varphi^*)}$$

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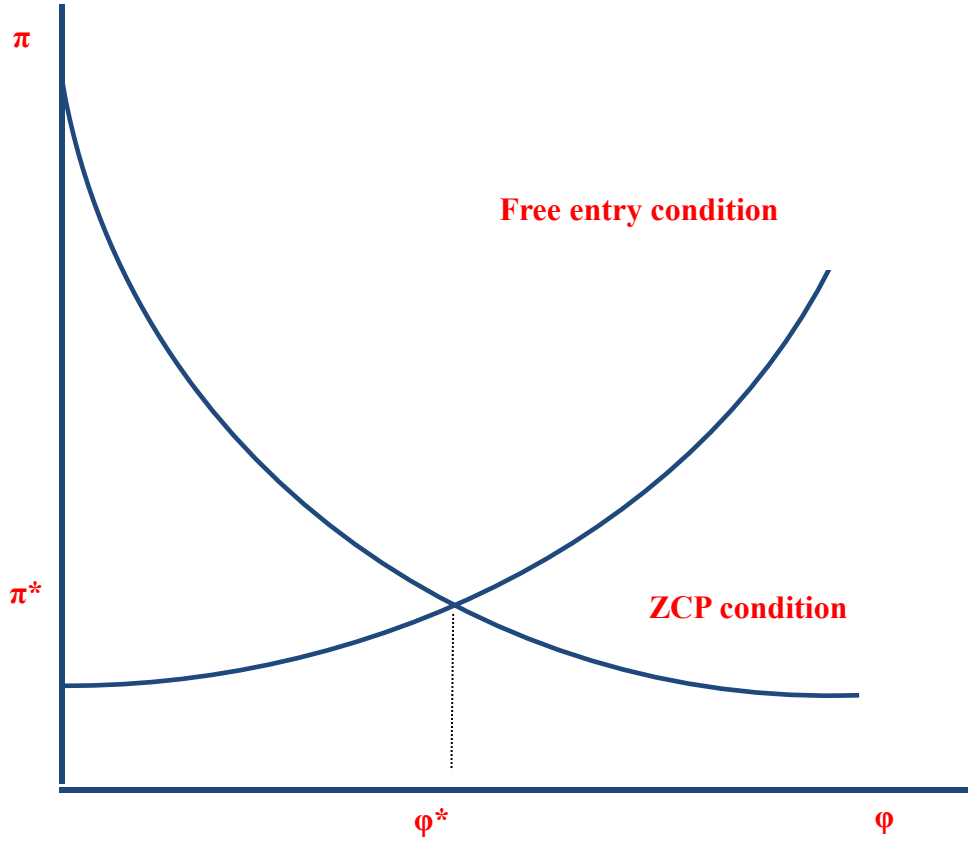
Melitz (2003): equilibrium in a closed economy



Free entry and zero cut off profit conditions determine the productivity level (ϕ^*) under which firms exit the domestic market

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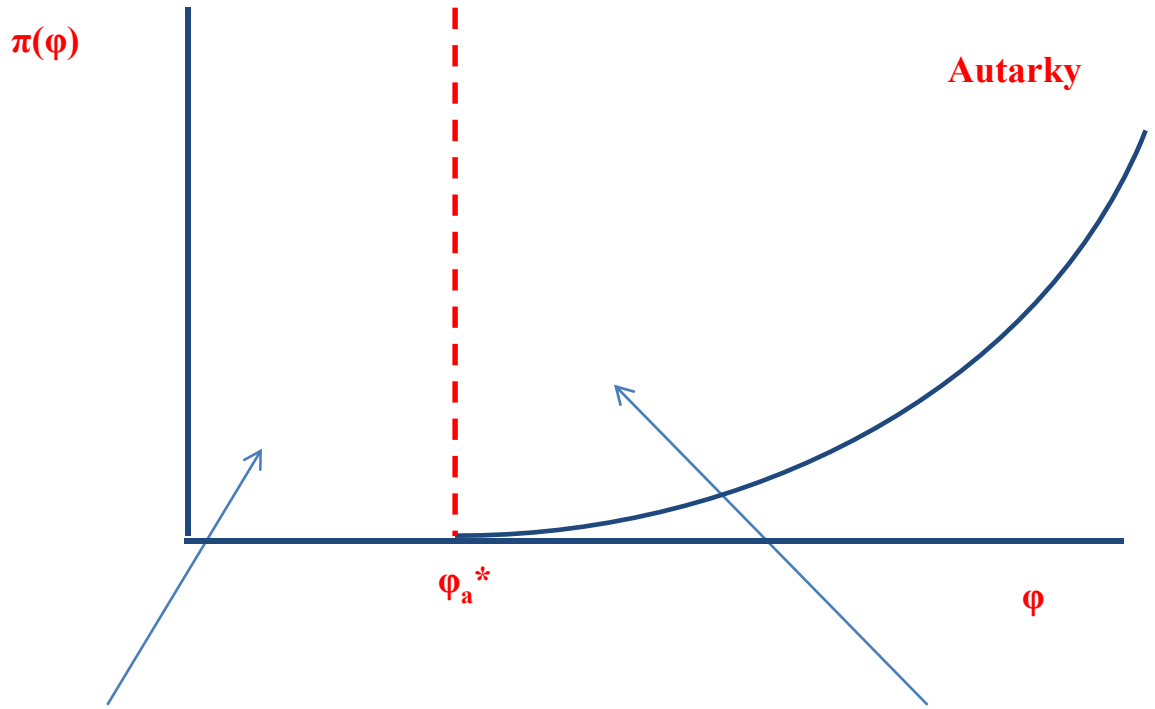
Melitz (2003): equilibrium in a closed economy

- In a stationary equilibrium aggregate variables must remain constant over time; number of firms must remain constant over time (i.e. number of new entrants must be equal to the number of exit firms)

- Equilibrium distribution of productivity is not affected by simultaneous entry and exit since all firms have the same distribution of productivity levels

Melitz (2003): equilibrium in a closed economy



Firms with φ<φ* do not enter the domestic market

Firms with φ≥φ* enter the domestic market and profits are increasing with productivity levels

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Melitz (2003): assumptions of the open economy model

- Assuming no trade costs, open economy model is a replication of the former outcome with a bigger country

- Assuming some trade costs (not only transportation costs, but also the fixed cost of entry in a new market) potential exporting firm has to consider such fixed cost in deciding whether enter or not into the foreign market

- Countries are assumed symmetric (same wage normalized at one, same aggregate variables)

- The pricing rule is the same for all firms in domestic and foreign countries; but exporting firms will set higher prices in foreign market reflecting increased marginal cost due to fixed (iceberg) cost τ

$$p_d(\varphi) = \frac{1}{\rho\varphi} \qquad p_x(\varphi) = \frac{\tau}{\rho\varphi}$$

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Melitz (2003): the open economy model

- The open economy assumption implies that revenue of firms (r) depends on the export status and on how many markets they serve (n)

$$r(\varphi)=\begin{cases} r(\varphi)_d & \text{if the firm exports} \\ r(\varphi)_d + nr(\varphi)_x = r(\varphi)_d\left[1+n\tau^{1-\sigma}\right] & \text{if the firm does not exports} \end{cases}$$

- As a consequence profits depend on the export status as well

$$\pi(\varphi)=\pi(\varphi)_d+\max\left(0;n\pi(\varphi)_x\right)$$

Melitz (2003): the open economy model

- Exporting firms will always also produce for domestic market

- It follows that the cut-off level for firms to export (φ^*_x) must satisfy the two following conditions
  1. Profits in the foreign market has to be positive (given the productivity level of firms)
  2. Productivity level has to be higher than cut off level in the domestic market

$$\varphi^*_x = \inf\left[\varphi : \varphi \geq \varphi^* \ \ and \ \pi(\varphi)_{foreign} > 0\right]$$

Melitz (2003): the open economy model

- By comparing the cut-off level in the domestic vs. foreign market one could classify firms on the base of their export status
  - If $\varphi^*_x=\varphi^*$ all firms producing at home also export
  - If $\varphi^*_x>\varphi^*$ some firms with productivity between φ^*_x and φ^* produce exclusively for the domestic market
  - If $\varphi>\varphi^*$ firms earn positive profits by both exporting and producing domestically (notice that by construction φ^*_x cannot be lower than φ^*)

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Melitz (2003): the open economy model

- Being p_x the ex-post fraction of exporting firms, the total number of exporting firms is: $M_x=p_xM$; and the total number of available varieties in any country is equal to the total number of competing firms in any country: $M_t=M+nM_x$

- Two average productivity measures until now:
  - Average productivity of all firms $\tilde{\varphi} = \tilde{\varphi}(\varphi^*)$
  - Average productivity of exporting firms $\tilde{\varphi}_x = \tilde{\varphi}(\varphi_x^*)$

- Therefore we can define the weighted productivity average that reflects combined market shares of all firms and the output shrinkage linked to exporting

$$\tilde{\varphi} = \left[\frac{1}{M_t} \left(M\tilde{\varphi}^{\sigma-1} + nM_x \left(\tau^{-1}\tilde{\varphi}_x \right)^{\sigma-1} \right) \right]^{\frac{1}{\sigma-1}}$$

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Melitz (2003): the open economy model

- In a similar way as in closed economy, one can compute the zero cut-off level and free entry conditions to define the equilibrium in the open economy

- Comparing equilibrium in closed vs. open economy we can derive the testable implication of the Melitz (2003) model about the impact of trade

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Melitz (2003): testable implications - first

- The open economy implies an eastwards shift in zero cut-off level curve and thus an increase in the cut-off productivity level

  - **Domestic market selection effect $\varphi > \varphi^*$** → *trade liberalization (from closed to open economy) makes less productive domestic firms exit*

  - **Export market selection effect $\varphi > \varphi_x^*$** → *only high productive firms serve foreign markets*

It follows that market shares are reallocated towards more efficient firms with an aggregate productivity gain (exit of less productive firms)

Melitz (2003): testable implications - second

- The number of firms decreases (domestic market selection) after trade but product varieties increase because of imports

$$M_t = M(1+np_x)$$

- Hence:
  - Decrease in the number of domestic producers is more than compensated by increase in foreign exporters
  - However, in case of very high trade costs, this number is not compensated, so that product variety drops

Melitz (2003): testable implications - third

- Reallocation of market shares and profits across firms:
  - All firms incur in a loss in domestic sales in the open economy. A non-exporting firm incurs a total revenue loss
  - Exporting firm is more than compensated for its loss of domestic sales by export sales and increased in total revenues. Hence exporting firms gain market share
  - Firms are partitioned into two groups: firms with profit gains or losses → only a subset of more productive firms who export gain from trade; among these firms the profit gain increases with productivity (see following picture)

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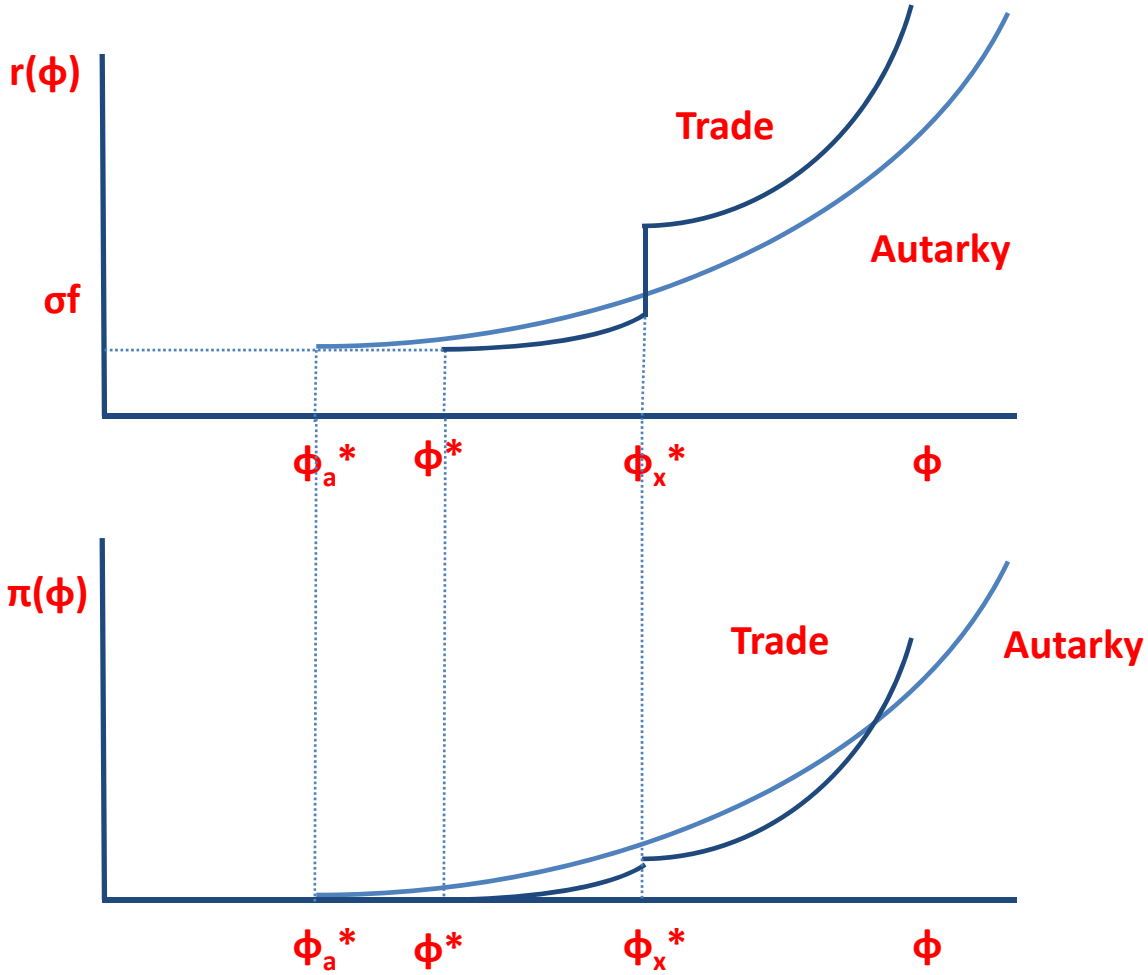
Melitz (2003): testable implications - third



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Empirical evidence on Melitz (2003) model

- Empirical evidence on the Melitz (2003) model is mostly based on US and French firms database and confirms heterogeneity of firms and the existence of destination-specific fixed costs for exporting

- These studies by comparing pre and post trade liberalization periods, find the impact of such trade reforms on industry productivity levels, the probability of firms to exit the market, etc.

- **Bernard et al. (2006)** using a sample of 234000 US plants in 337 manufacturing industries for the period 1987-1997; find that lower trade costs imply higher average industry productivity
  - A reduction in trade costs increases the probability that low productive plants exit the market
  - Thus the exit of low productive explains the rise in average industry productivity

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Empirical evidence on Melitz (2003) model

- **Pavcnik (2002)** observes an increase in average industry productivity level in Chile after some trade liberalization measures taken between 1979 and 1986.

- However, Pavcnik (2002) observes productivity gains for firms in import-competing sectors and an increasing productivity divergence compared with firms producing non-tradables, but does not find further productivity increases for exporters

- **Bustos (2007)** by looking at a panel of 1400 Argentinian firms and at a phase of liberalization between Argentina and Brazil from 1992 and 1996 finds that companies in sectors benefiting from comparatively higher reduction in Brazil's tariffs were more likely to export and increase their technology spending than firms in industries where opening was less ambitious

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Empirical evidence on Melitz (2003) model

- Bustos (2007) shows that the average productivity gains from trade at the sectorial level are not only explained by the exit of less productive firms or by an expansion of market shares of the more productive firms, but also by a positive impact of participation in export market on firm level performance

- **Muendler (2004)** shows that among the firms not previously exporting, it is the high-productivity firms that become exporters following a reduction in trade costs

- **Alvarez and Lopez (2005)** using firm level data for Chile (1990-1996) find that exporters have higher labor productivity and TFP than non-exporters. Firms make conscious efforts to increase productivity before starting to export. Moreover, they estimate insignificant (or negative) differences in labor productivity and TFP growth for export starters compared to non exporters

Empirical evidence on Melitz (2003) model

- **Wagner (2005)** with plants level German data (1995-2004) finds that three years before entry future exporters had significantly higher productivity in two out of seven years. Growth rates of labor productivity did not differ between starters and non-starters in years before start

- He also finds higher labor productivity for three out of four cohorts of starters compared to matched non-starters in three years following start but effect not statistically significant

- **Kimura and Kiyota (2004)** with data on Japanese firms in the period 1994-2000 find that firms with higher TFP have higher probability to enter export markets and that exporters have 2.4% higher TFP growth than non-exporters if initial TFP level is controlled for

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What we learned

1. In a closed economy only more productive firms enter the domestic market (given a fixed cost for producing a certain variety)

2. After trade liberalization (open economy) the minimum productivity level to have positive profits (and thus to survive in the market) increases:
   - Less productive incumbent firms exit the market
   - Only more productive firms enter the foreign market

3. It follows that trade liberalization reduces the number of domestic firms in the market but increases the average productivity level because less productive firms are driven away from the market

4. Empirical evidence largely confirms former theoretical implications