International Trade, 31E00500
Lecture 8: Firm heterogeneity and Melitz model

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Facts to be explained 3: Firm Heterogeneity and 'new new trade theory'

Figure 4
Belgian FDI-makers are more productive than Belgian exporters
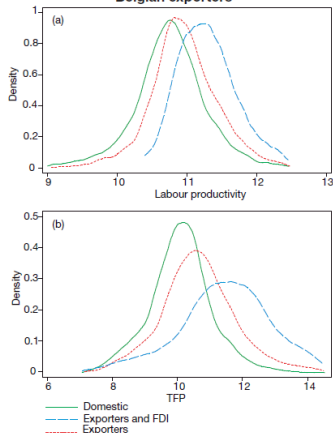
Note: Data for Belgium 2004.
Source: EFIM.

- The assumption of similarity between firms of different sectors does not seem to fit data
- Start of new field of international economics called 'firm heterogeneity'
- Many empirical papers and some theoretical, but still many questions open
- New theoretical models based on monopolistic competition with firm heterogeneity, most famous one = Melitz, 2003, Econometrica.

Small comparison

- Number of citations per article (according to google scholar), comparison of some of the most famous trade models:

  1. Melitz, 2003, The impact of trade on intra-industry reallocations and aggregate industry productivity: 6952 citations
  2. Eaton & Kortum, 2002, Technology, geography, and trade: 2056 citations
 3. Krugram, 1981, Intraindustry specialization and the gains from trade: 1215 citations

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Stylized facts on firm heterogeneity

- Various empirical articles have collected information on firm heterogeneity based on firm level microdatabases

- Few of the 'stylized facts' include (see e.g. Mayer& Ottaviano, 2008, "The happy few"):

  1. There is substantial dispersion in productivity of firms within sectors (in each country), especially between exporting and non-exporting firms.
  2. Exporting firms are more productive.
  3. Exporting firms are much larger, pay higher wages, have higher capital intensity and are more likely to survive in the competition.
  4. Only a small fraction of firms export.
  5. Most exporting firms earn only a small fraction of their revenues from exporting.
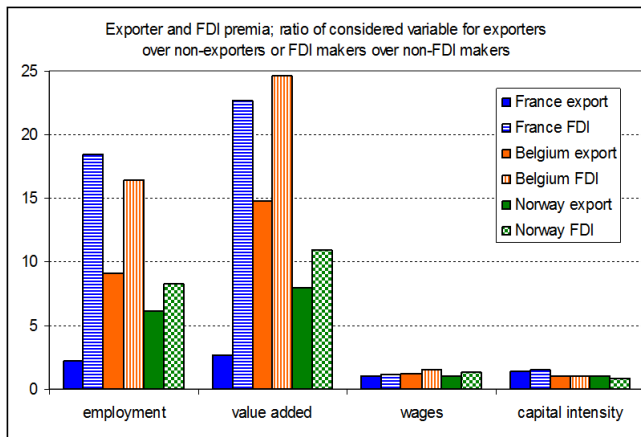
Productivity distributions, log of value added per employee
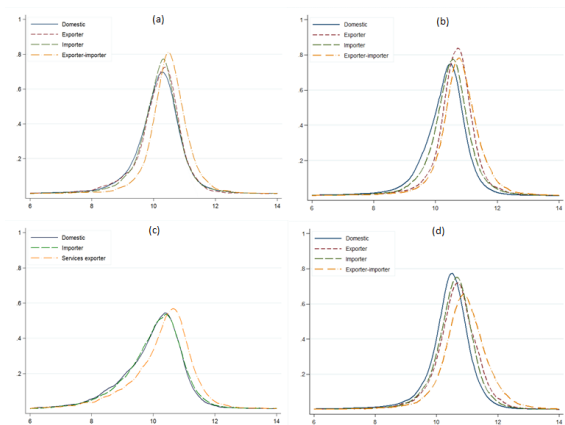
Source: Tamminen, van Berg & van Marrewijk, 2016
(a) = Manufacturing, FIN; (b) = Manufacturing, NL; (c) = Service sectors, FIN; (d)= Wholesale, NL
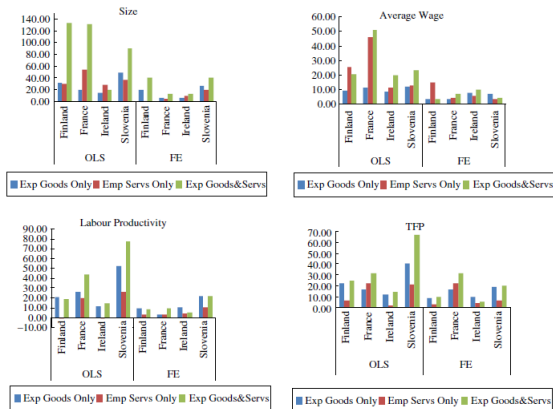
Exporters, FDI-firm vs. domestic

Source: Mayer & Ottaviano, 2008

Goods and services exporters vs. domestic firms

FIGURE 4
Exporters' Size, Wage and Productivity Premia Relative to Non-exporters in per cent
(OLS and Fixed Effects Regressions)

Source: Damijan et al, 2015, The World Economy, p. 17

Shares of firms that export

Export orientation of US manufacturing firms, 2002
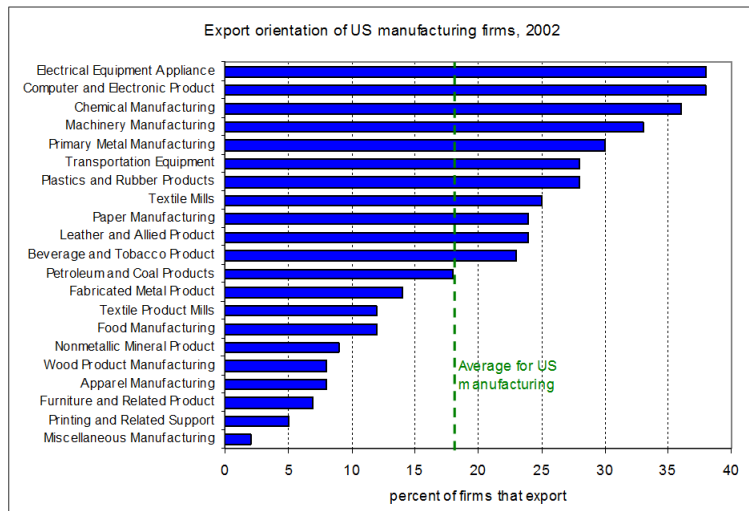
Source: van Marrewijk, 2012

Shares of exports in turnover - Finland, 2005-2009
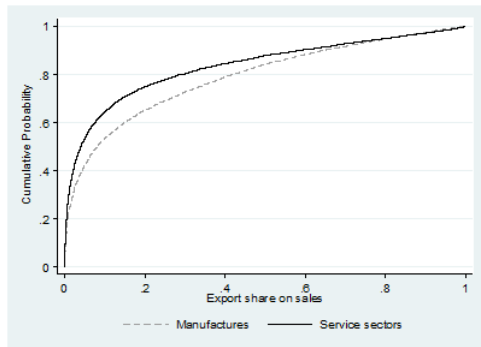
Shares of exports in turnover - Germany & France

Source: EFIM.
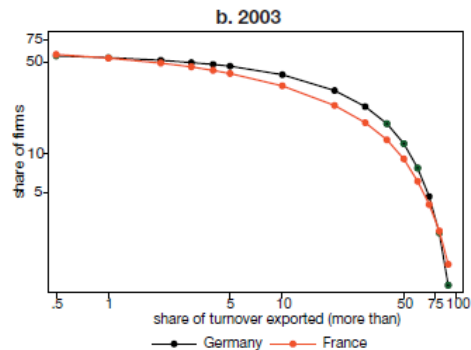
Source: Mayer & Ottaviano, 2008

Distribution by number of products and export destinations; USA, 2000

Comparison: 18 firms created 50% of Finland's gross exports in 2010. 2.3% of export firms (0.35% of all firms) accounted for 89% of Finland's gross exports in 2010.

Gravity with firm heterogeneity
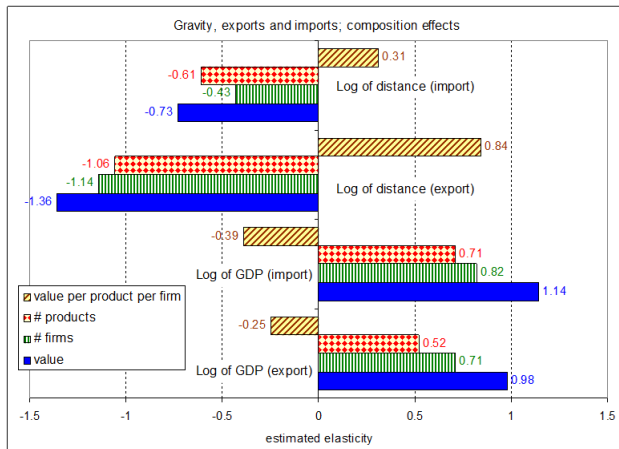
Source: Bernard et al, 2007

Intensive and Extensive Margin

- The analysis on the previous slide distinguishes between the intensive margin and extensive margin at the product level:
  - Intensive margin: the value of trade per product per country
  - Extensive margin: the number of products a firm trades and the number of export destinations
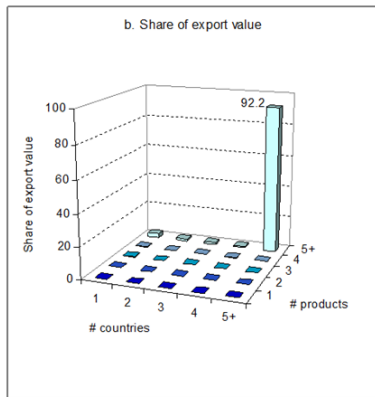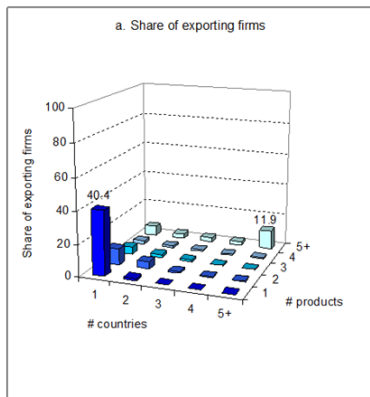- The analysis shows:
  - The extensive margin falls with distance and rises with GDP
  - The intensive margin rises with distance and falls with GDP
  - Total trade value falls with distance and rises with GDP
- Hence, the extensive margin effect dominates the intensive margin effect
- Possible explanation for intensive margin rising with distance: Only firms with higher quality goods (with higher prices and thus higher value) can make profits in exporting to destinations at a larger distance

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Melitz (2003): Dixit Stiglitz/Krugman Model with Firm Heterogeneity

- In Krugman-model (1980), all firms were identical
- In real world firms are different, in particular in productivity
- Melitz (2003, Econometrica) introduces heterogeneous productivity in Dixit Stiglitz model.
- Monopolistic competition, endogenous selection of heterogenous firms.
- The possibility to trade raises demand for scarce inputs (labor). This drives up real wages and drives least productive firms out of the market.
- Trade generates reallocation effect from trade (market shares, exit and entry), which increases aggregate industry productivity and thus welfare.

Demand Structure

- Demand for varieties is CES

$$U = \left[\int_{\omega \in \Omega} q(\omega)^{\frac{\sigma - 1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma - 1}} \tag{1}$$

- There is a continuum of varieties instead of a discrete sum of varieties. This is for technical reasons (to generate a smooth steady state of entry and exit)

- Optimal consumption and expenditure:

$$q(\omega) = Q \left[\frac{p(\omega)}{P} \right]^{-\sigma} \; ; \; r(\omega) = R \left[\frac{p(\omega)}{P} \right]^{1-\sigma} \tag{2}$$

- R=PQ is aggregate expenditure. P_ω is the price index defined by:

$$P = \left[\int_{\omega \in \Omega} p(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}} \tag{3}$$

Supply Structure

- Each firm produces amount q with varying productivity $\varphi > 0$ and fixed costs f equal for all firms. Only labor. (Productivity is simply the inverse of marginal costs). The cost function is thus given by:

$$C(q, \varphi) = \left(\frac{q}{\varphi} + f \right) w \qquad (4)$$

- To start producing firms have to pay a sunk entry cost f. Upon paying the sunk entry cost, they can draw a marginal cost parameter from a known initial distribution of productivity, $g(\varphi)$.

- After drawing their marginal cost, firms either exit immediately when they cannot make profits or they start producing

- To generate a smooth entry and exit process, Melitz (2003) works with a fixed death probability δ in each period.

Structure of Melitz - model
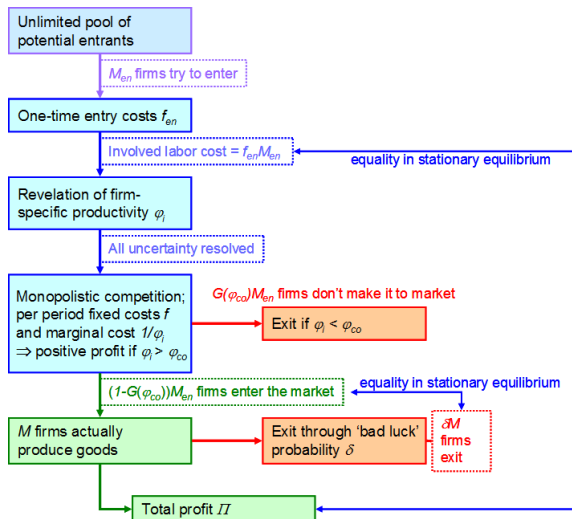
Source: van Marrewijk, 2012

Revenues and Profits in Melitz, 2003

- Revenues of a firm are equal to price times demand:

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

- Profits are thus equal to:

$$\pi(\varphi) = r(\varphi) - C(\varphi) = p(\varphi)^{1-\sigma}P^{\sigma-1}R - \left(\frac{p(\varphi)^{-\sigma}P^{\sigma-1}R}{\varphi} + f\right)w \tag{6}$$

- Maximizing profits wrt price generates the markup rule

$$p(\varphi) = \frac{\sigma}{\sigma - 1}\frac{w}{\varphi} \tag{7}$$

Melitz (2003), Supply

- Substituting the optimal pricing rule into the profit function and normalizing the wage at 1, we get the following expression for profit

$$\pi(\varphi) = r(\varphi)/\sigma - f = \frac{R}{\sigma}\left(\frac{\sigma - 1}{\sigma}\varphi P\right)^{\sigma - 1} - f \tag{8}$$

- The ratio of prices, the ratio of sales and the ratio of revenues can be expressed as a function of the ratio of productivity:

$$\frac{p(\varphi_1)}{p(\varphi_2)} = \frac{\varphi_2}{\varphi_1}; \; \frac{q(\varphi_1)}{q(\varphi_2)} = \left(\frac{\varphi_1}{\varphi_2}\right)^{\sigma}; \; \frac{r(\varphi_1)}{r(\varphi_2)} = \left(\frac{\varphi_1}{\varphi_2}\right)^{\sigma - 1} \tag{9}$$

Cumulative distribution function and probability density function
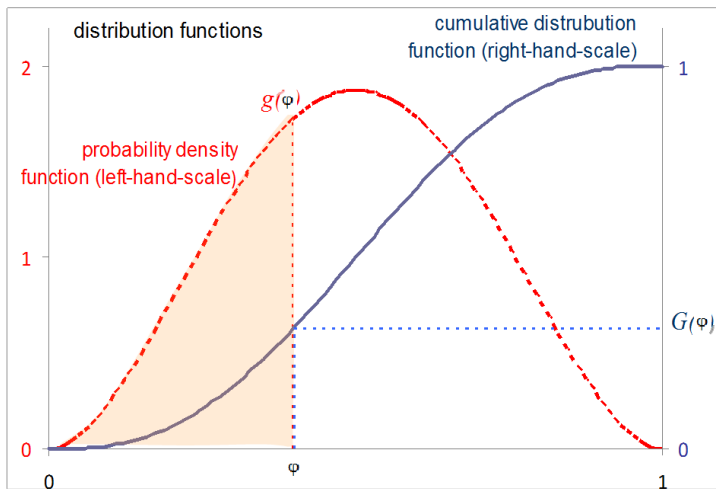
Source: van Marrewijk, 2012

Distribution of Producing Firms

- We can introduce a cutoff productivity level. Only firms with productivity above the cutoff productivity start to produce after drawing their marginal cost.

- From the initial productivity distribution from which prospective firms draw their productivity after paying sunk entry costs, we can define a new, equilibrium productivity distribution of actually producing firms. It is given by the following truncated distribution

$$\mu(\varphi) = \frac{g(\varphi)}{1 - G(\varphi_{co}^*)} \tag{10}$$

Productivity density function
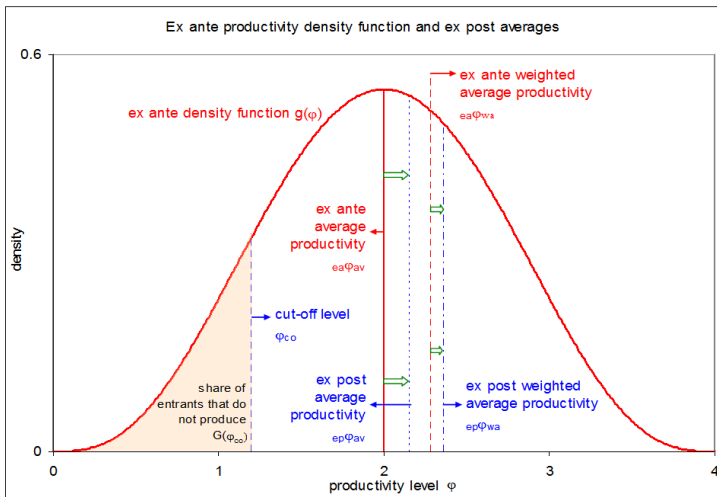
Source: van Marrewijk, 2012

Average productivity

- The truncated distribution 'rescales' probabilities such that they still add up to 1

- Using this truncated distribution, we can define a weighted average productivity $\bar{\varphi}(\varphi_{co}^*)$, such that the price index and other variables can be defined as a function of this weighted average productivity (weights come from output shares).

- Ex-post weighted average productivity equals:

$$\bar{\varphi} = \left(\int_{\varphi_{co}^*}^{\infty} \varphi^{\sigma-1} \mu(\varphi) d\varphi \right)^{\frac{1}{\sigma-1}} \tag{11}$$

- Weighted average productivity is a function of cutoff productivity, which is useful to define equilibrium in terms of cutoff productivity

Price index

- The price index can be expressed as a function of weighted average productivity (M = number of active firms)

$$P = \left(M \int_{\varphi_{co}^*}^{\infty} p(\varphi)^{1-\sigma} \mu(\varphi) d\varphi \right)^{\frac{1}{1-\sigma}} \qquad (12)$$

- Substituting the pricing equation:

$$P = \frac{\sigma}{\sigma - 1} \left(M \int_{\varphi_{co}^*}^{\infty} \varphi^{\sigma-1} \mu(\varphi) d\varphi \right)^{\frac{1}{1-\sigma}} \qquad (13)$$

- Using the definition of weighted average productivity:

$$P = \frac{\sigma}{\sigma - 1} M^{\frac{1}{1-\sigma}} \frac{1}{\bar{\varphi}(\varphi_{co}^*)} \qquad (14)$$

- To characterize equilibrium we define an ex post zero cutoff profit condition, ZCP, and an ex-ante free entry condition, FE.
- The firm with cutoff marginal cost, the cutoff firm, can just stay in the market. Hence, its profits in each period should be zero (**ZCP**):

$$\pi(\varphi_{co}^*) = r(\varphi_{co}^*)/\sigma - f = 0 \tag{15}$$

- The FE tells us that ex ante average profit times the probability of successful entry should be equal to the sunk entry cost. So, there is so much entry, that on average profits are driven down to zero:

$$\sum_{t=0}^{\infty}(1-\delta)^t(1 - G(\varphi_{co}^*))\bar{\pi} = f_e \tag{16}$$

- In each period firms have equal expected profits, $\bar{\pi}$ and their probability to not have died after t periods is equal to $(1 - \delta)^t$
- Using rules for geometric series, we can rewrite the **FE** as:

$$\bar{\pi} = \delta f_e/(1 - G(\varphi_{co}^*)) \tag{17}$$

Rewriting the ZCP

- We can rewrite average profit as a function of average productivity and use the expression for profit as a function of revenue, we have used before:

$$\bar{\pi} = \pi(\bar{\varphi}) = r(\bar{\varphi})/\sigma - f \qquad (18)$$

- Next, we use the expression for the ratio of revenues as a function of the ratio of productivities defined before, implying for the relation between weighted average productivity and cutoff productivity:

$$r(\bar{\varphi}) = r(\varphi_{co}^*) \left(\frac{\bar{\varphi}}{\varphi_{co}^*} \right)^{\sigma-1} \qquad (19)$$

- Using the ZCP $r(\varphi_{co}^*)/\sigma - f = 0$ implies then:

$$\bar{\pi} = \left[\left(\frac{\bar{\varphi}}{\varphi_{co}^*} \right)^{\sigma-1} - 1 \right] f \qquad (20)$$

ZCP and FE

- Equilibrium is now characterized by the FE and ZCP:

$$\bar{\pi} = \delta f / (1 - G(\varphi_{co}^*)) \tag{21}$$

$$\bar{\pi} = \left[\left(\frac{\bar{\varphi}}{\varphi_{co}^*} \right)^{\sigma - 1} - 1 \right] f \tag{22}$$

- ZCP and FE generate a unique value of the cutoff productivity and therefore also of average productivity. This can be proved by combining FE and ZCP and showing that LHS is monotone in the cutoff productivity

Equilibrium; impact of elasticity of substitution
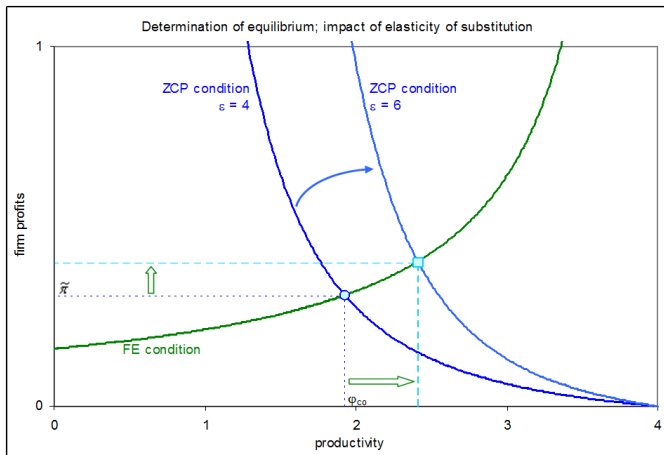
Source: van Marrewijk, 2012

Number of firms/varieties and welfare

- The number of firms can be found by dividing total revenue (equal to the number of workers with wages normalized at 1) by average revenue

$$M = R/\bar{r} = L/\sigma(\bar{\pi} + f) \tag{23}$$

- Welfare per worker is equal to the wage (equal to 1) divided by the price index:

$$W = 1/P = \frac{\sigma - 1}{\sigma} M^{\frac{1}{\sigma-1}} \bar{\varphi} \tag{24}$$

- Welfare rises with the number of varieties and average productivity

Open Economy 1

- International trade is introduced in the model with the following assumptions:
  - First, there are per unit 'transport costs' of the iceberg type with. So, $\tau > 1$ units have to be exported to make one unit arrive at the destination.
  - Second, it is assumed that there are sunk costs to enter a foreign market, f_{ex}. Sunk entry costs in export markets are a reasonable assumption, as firms have to gather all kinds of information before they can enter a foreign market and a distribution channel has to be set up.

Open Economy 2

- Prices charged abroad are still a mark-up over marginal cost, now including transport costs. So, export prices and export revenues are given by:

$$p_x(\varphi) = \frac{\sigma}{\sigma - 1} \frac{\tau}{\varphi} = \tau p_d(\varphi) \qquad (25)$$

$$r_x(\varphi) = \left(\frac{\sigma}{\sigma - 1} \frac{\tau}{\varphi}\right)^{1-\sigma} P^{\sigma-1} L = \tau^{1-\sigma} r_d(\varphi) \qquad (26)$$

- Variables with an index x denote export variables and with d domestic variables.
- Profits from domestic and exporting sales are:

$$\pi_d(\varphi) = \frac{r_d(\varphi)}{\sigma} - f \qquad (27)$$

$$\pi_x(\varphi) = \frac{r_x(\varphi)}{\sigma} - f_x = \frac{\tau^{1-\sigma} r_d(\varphi)}{\sigma} - f_x \qquad (28)$$

Open Economy 3

- The probability that a firm is exporting conditional on profitably selling in the domestic market is given by $a_x = (1 - G(\varphi^*_{co,x}))/(1 - G(\varphi^*_{co}))$
- Using this probability the number of exporting firms can be expressed as a fraction of the number of firms producing for the domestic market, $M_x = a_x M$
- Thus with 2 countries, the total number of varieties available in every country is $M_{tot} = M + M_x = (1 + a_x)M$
- We can write average productivity of all firms selling in a market as a function of the average productivity of domestic producing firms and average productivity of exporting firms:

$$\bar{\varphi}_t = \left\{ \frac{1}{M_{tot}} \left[M\bar{\varphi}^{\sigma-1} + M_x(\tau^{-1}\bar{\varphi}_x)^{\sigma-1} \right] \right\}^{\frac{1}{\sigma-1}} \tag{29}$$

- Like in the closed economy, the price index (and welfare) is a function of this average productivity and thus of the cutoff productivity:

$$W = 1/P = \frac{\sigma - 1}{\sigma} M_{tot}^{\frac{1}{\sigma-1}} \bar{\varphi}_t \tag{30}$$

- There are now two ZCP conditions, one for the domestic market and one for the export market:

$$r_d(\varphi_{co}^*) = \sigma f \tag{31}$$

$$r_x(\varphi_{co,x}^*) = \sigma f_x \tag{32}$$

- Average profit is found by adding up domestic profit and exporting profit times the probability of exporting:

$$\bar{\pi} = \pi_d(\bar{\varphi}) + a_x \pi_x(\bar{\varphi}_x) \tag{33}$$

- The ZCPs can be rewritten as in the closed economy to generate:

$$\bar{\pi} = \left[\left(\frac{\bar{\varphi}(\varphi_{co}^*)}{\varphi_{co}^*} \right)^{\sigma-1} - 1 \right] f + a_x \left[\left(\frac{\bar{\varphi}(\varphi_{co,x}^*)}{\varphi_{co,x}^*} \right)^{\sigma-1} - 1 \right] f_x \tag{34}$$

- Also, we can combine the two ZCPs to express the exporting cutoff as a function of the domestic cutoff:

$$\varphi_{co,x}^* = \varphi_{co}^* \tau \left(\frac{f_x}{f} \right)^{\frac{1}{\sigma-1}} \tag{35}$$

- We have three equations implying a unique cutoff cost level, the FE, the ZCP and the relation between exporting and domestic cutoff:

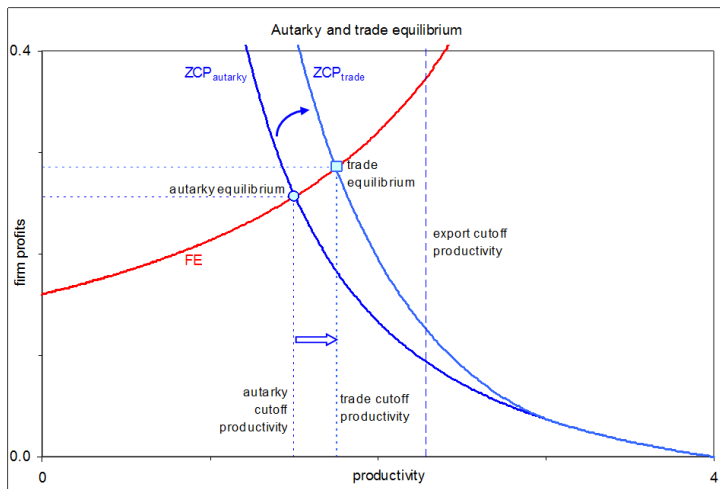$$\bar{\pi} = \delta f / (1 - G(\varphi_{co}^*)) \tag{36}$$

$$\bar{\pi} = \left[\left(\frac{\bar{\varphi}(\varphi_{co}^*)}{\varphi_{co}^*} \right)^{\sigma-1} - 1 \right] f + a_x \left[\left(\frac{\bar{\varphi}(\varphi_{co,x}^*)}{\varphi_{co,x}^*} \right)^{\sigma-1} - 1 \right] f_x \tag{37}$$

$$\varphi_{co,x}^* = \varphi_{co}^* \tau \left(\frac{f_x}{f} \right)^{\frac{1}{\sigma-1}} \tag{38}$$

- Crucial in Melitz' model to create a composition effect from freer trade is that only relatively more productive firms can export. This requires that the combination of exporting fixed cost and variable costs and high enough to generate the partitioning, and therefore:

$$\tau^{\sigma-1} f_x > f \tag{39}$$

Source: van Marrewijk, 2012

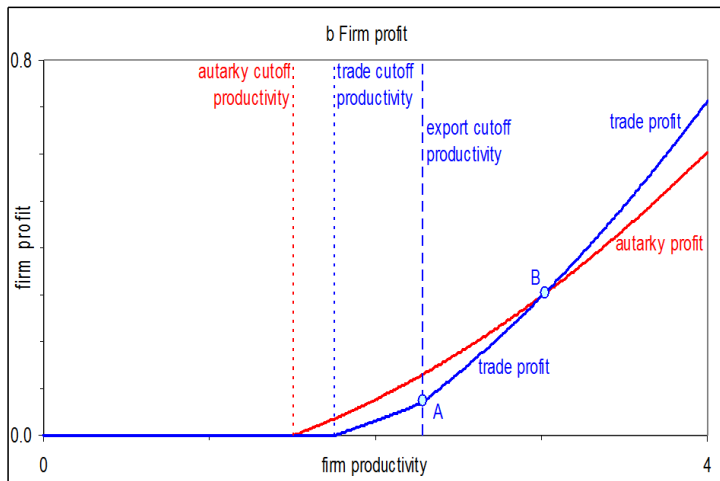# Autarky and trade sales

a. Firm sales

autarky cutoff productivity · trade cutoff productivity · export cutoff productivity · trade sales · autarky sales · firm sales · firm productivity
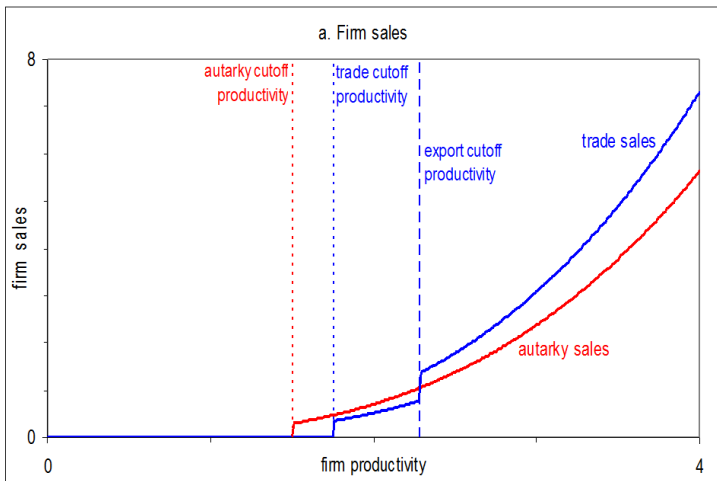
Autarky and trade profits

Effect of Lower Trade Costs

- To find effect of lower trade costs, we can totally differentiate ZCP, FE and relation between cutoff levels wrt cutoff levels and trade costs. This exercise shows that lower trade costs, both iceberg and fixed, reduce the cutoff cost level and therefore also reduce the average cost level and the price index.

- Lower trade costs generate a reallocation effect of market shares from low productive firms producing only for the domestic market towards high productive exporting firms. (The cut-off productivity increases but export cut-off productivity decreases.)

- The least productive firms are squeezed out of the market, because real wages rise due to increased demand for scarce (labor) resources

- Demand for scarce (labor) resources rises for two reasons:
  - First, in an open economy the most productive firms can not only sell at home, but also abroad. They expand their production and therefore need more (labor) resources.
  - Second, the probability of exporting rises, implying higher profits when entering successfully. Therefore, more firms will try to set up a new firm and enter. This also raises the demand for (labor) resources.

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Other Models of Firm Heterogeneity

- A disadvantage of Melitz is that it works with fixed markups. Intuition would suggest that trade implies intensified competition reducing markups and thus profits margins. This squeezes the least productive firms out of the market and creates reallocation effects

- Melitz and Ottaviano (2008) work with quasi linear demand for differentiated goods in model of monopolistic competition. In this model markups are endogenous. Trade intensifies competition, reduces markups and squeezes out the least productive firms. Disadvantage of Melitz and Ottaviano is that it is only partial equilibrium.

- Bernard, Eaton, Jensen and Kortum (2003), BEJK work with Dixit Stiglitz preferences across varieties and Bertrand competition between suppliers from different countries. The lowest cost supplier of a variety takes the entire market. Lower trade costs reduce the markups firms can charge and this raises welfare. Disadvantage is that the model is rather complicated

- The correlation between exporting and productivity raises the issue of causality. Do more productive firms become exporters or does exporting increase productivity? Most work finds support for an effect of productivity on exporting but not for exporting on productivity

- On the first question, Bernard and Jensen (1999, JIE) find that future exporters are 20% to 45% larger in terms of employment, 27% to 54% larger in terms of shipments, 7%-8% larger in terms of labor productivity and 2%-4% larger in terms of total factor productivity, although the last difference is not significant.

- The impact of exporting on productivity can be addressed by regressing growth rates in employment, shipments, TFP and value added per worker on initial export status.

- Controlling for initial size and other plant characteristics, Bernard and Jensen (1999) find that exporting firms show faster growth in shipments and employment but slower growth in TFP over annual horizons.

Empirical Evidence on Firm Heterogeneity 2

- Hence, older empirical research indicates that the individual productivity of firms is not affected by trade, but through reallocation effects aggregate productivity does increase with more trade: the market share of more productive firms picks up and this raises aggregate productivity

- Recent work on multiproduct firms (Melitz, Ottaviano and Mayer, 2010) shows that also within firms there are reallocation effects of trade: lower trade costs make competition between firms more intense. Firms reduce the number of products sold and concentrate on the sales of their best varieties.

- Research on episodes of trade liberalization summarized in Tybout (2001, NBER) shows that:
  - Sunk costs are important in international trade: already exporting firms have a larger probability of exporting in the next period. There is persistence in exporting
  - Increasing import competition reduces average markups
  - Increasing import competition reduces average firm size

Firm Heterogeneity and FDI

- Helpman, Melitz and Yeaple (2004) AER extend the Melitz model with FDI
- To set up a plant abroad (FDI) a firm has to pay fixed costs, larger than the fixed export costs implying the following ordering of firms

Mode of entry
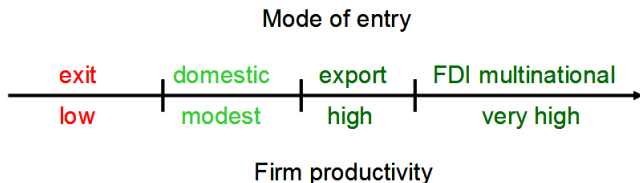
- HMY04 confirm this empirically: multinationals are 54% more productive than domestic firms and 15% more productive than exporting firms
- HMY04 derive and empirically confirm another prediction: in sectors where the productivity distribution is more dispersed, multinationals are more prevalent.
- Explanation: with a more dispersed productivity distribution, a larger fraction of the firms are very productive and thus engaged in FDI

Firm Heterogeneity and income inequality

- Few theoretical models with firm heterogeneity that analyse the effects of trade to income inequality:
  - Trade increases wage income inequality (Helpman et al, 2010, Econometrica, Basco & Mestieri, 2013, JIE)
  - Trade increases capital income inequality (Foellmi & Oechslin, 2010, JIE)
  - Trade increases unemployment rates and both wage and capital income inequality (Egger & Kreickemeier, 2012, JIE, later referred as EK)

Concluding Remarks

- Firms differ in productivity. Until Melitz (2003) this real world fact was not incorporated in trade models where firms play a role
- Firm heterogeneity implies that lower trade costs induce a reallocation effect: more productive exporting firms gain market share at the expense of less productive firms producing only for the domestic market
- Empirical evidence supports the notion that only more productive firms can export as exporting firms are more productive and bigger
- Firm heterogeneity is extended to the study of most topics covered and yet to come: neoclassical trade models, trade policy, labour economics and distributional effects, geographical economics and multinationals.

Next lecture

Tuesday 5.2, 10.15 - 12, on **Multinational Firms and Fragmentation of Production**

Read CvM chapter 15 before lecture.