Lecture 8: Heterogeneous Firms and the Decision to Export

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7 December 2016

Introduction

- Krugman model :
  - empirically successful at an aggregate level : gravity equation, intra-industry trade
  - but fails to explain 'zeros' in bilateral trade matrices and difference between exporters and non-exporters
- Mélitz (2003) extends Krugman with heterogeneous firms and fixed exportation costs
  - generates an aggregate gravity equation, but explains why some firms don't export
  - additional gains from trade through the reallocation of resources towards the most productive firms

The Mélitz model

See analytical details in MelitzAnalytics.pdf

Main features of the Mélitz (2003) model

- Dynamic industry model of trade with heterogeneous firms and imperfect competition
- Bilateral trade follows a gravity pattern, depending on technology, revenues and geographic barriers
- The fixed exportation cost implies that only firms above a minimum productivity level can export.
- Allows to study the response of trade to shocks at two margins : *extensive* margin (change in the number of firms) and *intensive* margin (change in the average exported quantity). that export)

Assumptions

- 2 symmetric countries ; symmetry insures wage equality.
- CES utility function :

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

with $\sigma > 1$ and Ω the (endogenous) mass of available goods

- Dixit-Stiglitz demand functions :

$$q(\omega) = \left(\frac{p(\omega)}{P} \right)^{-\sigma} \frac{R}{P}$$

where R is the country's nominal revenue and P the 'ideal' price index :

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

Assumptions (ii)

- Continuum of firms and varieties indexed by ω (with increasing returns, no incentive to replicate an existing variety)
- One factor of production, labor, in inelastic supply $L = L^*$.
- Increasing returns to scale :

$$l(\omega) = f + \frac{q(\omega)}{\varphi(\omega)}$$

where $\varphi(\omega) > 0$ is the *firm-specific* productivity level and $f > 0$

$\Rightarrow$ Optimal price :

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

where w is the wage rate (normalized to one)

$\Rightarrow$ Firm profit :

$$\pi(\omega) = \frac{p(\omega)q(\omega)}{\sigma} - f = \frac{R}{\sigma}\left(\frac{\sigma - 1}{\sigma} P\varphi(\omega)\right)^{\sigma - 1} - f$$

Assumptions (iii)

- A large unbounded pool of prospective entrants into the industry
- An entry cost f_e, sunk at the time of producing
- A common distribution of productivities $g(\varphi)$ with positive support $(0, \infty)$ and continuous cumulative distribution $G(\varphi)$
- Individual productivity assumed constant over time $\Rightarrow$ Allows to focus on steady state equilibria
- A constant death probability δ in every period (independent across firms)
- Zero time discounting

Timing

- Prospective entrants pay the sunk cost f_e if the present value of future profits is large enough

$\Rightarrow$ Free Entry condition :

$$v_e = p_{in}\bar{v} - f_e = 0 \qquad \text{((FE))}$$

p_{in} is the ex-ante probability of successful entry and $\bar{v} = \sum_{t=0}^{\infty}(1-\delta)^t\bar{\pi} = \frac{1}{\delta}\bar{\pi}$ is the average profit flow, conditional on entry

- Conditional on having paid f_e, firms draw their productivity level φ :
  - If $\pi(\varphi) < 0$, the firm immediately exits
  - If $\pi(\varphi) \geq 0$, the firm produces until being hit by the death shock

Timing (2)

⇒ Zero Cutoff Profit Condition (ZCP) :

$$\varphi^* = inf\{\varphi : v(\varphi) > 0\} \Rightarrow \pi(\varphi^*) = 0 \qquad \text{(ZCP)}$$

and

$$p_{in} \equiv 1 - G(\varphi^*)$$

⇒ Ex-post distribution of productivities :

$$\mu(\varphi) = \begin{cases} \frac{g(\varphi)}{1-G(\varphi^*)} & if\, \varphi \geq \varphi^* \\ 0 & otherwise \end{cases}$$

⇒ Aggregate productivity level :

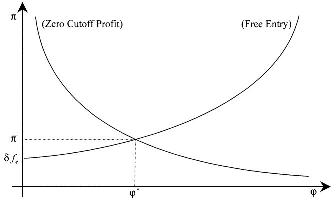
$$\tilde{\varphi}(\varphi^*) = \left[\frac{1}{1-G(\varphi^*)}\int_{\varphi^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi\right]^{\frac{1}{\sigma-1}}$$

Equilibrium in a closed economy

- (FE) and (ZCP) jointly determine $\bar{\pi}$ and φ^* :

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

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



- Equilibrium exists and is unique

Equilibrium in a closed economy (ii)

- In a stationary equilibrium, aggregate variables are constant :

$$\underbrace{p_{in} M_e}_{\textit{Successful entrants}} = \underbrace{\delta M}_{\textit{Incumbents exiting}}$$

$$\Rightarrow \quad L_e \equiv M_e f_e = \frac{\delta M}{p_{in}} f_e = \Pi$$

$$\Rightarrow \quad R = L_p + L_e = L$$

$$\Rightarrow \quad M = \frac{R}{\bar{r}} = \frac{L}{\sigma(\bar{\pi} + f)}$$

- This completes the characterization of the unique stationary equilibrium in the closed economy
- For given $\tilde{\varphi}$ and $\tilde{\pi}$, the model behaves as in an economy with representative firms (Krugman model) :

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

Open-economy Equilibrium

- **Without trade costs** : trade increases $L \Rightarrow$ same individual output and prices, more firms and gain from variety (same as Krugman)
- **With trade costs** : iceberg trade cost $\tau > 1$ and fixed per-period export cost f_{ex}

$\Rightarrow$ Pricing decision :

$$p_d(\varphi) = \frac{\sigma}{\sigma - 1}\frac{w}{\varphi} \quad and \quad p_x(\varphi) = \frac{\sigma}{\sigma - 1}\tau\frac{w}{\varphi} = \tau p_d(\varphi)$$

$\Rightarrow$ Revenues :

$$\begin{aligned} p_d(\varphi)q_d(\varphi) &= R\left(\frac{\sigma}{\sigma - 1}P\varphi\right)^{\sigma-1} \\ p_x(\varphi)q_x(\varphi) &= \tau^{1-\sigma}R^*\left(\frac{\sigma}{\sigma - 1}P^*\varphi\right)^{\sigma-1} \end{aligned}$$

International trade (ii)

- When φ is revealed the firm chooses whether to produce and whether to export (paying f_{ex})
- The firm exports if :

$$\pi_x(\varphi) = \frac{p_x(\varphi)q_x(\varphi)}{\sigma} - f_{ex} \geq 0$$

$\Rightarrow$ New productivity cutoff for exports :

$$\varphi_x^* = inf\{\varphi : \varphi \geq \varphi^* \; and \; \pi_x(\varphi) \geq 0\}$$

$\Rightarrow$ New productivity cutoff for successful entry :

$$\begin{aligned} \varphi^* &= inf\{\varphi : v(\varphi) \geq 0\} \\ where \quad v(\varphi) &= max\left\{0; \frac{\pi(\varphi)}{\delta}\right\} \\ and \quad \pi(\varphi) &= \pi_d(\varphi) + max\{0; \pi_x(\varphi)\} \end{aligned}$$

Selection in each market

- Assume

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

- Then $\varphi_x^* > \varphi^*$ and firms self-select into export markets :
  - Below φ^*, exit
  - Between φ^* and φ_x^*, produce for d
  - Above φ_x^*, produce for d and x

$\Rightarrow$ The cutoff levels thus satisfy :

$$\pi_d(\varphi^*) = 0 \quad \textit{and} \quad \pi_x(\varphi_x^*) = 0$$

Equilibrium in open economy

- Average productivity level :

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

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

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

Equilibrium in open economy (ii)

- (ZCP) and (FE) jointly determine $\bar{\pi}$ and φ^* :

$$(ZCP) \quad \bar{\pi} = \pi_d(\tilde{\varphi}) + p_x \pi_x(\tilde{\varphi}_x)$$

$$with \quad \pi_d(\varphi^*) = 0 \Leftrightarrow \pi_d(\tilde{\varphi}) = f\left[\left(\frac{\tilde{\varphi}(\varphi^*)}{\varphi^*}\right)^{\sigma-1} - 1\right]$$

$$and \quad \pi_x(\varphi_x^*) = 0 \Leftrightarrow \pi_x(\tilde{\varphi}_x) = f_x\left[\left(\frac{\tilde{\varphi}_x(\varphi_x^*)}{\varphi_x^*}\right)^{\sigma-1} - 1\right]$$

$$and \quad \pi_d(\varphi^*) = 0 \text{ and } \pi_x(\varphi_x^*) = 0 \Leftrightarrow \varphi_x^* = \varphi^* \tau \left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}}$$

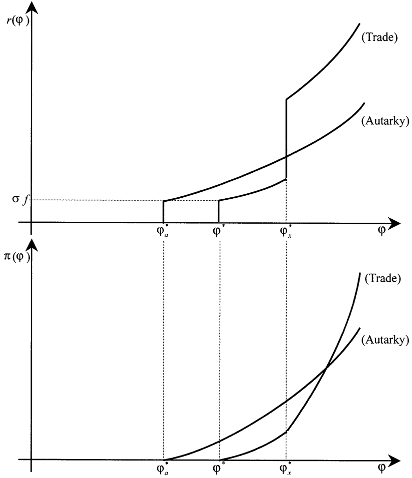
$$and \quad p_x = \frac{1 - G(\varphi_x^*)}{1 - G(\varphi^*)}$$

$$(FE) \quad \bar{\pi} = \frac{\sigma f_e}{1 - G(\varphi^*)}$$

- Equilibrium exists and is unique

Impact of trade

Figure – Impact of trade on sales and profits



Impact of trade (ii)

- At the extensive margin :
  - entry of the most productive firms in foreign markets
  - exit of the least productive domestic firms exit
- At the intensive margin :
  - low-productivity survivors lose sales and profit :

$$p_d(\varphi)q_d(\varphi) < p_a(\varphi)q_a(\varphi)$$

  - new exporters increase their sales :

$$p_d(\varphi)q_d(\varphi) + p_x(\varphi)q_x(\varphi) > p_a(\varphi)q_a(\varphi)$$

  - only the most productive of new exporters increase their profits , the gain in sales must cover the additional fixed cost : f_{ex}

Impact of trade (iii)

$\Rightarrow$ Aggregate productivity increases as the most productive firms gain market share

- extra labor demand by exporting firms and increased entry (since the value of entry increases)
- the least productive firms cannot survive the increases in the real wage

- No pro-competitive gains from trade in this model : output, prices and markups are constant (but see Melitz and Ottaviano, 2008).

Aggregate trade

$$X = \int_{\varphi_X^*}^{\infty} p_X(\varphi) q_X(\varphi) M g(\varphi) d\varphi = \underbrace{(1 - G(\varphi_X^*))\, M}_{\text{Mass of exporters}} \underbrace{p_X(\tilde{\varphi}_X(\varphi_X^*)) q_X(\tilde{\varphi}_X(\varphi_X^*))}_{\text{Mean exports per exporter}}$$

- Assume a *Pareto distribution* of productivity $G(\varphi) = 1 - \varphi^{-\gamma}$ and an exogenous mass of firms :

$$\begin{aligned} \tilde{\varphi}_X(\varphi_X^*)^{\sigma-1} &= \frac{\gamma}{\gamma - (\sigma - 1)} \, {\varphi_X^*}^{\sigma-1} \\ \varphi_X^* &= \lambda \left(\frac{f_X}{R^*} \right)^{\frac{1}{\sigma-1}} \frac{\tau}{P^*} \\ X &= \lambda' \, {R^*}^{\frac{\gamma}{\sigma-1}} \, {P^*}^{\gamma} \, \tau^{(1-\sigma)+(\sigma-1-\gamma)} f_X^{-\left[\frac{\gamma}{\sigma-1} - 1\right]} \end{aligned}$$

- Both variable and fixed costs of exporting affect trade flows. In the Pareto case the elasticity of trade w.r.t. τ only depends on γ and σ.

Empirical evidence

Heterogeneous behavior in export markets

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 (5.60)	
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)	14.80 (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 (6.10)	1.13 (0.90)	1.52 (0.72)	
Belgium	16.45 (6.82)	24.65 (11.14)	1.53 (1.20)	1.03 (0.82)	
Norway	8.28 (4.48)	11.00 (5.41)	1.34 (0.76)	0.87 (0.13)	

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

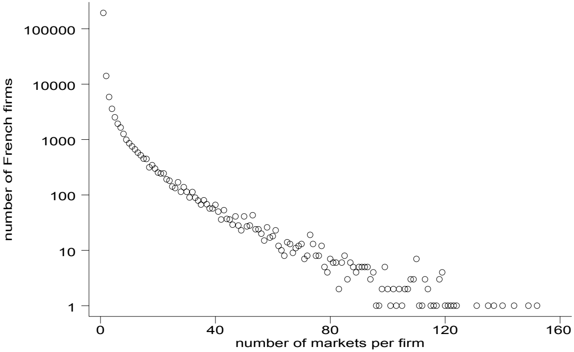
Source : Mayer & Ottaviano (2008) from EFIM

Heterogeneous behavior in export markets (ii)

- Eaton, Kortum & Kramarz (2004) using French firm-level data
- In the manufacturing sector, 17.4% of firms do export. 22% of producers' sales is realized in foreign markets
- 34.5% of exporters serve only one market (Belgium most of the time). This represents 0.7% of total exports
- 1.5% of exporting firms serve more than 50 markets. This represents 52% of aggregate exports

$\Rightarrow$ Huge granularity in exports

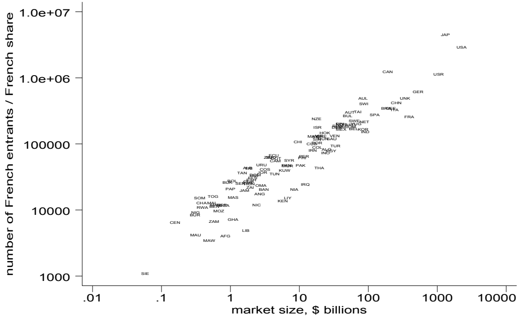
Heterogeneous behavior in export markets (iii)



Source : Eaton, Kortum & Kramarz (2004)

- Granularity in the distribution of firms entering foreign markets

Heterogeneous behavior in export markets (iv)



Source : Eaton, Kortum & Kramarz (2004)

- Extensive margin and the size of the destination country :

$$\ln \#Firms_n = \underset{(.069)}{-5.061} + \underset{(.030)}{.875} \ln F.MSh_n + \underset{(.021)}{.617} \ln Size_n$$

- A higher French market share in a destination reflects 88% more firms selling there and 12% more sales by firm

Structural Estimation : Crozet & Koenig (2010)

- Three-step method :
  i) Probability that a firm exports $P(\varphi > \bar{\varphi}_{ij}^h)$ determines $\delta^h \gamma^h$
  ii) Gravity equation on individual exports $x_{ij}^h(\varphi)$ determines $-\delta^h(\sigma^h - 1)$
  iii) Pareto distribution (relationship between φ and $x_{ij}^h(\varphi)$) determines $-[\gamma^h - (\sigma^h - 1)]$
- Main results :
  - Distance (proxy for τ_{ij}) has a significant effect on export probability for all industries and on export volume for all but 6 industries.
  - Results consistent with theory : $\hat{\sigma}^h > 1$ and $\hat{\gamma}^h > \hat{\sigma}^h - 1$
  - On average, the extensive margin accounts for 62% of the overall effect of distance or trade barriers on trade
  - Estimated on firms with more than 20 employees $\rightarrow$ Right tail of the distribution on which Pareto is more likely to hold (Axtell, 2001)

Structural Estimation : Eaton, Kortum & Kramarz (2011)

- Heterogeneous productivity in the Melitz model captures half of the variation across firms in market entry.
- But the model fails in several respects :
  - Firms do not enter markets according to an exact hierarchy.
  - The distribution of sales across markets deviates from the model.
  - Firms that export sell too much in France.
  - In the typical destination, too many firms sell small amounts.

⇒ Augment the model with market and firm-specific heterogeneity in entry costs and demand.

A structural estimation of Melitz (ii)

Assumptions :

i) Melitz-Chaney, i.e. Melitz + *exogenous* mass of entrants + Pareto distribution of productivities with parameter θ

ii) Fixed export cost (“Cost to acquire consumers”, Arkolakis, 2010) has a firm $\times$ destination random coefficient :

$$f_{ij}(\varphi) = \varepsilon_j(\varphi) E_{ij} M(f) \equiv \varepsilon_j(\varphi) E_{ij} \frac{1-(1-f)^{1-1/\lambda}}{1-1/\lambda}$$

where f is the share of the market's consumers reached, and $\lambda > 0$ reflects the increasing cost of reaching a larger fraction of consumers

A structural estimation of Melitz (iii)

iii) CES demand function that depends on the share f of consumers reached and a market×destination-specific demand shock :

$$X_j(\varphi) = \alpha_j(\varphi) f X_j \left(\frac{p_j(\varphi)}{P_j}\right)^{1-\sigma}$$

- Assume $\ln \alpha_j(\varphi)$ and $\ln \eta_j(\varphi) \equiv \ln \alpha_j(\varphi) - \ln \varepsilon_j(\varphi)$ are normally distributed with zero means, variance σ_α^2 and σ_η^2 and correlation ρ

$\rightarrow$ Model reduces to 5 parameters $(\theta, \lambda, \sigma_\alpha^2, \sigma_\eta^2, \rho)$

- Data :
  - Sales of French manufacturing firms in 113 countries+France
  - Restricted to firms selling in France *and* at least one market

A structural estimation of Melitz (iv)

The estimation procedure minimizes the distance between the observed and simulated 4 sets of moments :

- proportion of firms selling to each possible combination of the 7 most popular destinations
- qth percentile sales in each export market, $q = 50, 75, 95$
- qth percentile sales in France, $q = 50, 75, 95$
- qth percentile export/home sales ratio in each export market, $q = 50, 75, 95$

A structural estimation of Melitz (v)

Table – Results (EKK, 2011, p. 1479)

$\tilde{\theta}$	λ	σ_α	σ_η	ρ
2.46	0.91	1.69	0.34	−0.65
(0.10)	(0.12)	(0.03)	(0.01)	(0.03)

Bootstrapped standard errors in parentheses

- $\tilde{\theta} = 2.46$ implies that fixed costs equal 59% of gross destination profits !
- $\sigma_\alpha = 1.69$ implies enormous variation in a firm's sales across destinations ($\neq$ Melitz)
- $\sigma_\eta = .34$ means much less variation in the entry shock
- $\rho < 0$ reflects high variation of sales in a market
- λ close to 1 implies small entry costs for firms near the entry cutoff, explaining why many firms export small amounts ($\neq$ Melitz)

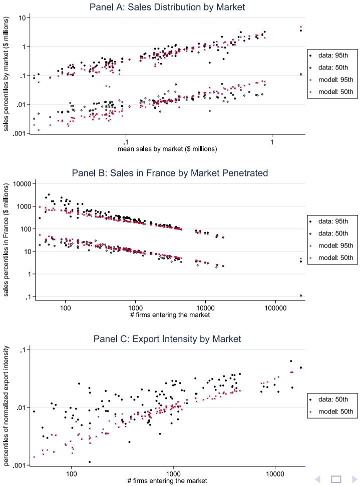
A structural estimation of Melitz (vi)

The model's fit is checked by comparing predictions of the model with data on moments not used in the estimation procedure :

- Total number of exporters
- Distribution of total sales in a market (mean and percentiles)
- Distribution of total sales in France, conditional on exporting
- Median export intensity in each market

A structural estimation of Melitz (vii)

Table – Model versus data (EKK, 2011, Figure 5)



Conclusions

- Melitz (2003) introduces firm heterogeneity in the Krugman model.
- The model predicts self-selection of the most productive firms into exporting, trade adjustments at the intensive and extensive margin, and gains from within-industry reallocation.
- Strong simplifying assumptions : no dynamics, Pareto distribution of firms, same fixed entry cost across firms...
- EKK (2011) : an extension of the Melitz model with demand and trade cost "shocks" fits the data.

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