Globalisation, heterogeneous firms and endogenous investment

Gonzague Vannoorenberghe

Francesco Risi-UC3M

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Observations

- Models of heterogeneous firms link firms characteristics, such as size and productivity, to their export behaviour.
- They suggest that trade liberalization leads to a reallocation of productive factors.
- This is a source of gain from trade (between firms) is confirmed by many studies: Pavcnik (2002), Trefler (2004) and Bernard (2006).
- However, empirical evidence points to another channel of productivity gains that occurs within firms.
- Firms can affect their productivity by investment.

Objectives

- Develope a model a la Melitz(2003) in which heterogeneous firms can affect their productivity by investing in process innovation.
- Show that the main results from Melitz(2003) still hold.
- Examine the investment decision of all firms and how trade liberalization affects it.

Objectives

- Adress a number of recent puzzles to the Melitz (2003) framework with the model:
  1. Nocke and Yeaple (2006): trade liberalisation reduces the skewness of the domestic size distribution of firms;
  2. Nocke and Yeaple (2006): the relationship between the Tobin*s* Q of a firm and its size is empirically negative;

What has been done

- Yeaple (2005), Ekholm and Midelfart (2005), Bustos (2005) or Navas and Sala (2007): firms can choose between two different production technologies: a low productivity, low cost technology, and a high productivity, high cost technology.
- Costantini and Melitz (2007): model of discrete investment decision in a dynamic framework.
- Ederington and McCalman (2006): dynamic model of trade liberalisation with ex-ante identical firms which can choose between two technologies.

- Van Long et al. (2007): investment decision of firms continuous and made before knowing the productivity draw.
- Atkeson and Burstein (2007): investment decision of firms continuous. Stronger assumptions on the functional form of the technology, which makes the returns of process innovation proportional to firm profits.

Demand

- Preference of representative consumer

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

where Ω are all the available varieties, q(ω) is the consumption of variety ω and σ is the elasticity of substitution between varieties assumed > 1

- Demand function for good ω

$$q(\omega) = \left(\frac{p(\omega)}{P} \right)^{-\sigma} Q \quad (2)$$

Where Q=U is an index of consumption and P is the ideal price index, i.e the price of boundle Q.

- Price index

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

- Aggregate budget constraint

$$PQ = L \tag{4}$$

Production

- Continuum of firms, each producing a different variety
- Firms are eterogeneous with respect to a productivity parameter $z > 0$, drawn from a continuous distribution $G(z)$ with support (0,Z].
- Production technology :

$$y = zlt(i)^{\frac{1}{\sigma-1}} \tag{5}$$

- Assumptions: $t'(i) > 0$, $t''(i) < 0$, $\lim_{i\to\infty} t'(i) = 0$, $\lim_{i\to 0} t'(i) = \infty$

Timing

- Stage one: an unbounded mass M of firms decide if they want to enter the market. They pay a labour sunk cost f_e to obtain a draw of the parameter z.
- Stage two: the firm decides if enter the market and how much to invest.
- Stage three: the firm set the price and decides how much to produce.
- Firms live only one period (different from Meltiz (2003) that considers the effects of exogenous dead and endogenous entry)

Otpimization problem of the firm

- The optimal price is a fixed markup over marginal cost

$$p(z) = \frac{\sigma}{\sigma - 1} \frac{t(i)^{\frac{1}{1-\sigma}}}{z} \tag{6}$$

- Using the optimal price

$$q(z) = \left(\frac{\sigma}{\sigma - 1} \frac{t(i)^{\frac{1}{1-\sigma}}}{zP} \right)^{-\sigma} Q = \left(\frac{P}{p(z)} \right)^{\sigma} Q \tag{7}$$

- The profits are

$$\pi_d(z) = A(zP)^{\sigma-1}t(i)L - i - f \tag{8}$$

- where $A = \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}$ Choosing an higher level of investment allows the firm to sell a lower price, thus to sell more, but at cost i
- FOC

$$A(zP)^{\sigma-1}Lt'(i_d) - 1 = 0 \tag{9}$$

1. higher i_d implies higher P
2. higher i_d implies higher productivity z

- Total derivative of FOC allows to compare the investment of firms having drawn different z

$$d_{i_d} \left. \frac{t''(i)}{t'(i)} \right|_{i=id} + (\sigma - 1)\frac{dz}{z} = 0 \tag{10}$$

where $-\frac{t'(i)}{t''(i)}$ is the sensitivity of optimal investment to a change in the conditions face by the firm

- **Proposition 1:** *The optimal investement of a firm is increasing in its size*

- The variables profits can be rewritten as:

$$VP_d(z) = \frac{t(i_d(z))}{t'(i_d(z))} \equiv \frac{i_d(z)}{\epsilon(i_d(z))} \tag{11}$$

- The sales of the firm are:

$$s_d(z) = \sigma VP_p(z) = \sigma \frac{t(i_d)}{t'(i_d(z))} \tag{12}$$

where $\epsilon(i) = \frac{it'(i)}{t(i)}$ is the elasticity of $t(i)$

- **Assumption 2:**
  1. $\epsilon(i) < 1 - \mu$ for small μ and all i
  2. $\epsilon(i)$ is monotonic over i and bounded away from zero

The cutoff productivity level

- z^* is the cutoff such that, given the optimal investment decision $i_d(z^*)$ the firm breaks even:

$$\frac{t(i_d(z^*))}{t'(i_d(z^*))} - i_d(z^*) - f = 0 \tag{13}$$

where the first term is $VP_p(z^*)$

- **Lemma 2:**
  1. Under Assumption 1, the optimal level of investment of the cutoff firm z^* is uniquely determined, and is independent of the level of z^*.
  2. There exists a strictly positive and unique cutoff level z^* such that all firms with $z > z^*$ make strictly positive profits, and all firms with $z < z^*$ decide to exit the market.

- Ideal price index as a function of cutoff firm z^*

$$P^{\sigma-1} = \frac{f + i^*}{ALt(i^*)} z^{*1-\sigma} = \frac{f + i^*}{ALt(i^*)} \frac{1}{z^{*\sigma-1}} \tag{14}$$

where $i^* = i_d(z^*)$ is constant by lemma 2

- Free entry condition

$$\int_{z^*}^{Z} \pi_d(z) dG(z) = f_e \tag{15}$$

- Labour market equilibrium

(16)

$$L = M\left[\left(\int_{z^*}^{Z} (\sigma - 1)\frac{t(i_d(z))}{t'(i_d(z))} + i_d(z) + f dG(z)\right) + f_e\right]$$

where M is the mass of interpreneus paying the sunk cost f_e

The Open Economy The setup

- Two symmetric countries: Home and Foreign
- Two additional costs:
  1. iceberg trade costs $0 < \tau < 1$ defined as the fraction of good that arrives at destination for unit shipped
  2. fixed costs of exporting f_x paid in units of labour.

- Optimal pricing rule

$$p_F(z) = \frac{\sigma}{\sigma - 1} \frac{t(i)^{\frac{1}{1-\sigma}}}{\tau z} = \frac{p_H(z)}{\tau} \tag{17}$$

- Given the optimal price and the symmetry assumption

$$q_F(z) = q_H(z)\tau^{\sigma} \tag{18}$$

- Due to the higher price a Home firm sells less in Foreign than at Home. The higher the price elasticity of demand, the higher this effect.

- Profit of an exporting firm

$$\pi_x(z) = \left(1 + \tau^{\sigma-1}\right) A(zP)^{\sigma-1} t(i) L - (i + f_x + f) \tag{19}$$

- FOC

$$\left(1 + \tau^{\sigma-1}\right) A(zP)^{\sigma-1} t'(i_x) L - 1 = 0 \tag{20}$$

where $i_x(z)$ are the optimum investement for a firm with productivity z and that decides to export

- The optimal investment level of a firm having drawn z is higher if it exports than if it does not
- Since it sells more it is more profitable to save on the variable costs by investing in fixed costs

- A firm will decide to export if it makes higher profits by exporting than by producing only for its domestic market

$$\pi_x(z) - \pi_d(z) \geq 0 \tag{21}$$

$$A(zP)^{\sigma-1}L[(1+\tau^{\sigma-1})t(i_x(z))-t(i_d(z))]-i_x(z)-f_x+i_d(z) \geq 0 \tag{22}$$

where i_x and i_d respectively denote the optimal investment decision of a firm z.

- In contrast to Melitz (2003) the decision to export is not taken independently of domestic considerations, because it influences i_x that affect domestic profits.

- **Proposition 2:**For f_x sufficiently high, there exists a unique cutoff firm $z_x > z^*$ which is indifferent between exporting and producing only for its domestic market. Firms having drawn a z above this cutoff export, while firms having drawn a lower z do not. The firm z_x invests discretely more than the most productive non-exporting firm.
- Two main differences with the literature:
  1. f_x should be sufficiently higher than f
  2. there is a jump in optimal investment at the cutoff export level

Trade liberalization

- Trade liberalization as reduction of variable costs: τ increases.
- From the condition that expected profit must be equal to the fixed entry costs:

$$E(\pi) = \int_{z^*}^{z_x^*} \pi_d(z) dG(z) + \int_{z_x^*}^{Z} \pi_x(z) dG(z) = f_e \tag{23}$$

- Rewriting the equation

$$(24) \qquad f_e = \int_{z^*}^{z_x^*} AP^{\sigma-1}Lz^{\sigma-1}t(i_d(z)) - i_d(z) - fdG(z)$$

$$+ \int_{z_x^*}^{Z} \left(1+\tau^{\sigma-1}\right) AP^{\sigma-1}Lz^{\sigma-1}t(i_x(z)) - i_x(z) - f - f_x dG(z)$$

- An increase in τ has a direct positive impact on the profit level of exporting firms, and tends to raise expected profits
- The cutoff z^* therefore has to increase in order for the expected profits to remain constant.
- The price index (14) decreases, and welfare increases, as in Melitz (2003).

- The percentage change in the domestic cutoff level is higher the larger the proportional size of the exporting sector.
- **Proposition 3**
  1. A marginal decrease in variable trade costs raises the domestic cutoff level z^* and therefore induces a selection effect.
  2. A marginal decrease in variable trade costs decreases the optimal investment level of all firms that remain non-exporters.
  3. A marginal decrease in variable trade costs induces an increase in the investment of exporting firms.

- Effect of trade liberalization on z_x^*

  (25)

  $$A(z_x^* P)^{\sigma-1} L[(1+\tau^{\sigma-1})t(i_x(z_x^*))-t(i_d(z_x^*))]-i_x(z_x^*)-f_x+i_d(z_x^*) = 0$$

- Direct positive effect on the left side.
- Indirect negative effect through the decrease of P
- The direct positive effect dominates and the export cutoff decreases increasing the number of exporters(**Prop.4**).

Innovation intensity at firm level

- Innovation intensity $\iota(z)$ is defined as the ratio of spending on innovation divided by sales.

$$\iota_k \equiv \frac{i_k(z)}{s_k(z)} = \frac{1}{\sigma}\epsilon(i_k(z)) \tag{26}$$

for $k = d, x$

- If $\epsilon'(i) > 0$ the innovation intensity is increasing in size.
- **Proposition 5:**
  - if $\epsilon'(i) = 0$, a marginal decrease in the costs of trade has no impact on the innovation intensity at the firm level.
  - if $\epsilon'(i) > (<)0$,a marginal decrease in the costs of trade raises (decreases) the skill intensity of exporting firms while decreasing (raising) that of non-exporting firms.

Aggregate innovation intensity

- It is a priori unclear how the aggregate innovation intensity changes.
- Relative sensitivity of investment to external conditions:

$$E(i) \equiv \frac{-t'(i)^2}{t''(i)t(i)} \tag{27}$$

- The higher the E, the higher will be the proportional adjustment of investment by a firm to changes in external conditions
- Lemma 3 Under Assumptions 1 and 2, $\epsilon'(i)$ and $E'(i)$ have the same sign.

- Aggregate innovation intensity (R) is defined as the ratio of aggregate innovation to aggregate sales.
- A decrease in trade costs has two types of effects on the aggregate innovation intensity:
  1. Effect on the cutoff points (B)
  2. The impact of the change in the innovation intensity of all other firms and not only cutoff (C)
- **Proposition 6**:
  1. if $\epsilon'(i) = 0$, Effect C has no impact on the aggregate innovation intensity, which remains constant.
  2. if $\epsilon'(i) > (<)0$, Effect C raises (decreases) the aggregate innovation intensity.

Criticisms and Possible extensions

- Lack of temporal dynamics
- Do firms always invest?
- Try to develope the model with temporal dynamics
- Try to avoid to use symmetry among countries
- Try to construct a model for more than two countries