Globalisation, heterogeneous firms and endogenous investment

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Introduction

Close economy

Open Economy

Conclusion
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

- Develop a model à 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 Tobins 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.


- 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

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

where \( \Omega \) are all the available varieties, \( q(\omega) \) is the consumption of variety \( \omega \) and \( \sigma \) is the elasticity of substitution between varieties assumed > 1

- Demand function for good \( \omega \)

\[ q(\omega) = \left( \frac{p(\omega)}{P} \right)^{-\sigma} Q \]

Where \( Q = U \) is an index of consumption and \( P \) is the ideal price index, i.e. the price of bundle \( Q \).
Price index

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

Aggregate budget constraint

\[ PQ = L \]
Production

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

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

- 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)
Optimization problem of the firm

- The optimal price is a fixed markup over marginal cost

\[ p(z) = \frac{\sigma}{\sigma - 1} \frac{t(i)^{1-\sigma}}{z} \]  \hspace{1cm} (6)

- Using the optimal price

\[ q(z) = \left( \frac{\sigma}{\sigma - 1} \frac{t(i)^{1-\sigma}}{zP} \right)^{-\sigma} \]  \hspace{1cm} Q = \left( \frac{P}{p(z)} \right)^{\sigma} Q \]  \hspace{1cm} (7)
The profits are

\[
\pi_d(z) = A(zP)^{\sigma-1} t(i)L - i - f
\]

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

\[
A(zP)^{\sigma-1} L t'(i_d) - 1 = 0
\]

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 $z$

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

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 investment of a firm is increasing in its size.
The variables profits can be rewritten as:

\[
VP_d(z) = \frac{t(i_d(z))}{t'(i_d(z))} = \frac{i_d(z)}{\epsilon(i_d(z))}
\]

The sales of the firm are:

\[
s_d(z) = \sigma VP_p(z) = \sigma \frac{t(i_d)}{t'(i_d(z))}
\]

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

**Assumption 2:**

1. \(\epsilon(i) < 1 - \mu\) for small \(\mu\) 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:

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

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 $z^*$

\[
\begin{align*}
P^{\sigma-1} &= \frac{f + i^*}{\text{ALt}(i^*)} z^{*1-\sigma} = \frac{f + i^*}{\text{ALt}(i^*)} \frac{1}{z^{*\sigma-1}} \\
\end{align*}
\]

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

Free entry condition

\[
\int_{z^*}^{Z} \pi_d(z) dG(z) = f_e
\]

Labour market equilibrium

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

where $M$ is the mass of interpreneurs 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

\[(17) \quad p_F(z) = \frac{\sigma}{\sigma - 1} \frac{t(i)^{\frac{1}{1-\sigma}}}{\tau Z} = \frac{p_H(z)}{\tau}\]

Given the optimal price and the symmetry assumption

\[(18) \quad q_F(z) = q_H(z) \tau^{\sigma}\]

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

\[ \pi_x(z) = (1 + \tau^{\sigma-1}) A(zP)^{\sigma-1} t(i)L - (i + f_x + f) \]

FOC

\[ (1 + \tau^{\sigma-1}) A(zP)^{\sigma-1} t'(i_x)L - 1 = 0 \]

where \( i_x(z) \) are the optimum investment 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

\[ \pi_x(z) - \pi_d(z) \geq 0 \]  

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

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: \( \tau \) increases.

▶ From the condition that expected profit must be equal to the fixed entry costs:

\[
E(\pi) = \int_{z^*}^{Z} \pi_d(z) dG(z) + \int_{z^*_x}^{Z} \pi_x(z) dG(z) = f_e
\]
Rewriting the equation

\[(24) \quad f_e = \int_{z^*}^{Z_x} AP^{\sigma-1} Lz^{\sigma-1} t(i_d(z)) - i_d(z) - fdG(z) \]

\[+ \int_{z^*_x}^{Z} (1 + \tau^{\sigma-1}) AP^{\sigma-1} Lz^{\sigma-1} t(i_x(z)) - i_x(z) - f - f_x dG(z) \]

An increase in $\tau$ 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 $\nu(z)$ is defined as the ratio of spending on innovation divided by sales.

\[
\nu_k \equiv \frac{i_k(z)}{s_k(z)} = \frac{1}{\sigma} \epsilon(i_k(z))
\]

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 $\epsilon'(i) > (\textless)0$, 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:

  \[
  E(i) \equiv \frac{-t'(i)^2}{t''(i)t(i)}
  \]

- 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 $\epsilon'(i) > (\leq) 0$, Effect C raises (decreases) the aggregate innovation intensity.
Criticisms and Possible extensions

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