Entry and Exit Thresholds and Firms Heterogeneity in an Export-Led Growth Model.

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(preliminary version, to be completed and revised)

Abstract

In this paper, I describe an export led growth model a là Fagerberg (1988) which exhibits endogenous cycles driven by Schumpeterian behaviour. The existence of entry and exit threshold permits to invest pro…ts in technology and innovation, by this way R&D expenditure which is exogenous in Fagerberg's model becomes endogenous. Entry and exit thresholds are …rm speci…c and play a crucial role because gives to the incumbents a monopoly power on respect to entrants, this monopoly power are destroyed by the growth of the demand which makes other …rms trespass entry thresholds. When monopoly pro…ts are destroyed by entry, investment in R&D decreases and by this way also non-price competitiveness deteriorates, making growth slower. The main results of the model is the emergence of endogenous cycles. Moreover depending on the sequence of entry (or exits) both catching up and falling behind are possible results.

1 Introduction

The classic Thirlwall (1979[14]) model and, generally, export-led growth models explain the di¤erences in the rate of growth among countries and regions.

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The idea behind these models is that the demand explains the growth because exports are the main component of autonomous demand and on the other hand because the balance of payment constitutes a constraint for growth: if the income of a country grows at a higher rate than the one which grants the equilibrium of the balance of payment, the country incurs problems due to growth in imports and so more and more di¢culties in …nancing foreign de…cit[1].

The dynamic equilibrium of the balance of payment is:

$$p + x = pw + e + m$$

where m is the rate of growth of imports, x is the one of exports, pw is the foreign in‡ation, p is the home one, e is the growth of the exchange rate. The rate of growth of imports (m) and exports (x) depends on demand (home and world's, respectively) and on prices

$$m = ´_m (p ¡ pw ¡ e) + ¼y \quad (1)$$

$$x = ´_x (pw + e ¡ p) + "z \quad (2)$$

where $´_x > 0; ´_m > 0$ are the price elasticities of exports and of imports respectively, $" > 0; ¼ > 0$ are the income elasticities of exports and of imports respectively; y is the growth rate of income and z is the growth rate of world demand.

Since the e¤ects of prices on the long run are not signi…cant (see McCombie and Thirlwall 1994[10]) the rate of growth consistent with the balance of payments constraint is:

$$y = \frac{x}{¼} = \frac{"}{¼}z \quad (3)$$

the equation [3] is usually called Thirlwaal's law.

In this context it is easy to explain why the rate of growth di¤ers among countries and regions: there are the structural characteristics of countries, summarized by the income elasticities of exports and of imports that could explain the di¤erent levels of the rate of growth. It is clear that countries with higher technological competitiveness and higher income elasticity of exports will have higher balance of payment constraint rate of growth. If we want to explain why the rate of growth changes we have to explain how these elasticities change. A …rst attempt to endogenise the income elasticity is due

[1] Empirically there are lots of arguments for this idea (McCombie and Thirlwall 1994).

to Fagerberg (1988 [5], see also Padoan 1996[11]) who suggests that R&D improves export competitiveness. The growth rates of import and export become:

$$m = \eta_m (p - pw - e) + \chi_m (gw - g) + \varphi_m y \qquad (4)$$

$$x = \eta_x (pw + e - p) + \chi_x (g - gw) + \varphi_x z \qquad (5)$$

where $\chi_m (gw - g)$; $\chi_x (g - gw)$ represent non-price competitiveness of import and export which depend on home and abroad technical progress g, gw. The income elasticities (φ_m; φ_x) have a different meaning on respect Thirlwall's definition, since they do not depend on technology. It is possible to write Thirlwall's definition

$$\pi = \frac{\chi_m (gw - g) + \varphi_m y}{y}$$

$$\varepsilon = \frac{\chi_x (g - gw) + \varphi_x z}{z}$$

moreover in Thirlwall's law high income elasticities mean high non-price competitiveness, in Fagerberg's model the income elaticities are set equal to 1:

The technical progress rate of growth has not a unique definition neither at theoretical nor at empirical level, in effect an exaustive definition of technology does not exists, on the contrary it may be inferred by proxies (Fagerberg 1988[5]).

Moreover technology may be endogenised considering international spillover (Coe and Helpman 1993[2]), lerning by doing and R&D expenditure (Fagerberg 1994[6], De Benedictis 1996[3])

$$g = a_1 \cdot gw + a_2 \cdot k + a_3 \cdot rd$$

where k is the rate of growth of cumulate production and rd is the rate of growth of R&D expenditure. International technology reduces home competitiveness (equations 4, 5) but it increase home technology throuout international diffusion and spillover. If the elasticity $a_1 < 1$ the overall effect on competivenss is negative, on the contrary when $a_1 > 1$; technological spillover raise competitiveness. Finally the elasticity a_1 depends on appropriability and so on social capabilities (Abramovitz 1986[1]) and on similarities among national and international productive structures.

In spite of the explicit consideration of technology and generally of non-price competitiveness, this kind of export-led growth model does not consider the pro…ts dynamics. Income growth raises pro…ts which are invested in R&D, and pushing growth againg.

Pro…ts have a key role for technological accumulation, so it is necessary to justify them at micro level. It is clear that perfect competition makes pro…ts equal to zero. On the contrary market structure as monopoly, oligopoly and generally entry and exit thresholds make pro…ts and losses possible.

In the paper the existence of entry and exit thresholds permits to invest pro…ts in technology, by this way R&D expenditure which is exogenous in Fagerberg's model becomes endogenous.

Entry and exit thresholds are …rm speci…c and play a crucial role because gives incumbents a monopolistic power on respect to entrants, this power are destroyed by the growth of the demand which makes other …rms trespass entry thresholds. When monopoly pro…ts are destroyed by entry, investment in R&D decreases and by this way also non-price competitiveness deteriorates, making growth slower, an endogenous cycle emerges

2 The model

2.1 The micro level

2.1.1 Entry and exit dynamics

There are N …rms which produce N di¤erentiated producs as in Dixit-Stiglitz's framework (1977[4]).Each period the only factor is labour, for each …rm i the inverse of production function is

$$L_i = ©_i ¢ Q_i$$

where Q_i is the production and $©_i$ is the inverse of marginal labour productivity of …rm i.

Furthermore each …rm has to pay a lump sum sunk cost K_i to enter the market, this cost is a sum of plant costs, knowledge costs, localisation costs and so on (Perez-Soete 1988[12]). I assume that …rms produce the same quantity ($Q_i = Q$) at the same price ($P_i = P$); moreover the share the same labour productivity ($©_i = ©; L_i = L$); then revenue and cash ‡ow of each …rm are the same.

Firms set their prices maximising the cash ‡ow on respect to Q

$$Max\, fCF = PQ \text{ ¡ } WLg$$

$$P = \Phi W \frac{\sigma}{\sigma - 1}$$

then the cash flow is a constant share of the revenue

$$CF = \frac{PQ}{\sigma}$$

With free entry the actual value of the sum of the cash flow has to equalise the sunk cost K

$$\sum_{t=0}^{\infty} \frac{CF_t}{(1+r)^t} = K_i$$

then

$$CF_i = rK_i = \gamma_i \tag{6}$$

where r is the interest rate for risk-free investment. Profits (and losses) are equal to

$$\Pi_i = \frac{1}{\sigma}(PQ - \sigma \cdot rK_i) \tag{7}$$

which are equal to zero with free entry and homogeneous firms.

Conjecture 1 Firms are heterogeneous regarding on sunk costs.

Conjecture 2 There are entry and exit thresholds, different among firms.

When cash flow is higher than α_i firm i enters, when cash flow is lower than β_i firm i exits. We may represent firms on an $\beta\alpha$ diagramme[2]

Entries and exits are sequential, low α firms enter first, high β firms exits first.

Definition 3 The hysteresis operator ($h(PQ; i)$) is equal to 1 if firm i produces, is equal to 0 if firm does not produce:

$$h(PQ; i) = \begin{cases} 1 & PQ \geq \sigma \cdot \alpha_i \\ 0 & PQ \leq \sigma \cdot \beta_i \end{cases}$$

where there is a one to one relation between each firm i and each pair $(\beta_i; \alpha_i)$:

[2] This diagramme follows Mayergoyz's representation[9], see also Fiorillo ([?]; [?]).

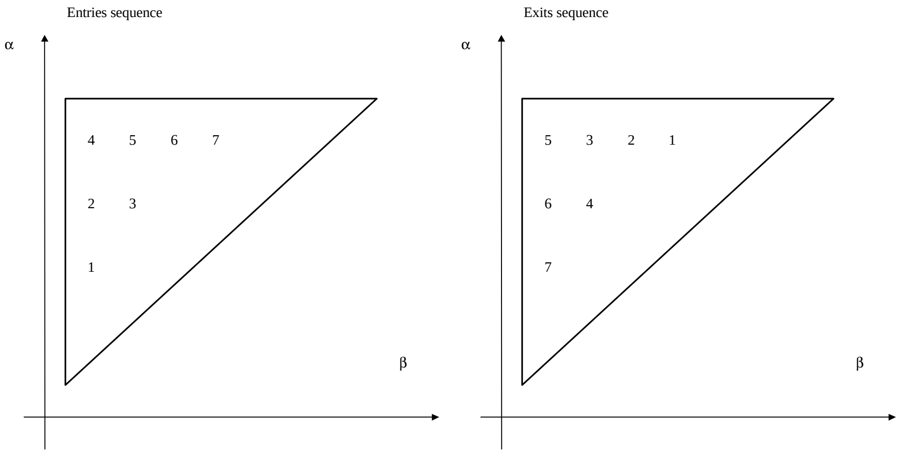

Figure 1: Mayergoyz's Diagramme

Until no firms enter a demand increase (an increase in PQ) raises profits, on the contrary, until no firms exit, a demand decrease make incumbents suffer losses. As soon as the cash flow $\left(\frac{PQ}{\sigma}\right)$ reachs the threshold α_i firm i enters, as soon as $\frac{PQ}{\sigma}$ falls under β_i firm i exits.

The number of firms producing is

$$N = \sum_i h(PQ; i)$$

The total production is $\Theta = NPQ$[3].

Conjecture 4 The production (PQ) of each firm i is calculated assuming that neither entries nor exits occur.

$$PQ = \frac{\Theta}{N_{-1}}$$

where N_{-1} is the number of firm a period before; then the hysteresis operator becomes

$$h\left(\frac{\Theta}{N_{-1}}; i\right) = \begin{cases} 1 & \frac{\Theta}{N_{-1}} \geq \sigma \cdot \alpha_i \\ 0 & \frac{\Theta}{N_{-1}} \leq \sigma \cdot \beta_i \end{cases} \qquad (8)$$

[3] Mathematically both N and Θ are strong hysteresis functions.

2.1.2 R&D accumulation.

R&D expenditure depends on profits, namely each period a quote of cash flow has to be invested in R&D to face other firms competition.

Conjecture 5 R&D investment at firm level is a share of the difference between actual cash flow and exit cash flow β_i:

Aggregating for i we have the stock of R&D of the economy is

$$RD(t) = \int_{-\infty}^{t} \eta \cdot \left(\frac{\Theta}{\sigma} - \sum_i \beta_i h(PQ; i) \right) e^{\delta \cdot (\tau - t)} d\tau$$

where $\eta \leq 1$ is the share each firm invest in R&D, δ is the depreciation rate of old R&D due to technological obsolescence and to creative destruction, finally $\sum_i \beta_i h(PQ; i)$ sums the exit cash flows of the incumbents. In advance sectors, both the share invested in R&D (η) and the technological obsolescence (ϕ) are high. In mature ones, the share of extraprofits devolved to investment η decreases, at the same time the obsolescence rate δ decreases.

Taking the log of RD and differentiating

$$\frac{1}{\partial t} \ln(RD) = -\delta + \eta \frac{\frac{\Theta}{\sigma} - CX}{RD} \tag{9}$$

where $CX = \sum_i \beta_i h(PQ; i)$ is the aggregate exit cash flow.

2.2 The macro level

The export-led growth model I use is a partial adjustment continuous time model (Padoan 1996[11]) which is modified to consider that entry and exit are discontinuous process and that firms are heterogeneous on respect to their entry and exit decisions.

Each variable $*$ of the model adjusts to its equilibrium value $*^*$ which move depending on the other variables. Adjustment can be described by a differential equation where $*$ adjusts to $*^*$ at a speed of ψ and by an equlibrium relation among variables. $\frac{1}{\psi}$ is the average lag, i.e. the time necessary to eliminate about 63% of the difference between $*$ and $*^*$: As Padoan does I consider the log of variables. Moreover for simplicity I assume that price are constant.

Let me de…ne

$$D = \frac{1}{@t}$$

The movement of export share is

$$\begin{aligned} D \ln(SX) &= \tilde{A} ¢ [\ln(SX^{¤}) ¡ \ln(SX)] \quad (10) \\ \ln(SX^{¤}) &= \ln(°X) + \hat{A}X ¢ [\ln(G) ¡ \ln(Gw)] \end{aligned}$$

where G and Gw are home and world technology stocks respectively, ÂX is the elasticity of exports to the technological di¤erential, ln (°X) is a constant. Note that X = SX ¢ Z; where Z is the world demand.

Import share (SM) is

$$\begin{aligned} D \ln(SM) &= \tilde{A} ¢ [\ln(SM^{¤}) ¡ \ln(SM)] \quad (11) \\ \ln(SM^{¤}) &= \ln(°M) ¡ \hat{A}M ¢ [\ln(G) ¡ \ln(Gw)] + ' ¢ \ln(SX) \end{aligned}$$

where ÂM > 0 is import elasticity to technology, the negative e¤ects of technology indicates that import is a substitue for export. Moreover import and export are in part complementary since import is used as export factor of production, ' > 0 is the intermediate goods elasticity.

Technology depends on the stock of R&D expenditure and on technological spillovers

$$\begin{aligned} D \ln(G) &= \tilde{A} ¢ [\ln(G^{¤}) ¡ \ln(G)] \quad (12) \\ \ln(G^{¤}) &= \ln(°G) + Á \ln(RD) + ! \ln(Gw) \end{aligned}$$

where Á is the R&D elasticity and ! is the elasticity to world technology. I assume that Á < 1 since only a quote of R&D expenditure actually improves the technological level, moreover at the aggregate level we have to consider the possibility that more than one …rm can develop the same problem, being redundant.

R&D expenditure moves as in equation [9]:

$$\frac{1}{@t} \ln(RD) = ¡ ± + ´ \frac{\frac{£}{¾} ¡ CX}{RD} \quad (9)$$

At constant prices home production £ is equal to income plus export less import:

$$\begin{aligned} D \ln(£) &= \tilde{A} ¢ [\ln(£^{¤}) ¡ \ln(£)] \quad (13) \\ £^{¤} &= Y ¢ (1 ¡ SM) + SX ¢ Z \end{aligned}$$

Balance of payment constraint is

$$\begin{aligned} D\ln(Y) &= \psi \cdot [\ln(Y^{*}) - \ln(Y)] \\ \ln(Y^{*}) &= \ln(SX) - \ln(SM) + \ln(Z) \end{aligned} \quad (14)$$

Finally the aggregate exit cash flow and the number of firms are

$$\begin{aligned} CX &= \sum_i \overline{\ }_{-}h\left(\frac{\Theta}{N_{-1}}; i\right) \\ N &= \sum_i h\left(\frac{\Theta}{N_{-1}}; i\right) \end{aligned} \quad (15)$$

where $h\left(\frac{\Theta}{N_{-1}}; i\right)$ is the hysteresis operator describe in equation [8].

2.3 Steady state growth

To solve the model and calculate the steady state path it is necessary to ignore equations [15] which describes both CX and N like stepwise hysteresis maps. Thus I assume that CX grows at the same rate of Θ[4]. Then I apply the indeterminate coefficients method like Padoan (1996) obtaining similar results[5]:

$$\rho\Theta = \rho Y = \rho Z + \rho X - \rho M$$

where ρ indicate the rate of growth of the variable. Moreover I assume two other constraint on parameters to make calculation easier and to overlight the difference between steady state path and simulations of the next section.

1. $\chi M = \chi X \cdot \varphi$
2. $\omega + \phi = 1$

First condition suggests the import share does not grow in long run ($\rho M = 0$), differences from equilibrium value is due to not instantaneous adjustment[6]. So

$$\rho\Theta = \rho Y = \rho Z + \rho X = \rho RD \quad (16)$$

[4] Also the profits invested in R&D $\equiv \frac{\Theta}{\sigma} - CX$ grows at the same rate.

[5] See appendix

[6] In fact:

$$\rho M = -\chi M \cdot (\rho G - \rho Gw) + \varphi \cdot \chi X \cdot (\rho G - \rho Gw)$$

Note that when $\rho_G = \rho_{Gw}$; $\rho_X = 0$ and $\rho_Y = \rho_Z$.

The second supposes constant returns to scale in technology and is made to simplify calculation.

Equilibrium rate of growth of technology is

$$\rho_G = \phi \cdot \rho_{RD} + \omega \cdot \rho_{Gw} \tag{17}$$

substituting

$$\rho_G = \phi \cdot (\rho_Z + \rho_X) + \omega \cdot \rho_{Gw} = \phi \cdot (\rho_Z + \chi X \cdot (\rho_G - \rho_{Gw})) + \omega \cdot \rho_{Gw}$$

then

$$\rho_G = \frac{\phi}{1 - \phi \cdot \chi X}\rho_Z + \frac{\omega - \phi \cdot \chi X}{1 - \phi \cdot \chi X}\rho_{Gw}$$

Then the rate of growth of world income pushes technology up if $\frac{\phi}{1-\phi\chi X} > 0$, while the effect of the world technology depends on the prevalence of diffusion effects due to technological spillover on negative effects due to losses in competitiveness.

We have catching up if $\rho_G - \rho_{Gw} > 0$; then substituting condition 3 in 17 if the rate of R&D accumulation is greater of the world technical progress $\phi \cdot (\rho_{RD} - \rho_{Gw}) > 0$[7]

R&D expenditure in steady state is

$$RD = \frac{\phi\left(\frac{\Theta}{\sigma} - CX\right)}{\rho_{Gw} + \delta} \tag{18}$$

The model then is not different from Padoan's (1996), starting from different initial condition, only adjustment path changes, not equiibrium. The number of firms N and the aggregate exit cash flow CX are described like hysteresis maps, dynamics changes and becomes path-dependent. The ratio between the production Θ and the exit cash flow CX is not a constant, but it grows with production. Until the number of firms remains unchanged, an increase in production lets incumbents gains profits, on the contrary a slump make incumbents share losses.

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[7] Or it is equivalend to say if

$$\frac{\phi}{1 - \phi \cdot \chi X}(\rho_Z - \rho_{Gw}) > 0$$

$\rho_Z > \rho_{Gw}$; when $\phi \cdot \chi X < 1$.

Negative rate of R&D expenditure induce a losses in non price competitiveness and reduce the share of exports. When pro…ts increases, R&D expenditure may grow up to a point when technological competitiveness lead a backward region to catch up. On the contrary each new entry reduce R&D accumulation and worsen competitiveness.

2.4 Introducing strong hysteresis

Let us study the dynamics within no changes in the number of …rms.

From equations [14] and [9] we obtain a system of di¤erential equations

$$\begin{cases} \dot{£} = [\hat{A}X\,((¡±Á¾RD + ´Á(£ ¡ ¾CX)) ¡ Á½Gw¾RD) + ½Z¾RD]\,\frac{£}{¾RD} \\ \dot{RD} = ¡±RD + \frac{´}{¾}(£ ¡ ¾RD) \end{cases} \quad (19)$$

£ is constant if

$$\begin{cases} £ = 0 \\ £ = ¾CX + \frac{¾RD}{´}(± + ½Gw) ¡ \frac{1}{\hat{A}X´Á}½Z¾RD \end{cases}$$

RD is constant if

$$£ = ¾CX + \frac{±}{´}¾RD$$

There is a unique point with economic meaning $(RD = 0; Q = ¾CX)$[8] where both £ and RD are constant. This point presents a discontinuity: in its neibourugh production grow at a rate equal to

$$½Q = ½Z ¡ \hat{A}XÁ½Gw$$

which is positive if the world demand is enough strong to overtake the negative impact of world technology on exports competitiveness. Asintotically, ½RD is equal to ½£ if the rate of growth of production is positive.

When the number of …rms and CX are hysteretic variables, phase diagramme changes. When …rms enter CX increases and shift the the phase diagramme up, depending on how many …rms enter. A very massive entry

[8] The other is $\left(RD = ¡\frac{´}{¾}CX; Q = 0\right)$; this point is not attractive if $½Z > \hat{A}X ¢ (Á¢½Gw + ± ¡ ¾)$.
Proof. the eigenvalues of Jacobian are $¡±$ and $½Z ¡ \hat{A}X ¢ (Á¢½Gw + ± ¡ ¾)$, the …rst is always negative. Then the equilibrium is a saddle point only if the second is positive.

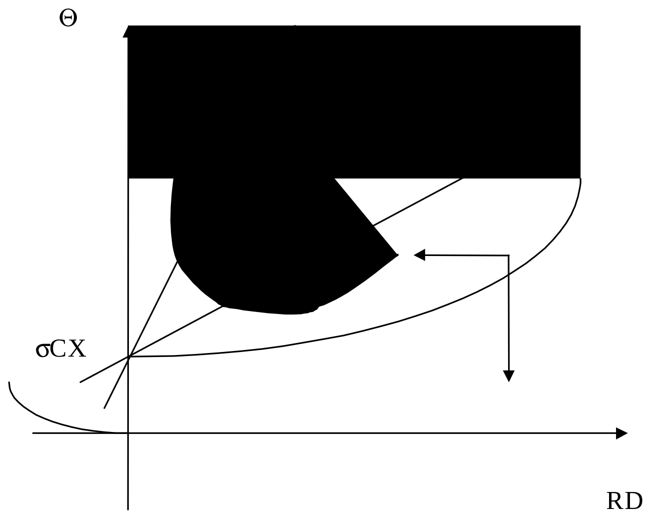

Figure 2: Phase Diagramme

may destroy monopolistic power reducing the R&D accumulation and by this way it may worse competitiveness reducing growth rate. When …rms exits the shift is downward, in the long run the rate of growth teoriccally can converge towards a certain value, can be cyclical or can be explosive

In the following section I simulate the system starting from a steady state situation and considering that CX is a stepwise function coming from the aggregation of weak hysteresis operators h:

3 Simulation analysis

3.1 The emergency of endogenous cycles due to entry and exits dynamics

The model has been simulated for 50 periods (years), each one corresponds to 200 iteractions. The starting point is a steady state condition like the one

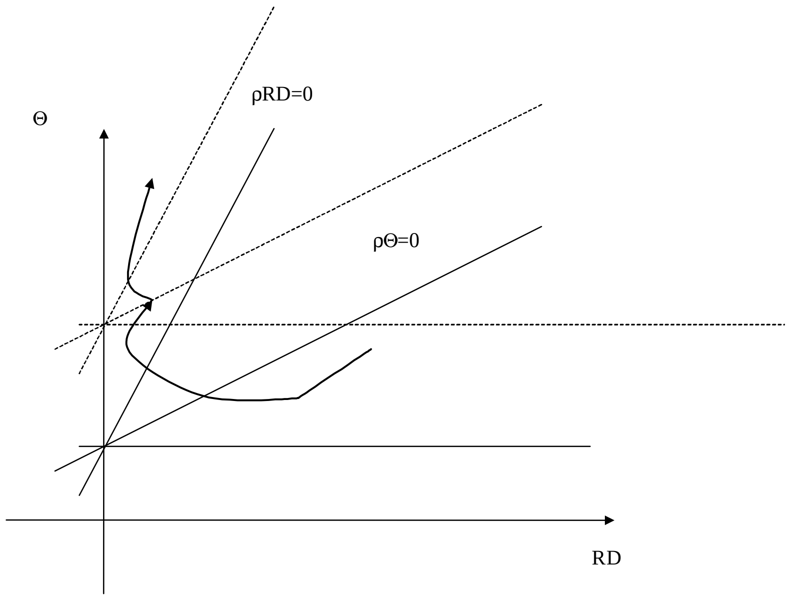

Figure 3: Phase Diagramme with Hysteresis

described above[9]; in spite of this dynamics of the relevant variables move away from steady state.

As we expect from condition 2, the import share rate of growth ½M ‡uctuates around zero, moreover the rate of growth of production, of income and of export (½X + ½Z) are very similar. Di¤erence from equilibrium value depends on not instantaneous adjustment, then higher the speed of adjustment (Ã) is, smaller the di¤erences from teoretical values are.

Looking at the motion of the growth rates of technology and R&D expenditure relative to the number of ...rms

The growth rate of R&D is not continuos when new ...rms enter (exit), these points correnspond to local maxima for the growth rate of technology. Until new ...rms enter both the growth rates grow, in particular the growth of R&D expenditure raises the equilibrium value of technology G¤. As soon as new ...rms enter, R&D expenditure rate of growth decreases, then also

[9] The following tables show the values of parmeters

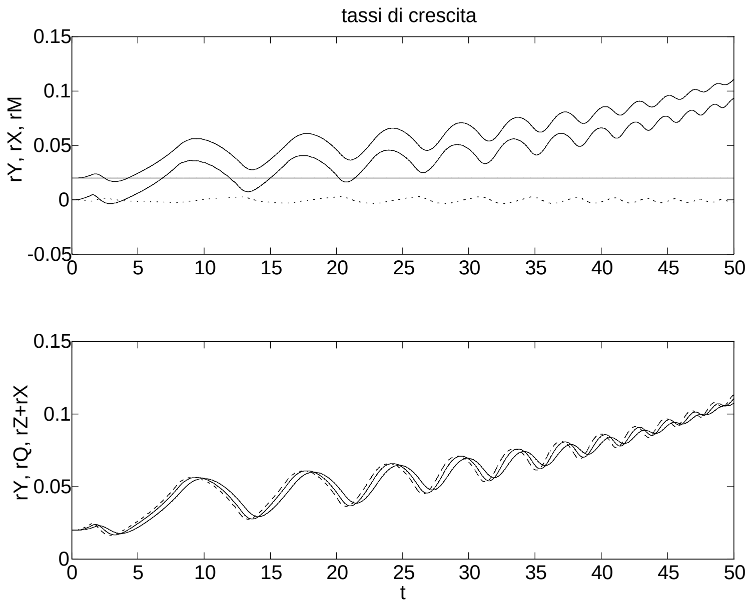

Figure 4:

the growth of G¤ is slower. By this way the growth rate of export share, of production and of income decrease. Since the rate of growth of production decreases the extrapro…ts at …rm level decreases, however the number of …rms increases so the aggregate extrapro…ts may overtake the previous level, increasing the growth rate of R&D and of technology

The existence of entry thresholds provokes discontinuos changes in the number of …rms (N) and in the exit cash ‡ow (CX) : each new entry reduces both total and average extrapro…ts, and by this means the R&D expenditure, when no …rms enter the R&D stock grows with productions since the incumbents share increasing pro…ts. The sequence of entries (exits) produces a Shumpeterian dynamics with endogenous cycle, in the expansionary phases …rms are protected by entry thresholds and have a monopolistic power on respect to potentials …rms. Monopoly induce incumbent to invest their profits in technology. When entrants succed in breaking monopoly the recessive phase starts, due to lower investment in R&D. Then a new cycle starts. If each …rm pro…ts are constant, there is no trend in the cycle, when they increase the trend of growth rate is positive, the region characterised by this

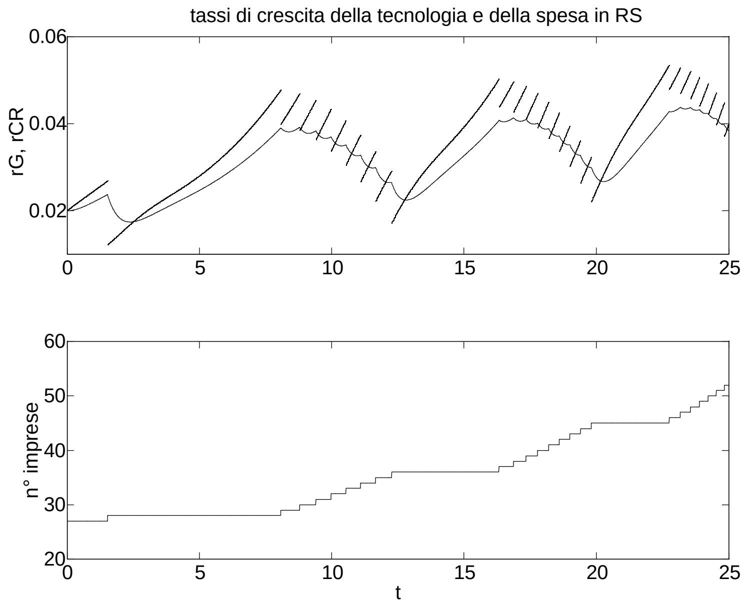

Figure 5:

trend catches up other regions, on the contrary when the pro…ts of each …rms are decreasing the trend is negative and the region is a falling behind one.

3.2 Simulation exercises

In this section I propose two exercise varing parameters, namely I reduce technology elasticity to R&D expenditure in the former and I narrow the inertia gap between thresholds in the latter. Results of section 3.1 are the dotted line of the …gures.

3.2.1 A lower elasticity of technology to R&D expenditure (Á = :4)

If the elasticity Á decreases technological accumulation is slower, then for identical rate of growth of R&D expenditure technical progress is lower. By this way non-price competitiveness also the growth rate of income are reduced. Lower rate of growth of income is, slower the growth of pro…ts is. The number of …rms grows slower as the pro…ts of each …rm and overall prof-

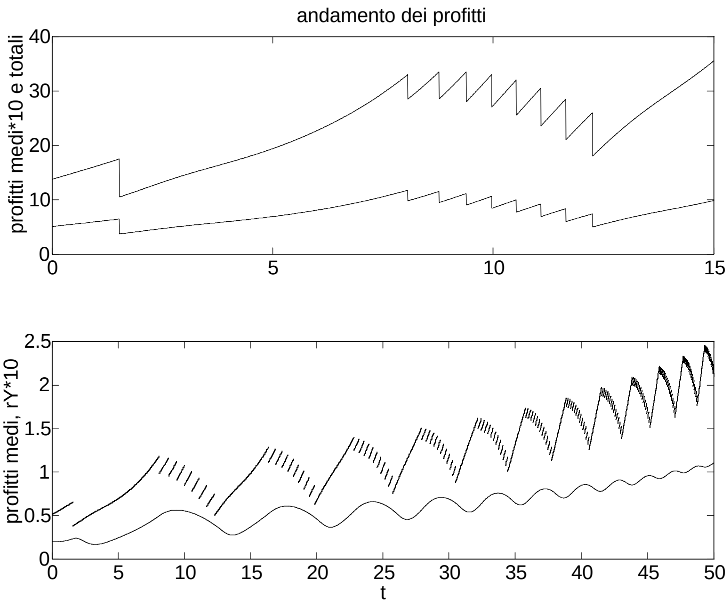

Figure 6:

its do. Dynamically a vicious circle appears, reducing the trend of growth rate.

…gure

3.2.2 A proportional reduction in thresholds

I multiply each threshold ¯; ® for a constant value less than 1: By this way the entries (such as the exits) are easier since the inertia gaps between each ¯ and ® are narrower. Thus entries are easier, monopolistic power and technological accumulation are weaker; the frequency of entries is higher and the pro…ts at …rms level are reduced.

In the simulation exercise the fall of …rm pro…t cannot compensate the increase in the number of …rms, so total pro…ts falls (thik line in …gure). Then the R&D growth slows and technological competitiveness decreases. Region becomes a falling behind one on respect to the initial simulation when whe have catching up.

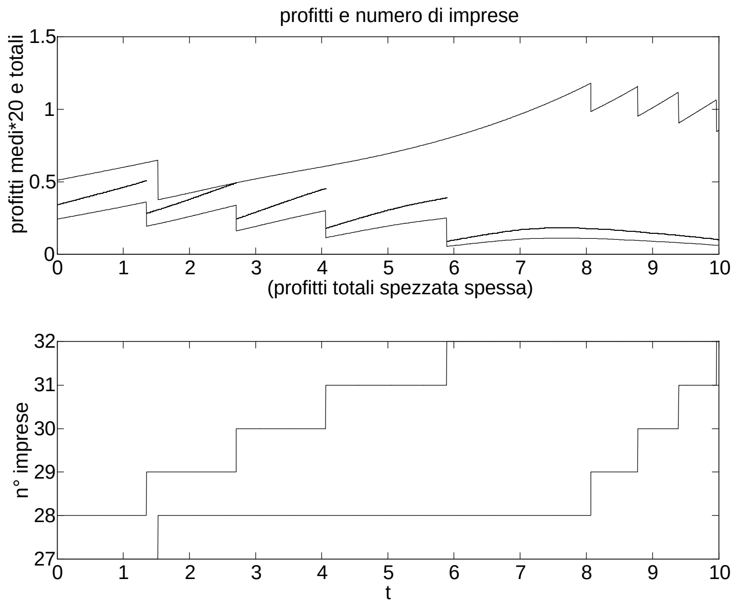

Figure 7:

4 Concluding remarks

The main results of the model is the emergence of endogenous cycles which have a Schumpeterian explanation. Incumbents have monopolistic power since the entrants have to face …rm speci…c entry and exit thresholds due to sunk costs. Monopoly pro…ts are invested in R&D and stimulate growth. The growth of production has opposite e¤ects: from one hand it makes …rms invest in R&D and determinates a virtuous circle since it raises non-price competitiveness, increases demand and pro…ts; on the other hand the faster is the growth the stronger is the incentive to enter. When a new …rm enters pro…ts of incumbents decrease; then entry phase destroys pro…ts.

Depending on the sequence of entry (or exits) both catching up and falling behind are possible results. A limit of this model is that it is a deterministic one, it is clear that if we consider some variables stocastic the shift of the phase diagramme of section 2.4 is strongly path-dependent. Thus identical measures of policy may have very di¤erent e¤ects when applied in di¤erent time.

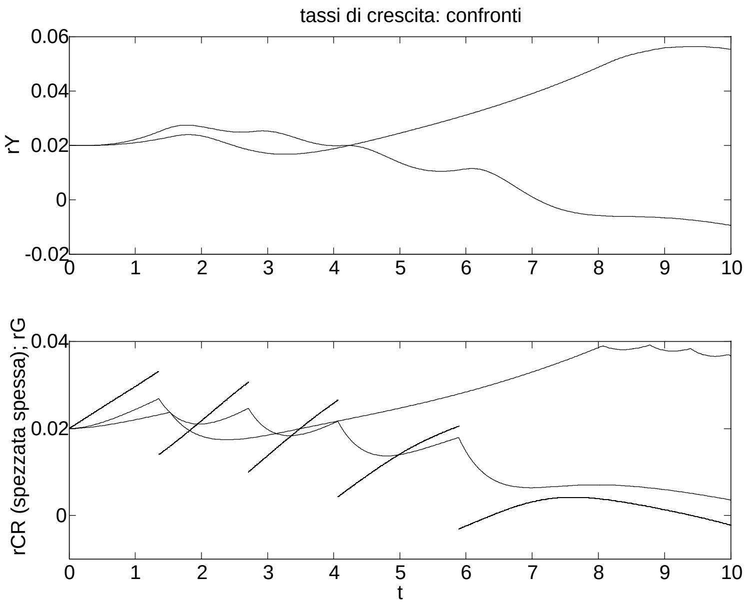

Figure 8:

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