

UNIVERSITÀ DEGLI STUDI DI ANCONA

DIPARTIMENTO DI ECONOMIA

RATE OF GROWTH AND SECTORAL SPECIALISATION COEVOLUTION IN AN EXPORT-LED GROWTH MODEL

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Rate of Growth and Sectoral Specialisation Coevolution in an Export-Led Growth Model

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Abstract

The aim of this paper is to describe and simulate how the rate of growth and the specialisation coevolve in an export led growth model along Kaldorian tradition. The sector specialisation determines aggregate growth, while aggregate growth modifies sector specialisation, endogenous structural changes emerge. In this model the casual chain "growth - profits - technology - income elasticity of exports" describes explicitly the feedback from growth to exports. Moreover, sectors heterogeneity and the impact of sector specialisation on growth are considered; sectors are heterogeneous because of the different dynamic of profits and because of different income elasticities. Taking account of these two elements, growth and specialisation coevolve: an economic system converges towards a medium–period macro equilibrium where the rate of growth and sector specialisation is constant. After some periods the system endogenously changes the regime of growth and shifts towards another equilibrium. The result is strongly path and time dependent. Some simulations show the strong differences in the possible patterns.

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1. Introduction.

The classic Thirlwall (1979) model and, generally, export-led growth models explain the differences in the rate of growth among countries and regions. The idea behind these models is that the demand explains the growth because on the one hand exports are the main component of autonomous demand, 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 difficulties in financing foreign deficit[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 inflation, 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

$$m = \eta_m (p - pw - e) + \pi y$$

$$x = \eta_x (pw + e - p) + \varepsilon z$$

where η_x, η_m are the price elasticities of exports and of imports respectively, ε, π 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.

Substituting we obtain:

$$y = \frac{(\eta_x + \eta_m - 1) \cdot (pw + e - p) + \varepsilon z}{\pi}$$

Since the effects of prices on the long run are not significant (see McCombie and Thirlwall 1994) the rate of growth consistent with the balance of payments constraint is:

$$y = \frac{x}{\pi} = \frac{\varepsilon}{\pi} z \tag{1}$$

the equation [1] is usually called Thirlwaal's law.

In this context it is easy to explain why the rate of growth differs among

[1] Empirically there are lots of arguments for this idea (Bairam 1988; McCombie and Thirlwall 1994).

countries and regions: there are the structural characteristics of countries, summarized by the income elasticities of exports and of imports that could explain the different 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. As Thirlwall wrote (1991), the supply characteristics of goods, such as technological level and quality, determine income elasticities.

The aim of this paper is to modify Thirlwall's law by describing and simulating how rate of growth and specialisation coevolve. Catching up, forging ahead and falling behind (Abramovitz 1986) are possible results of this model. The idea is to endogenize the evolution of the income elasticity of exports in Thirlwall's law (equation 1), following the suggestion of Setterfield (1992, 1993) who affirms that the traditional model of the Kaldorian tradition describes short run equilibria, thus the actual problem in making macroeconomic models is to connect these equilibria to each other and to the structure. Setterfield's idea is that parameters, exogena and also the structural form are deep endogena, so each path of disequilibrium adjustment can modify the deep endogena and shift the economy towards another equilibrium.

There are two channels through which income elasticities can be modified: the former is the sectorial composition of exports and its modification which is important to understand the evolution of the growth rate; the latter is the causal chain that considers explicitly the positive feedback from growth to exports.

Taking account of these two elements we have a model where growth and specialisation coevolve: sector specialisation determines aggregate growth, while aggregate growth modifies sector specialisation. The economic system converges towards a medium–period macro equilibrium where the rate of growth and sector specialisation are constant. After some periods, the system experiments a structural change and endogenously shifts towards another equilibrium, if the underlying dynamic of sectors drives the system to some critical values.

The result is strongly path and time dependent. Some simulations describe the strong differences in the possible patterns.

2. Does the structure matter? Composition effects.

A limit of the traditional export led growth model is not to consider the structure. As recalled by Pasinetti (1981), the aggregate rate of growth depends on the sectorial composition of the economy, then different sectorial rates of growth modify specialisation and hence explains growth. It is clear that technologically advanced countries grow at higher rates, but if sectorial composition is not considered, it is ambiguous if the higher technological level is due to different specialisation or to a higher technology with identical sectorial distribution. Only recently, some authors (Amable and Verspagen 1995; Padoan 1996) have investigated the effects of composition in the export–led growth model: Amable and Verspagen affirm that the export ratio of different sectors have different elasticities with respect to relative prices and some technological indicators.

Then the growth rate of the aggregate export is a weighted average of each sector's growth rate:

$$x = \sum \frac{X_i}{X} \cdot x_i$$

where x_i is the growth rate of exports of sector i, the ratio $\frac{X_i}{X}$ is the level of the exports of sector i on the aggregate ratio.

Supposing that each sector has different income elasticities[2], since $x_i = \varepsilon_i z$.

$$\varepsilon = \sum \frac{X_i}{X} \cdot \varepsilon_i \qquad (2)$$

then the income elasticity of exports is a weighted average of the elasticities of sectors[3]. The higher the quote of sectors with higher elasticities is, the higher the rate of growth is. Moreover, it is easy to show that if the income elasticities of export of each sector are constant the country becomes more and more specialized in the sector with the highest elasticity.

In spite of the inclusion of sectors in their model, these authors (Amable and Verspagen 1995; Padoan 1996) do not consider that structure and growth rate coevolve. They supply no analysis of the feedback from growth to exports,

[2] See Amable and Verspagen (1995).

[3] For simplicity, from this point to the end of the paper, I'll consider only the income elasticity of export and I set the income elasticity of import equal to one ($\pi = 1$). Then I concentrate the analysis on the internal structural changes and on how these determine income elasticity of exports. Note that considering the income elasticity of imports the qualitative results does not change.

such as the one suggested by McCombie (1988). In the Amable and Verspagen model (1995) and the Padoan model (1996), R&D expenditure has a positive effect on the market share of exports and on the rate of growth; in spite of this, R&D expenditure is basically exogenous. On the contrary, in this paper I affirm that there is circular and cumulative causation between growth and exports depending on the following casual chain: growth reduces the cost of labor per unit of product (Verdoorn's effect), this raises the profits, profits permit technological accumulation (both embodied and disembodied technological progress), technological accumulation permits the income elasticity to rise since the income elasticity of export depends on technological characteristics in the broad sense.

3. The feedback from growth to exports: the Verdoorn's Law.

A crucial point must be clarified: the Kaldorian tradition of export–led growth indicates the Verdoorn's law (Verdoorn 1949; Kaldor 1981, 1985) as the main source of cumulative causation, but it works through prices. So if changes in prices are ineffective on the long–run, it is clear that the cumulative effects seem to be put aside (Thirlwall 1979).

Following McCombie (1988), in this model I propose an alternative channel to keep in consideration the effects of Verdoorn's law, moreover I'm looking for a *localized*[4] version of Verdoorn's law which permits me to consider that the Verdoorn effects are different among sectors and countries.

The first step of the casual chain "profits -technology - income elasticity of exports" is due to different factors which can explain the link between profits and technology:

- Kaldor (1957, 1962 with Mirrless) affirms that profits are invested in new vintage of capital, then from his point of view technical progress is partially embodied in new vintage of capital, partially it depends on learning. Verdoorn's law depends on both these aspects[5].

[4] See Atkinson and Stiglitz 1969.
[5] See McCombie and Thirlwall 1994.

- Endogenous growth theory suggests a disembodied explanation for technical progress (Romer 1990; Grossman and Helpman 1991; Aghion and Howitt 1992): positive profits permits R&D and blueprints productions.
- Authors of the Schumpeterian tradition, such as Cohen and Levinthal (1989), affirm that R&D activity is not costless and positive profits can be invested both to innovate and to imitate.

These factors work at sector and sometimes at firm levels, since sectors are heterogeneous because of technology and of entry and exit barriers, so let me define a *localized* Verdoorn's law:

$$f_i = a_i + \lambda_i y \tag{3}$$

where f_i is the growth rate of the productivity of sector i, a_i is the exogenous growth of productivity, λ_i is Verdoorn's coefficient[6]. Note that Verdoorn's coefficient indicates the impact of the growth of aggregate income on productivity, not the impact of the growth of production of sector i. This point of view is consistent with Kaldor's (1985). For this author, Verdoorn's law is a channel for technical progress and it can be justified by the presence of dynamic increasing returns to scale due to learning and to the new vintages of capital: an enlargement of the market permits specialisation and releases resources, making productivity growth. So it is the enlargement of the entire market relevant for each sector, even if it is clear that the impact on productivity is different among sectors. In particular, the enlargement of the market has higher impact on new and technologically advanced sectors (high λ_i) than on traditional ones (low λ_i).

As in classic export-led growth models, prices follow a mark-up rule

$$p_i = s - f_i + \xi_i \tag{4}$$

where s is the wage common for each sector, ξ_i is the rate of growth of the mark-up[7]. Since prices and wages have no effects in the long run, let me assume that prices ($p_i = pw_i = 0$) and exchange rate ($e = 0$) are constant, moreover following Kaldor 1970, the growth rate of wages is the same all over

[6] The Verdoorn's law reduces the labour costs per unit of product.
[7] A similar definition describes world prices adding a w to the variables.

the world ($s = sw$)[8]; then the mark-up grows proportionally with productivity. Substituting [3] in [4] the rate of growth of mark-up is:

$$\xi_i = \lambda_i \cdot (y - z) + (\lambda_i - \lambda w_i) \cdot z \tag{5}$$

The increasing mark-ups are invested in technology and then they raise the elasticity of export[9]. Technology improves the income elasticity of export because it increases product differentiation (Krugman 1989); or because it improves the quality of goods and so the non-price competitiveness. Authors belonging to the Kaldorian tradition and dealing with export-led growth models prefer this second explanation (Fagerberg 1988; McCombie and Thirlwall 1994; Padoan 1993, 1996)[10]. I assume the broadest meaning for technology and I do not specify further functions to link profits to technology and technology to the income elasticities of exports. I only assume that there is an increasing relation between an input (profits) and an output (the income elasticity of exports).

The growth of income elasticities of each sector i depends on:

$$\epsilon_{i,t+1} = \epsilon_{i,t} \cdot (1 + \Phi(\Pi_{i,t})) \tag{6}$$

where the growth rate of exports income elasticity of sector i, $\Phi(\Pi_{i,t})$, is a function of profits $\Pi_{i,t}$ with the following properties:

- $\frac{\partial}{\partial \Pi_{i,t}} \Phi(\Pi_{i,t}) > 0$, the growth rate of the elasticity is increasing on profits
- $\exists \Pi_i^*$ that $\Phi(\Pi_i^*) = 0$, then for profit equal to Π_i^* the income elasticity of exports is constant.

It is clear that if profits are less than Π_i^*, the elasticity decreases; Π_i^* is a sort of *normal* value, where *normal* indicates the value of profits which can exactly avoid technological obsolescence. The idea is that the only way to have technological accumulation is to invest profits in R&D. In a multi-region framework, if other regions or countries improve their technology, the home country suffers some technological obsolescence due to creative destruction (Schumpeter 1942; Aghion Howitt 1992), since the new technology of other countries displaces the old one of the home country. We may consider the difference between

[8] For simplicity I suppose that the rate of growth of the mark-up in the world is equal to zero $\xi w_i = 0$.

[9] This is the second step of the casual chain "profits - technology - elasticity".

[10] Aghion and Howitt (1992) follow a similar way to deal with technological progress.

normal and actual profits as an obsolescence index.

4. Limits on the growth of profits.

In the previous paragraphs I suppose that the growth of productivity raises the mark-up, making technological accumulation possible. Implicitly it seems that there are no limits to the growth of profits and mark-ups. On the contrary, the mark-up cannot grow without boundaries; there is a lot of empirical evidence[11] that shows the lack of correlation between profits and growth.

In the face of decreasing costs and of increasing expected profit (Πa_i), there is a higher pressure of entrants which reduces the growth of mark-up. Let me define α_i as the level of aggregate expected profits of sector i beyond which firms enter, reducing the mark-up; the same happens when profits go under β_i, some firms exit and the others which remain recover their profitability.

In addition to this micro explanation, there are some macro ones that can suggest why profits have ceiling and floor thresholds: a higher mark-up causes higher pressure on reducing prices or increasing wages; in the former, the rest of the world devaluates to recover price competitiveness, appreciating the exchange rate (Padoan 1993); in the latter, a distributive conflict emerges between labour and capital, then labour force asks for increased wages in proportion to productivity[12].

The law of motion of profits is:

$$\begin{aligned} &\Pi_{i,t+1} = \Pi_{i,t} \cdot (1 + \xi_{i,t+1}) \text{ with } \beta_i \leq \Pi a_{i,t+1} \leq \alpha_i \\ &\Pi_{i,t+1} = \Pi_i^* \text{ with } \Pi a_{i,t+1} < \beta_i,\ \Pi a_{i,t+1} > \alpha_i \end{aligned} \tag{7}$$

Whilst expected profits ($\Pi a_{i,t+1}$)[13] remain within the inertia gap $[\beta_i, \alpha_i]$, profits grow at a rate equal to the rate of growth of mark-up. As soon as the expected profits cross a threshold, one of the feedbacks described leads profits to their normal value (Π_i^*).

[11] See Dosi, Pavitt and Soete 1990

[12] This is consistent with Kaldorian theory of growth and distribution (Kaldor 1957).

[13] Note that crossing thresholds depend on expected not actual profit.

It is important to note that thresholds are heterogeneous among sectors[14].

In conclusion, the expected profits are the profits a step forward. In this framework it is consistent to assume bounded rationality then the rule followed by agents is:

If at period t, agents think that expected profits $(\Pi a_{i,t+1})$ a step forward will cross a threshold, then they anticipate their decisions to the present period (t), so entrants enter, workers ask for higher wages, prices and the exchange rate change.

The expected profits is calculated as

$$\Pi a_{i,t+1} = \Pi_{i,t} \cdot \left(1 + \xi_{i,t+1}\right) \tag{8}$$

The meaning of equation [8] is that in a deterministic framework agents calculate the expected profits a step forward without errors and each period they correct their expectations[15].

5. The dynamics in a one-sector model.

Simplifying, the reduced form of the system can be described by 3 sets of discrete difference equations:

Exports

$$X_{i,t+1} = X_{i,t}\left(1 + \epsilon_{i,t}\left(1 + \Phi\left(\Pi_{i,t}\right)\right) z\right) \tag{9}$$

Income elasticity

$$\epsilon_{i,t+1} = \epsilon_{i,t}\left(1 + \Phi\left(\Pi_{i,t}\right)\right) \tag{10}$$

[14] This means that the aggregate effect on the rate of growth has the characteristic of strong hysteresis (Cross 1993; Fiorillo 1996, 1997). Since in the simulation I use only a few agents (sectors) and since I want to avoid using complicated notations, to describe this process I do not use the strong hysteresis tool as I do in Fiorillo 1997.

[15] So within the inertia gap, expected profits are always equal to the profits of the next period.

Profits

$$\Pi_{i,t+1} = \Pi_{i,t}\left(1 + \lambda_i\left(\frac{\sum_i \frac{X_{i,t}}{\sum_i X_{i,t}} \epsilon_{i,t}\left(1+\Phi\left(\Pi_{i,t}\right)\right)}{\pi} - 1\right) z + \left(\lambda_i - \lambda w_i\right) z\right)$$

with $\beta_i \leq \Pi a_i \leq \alpha_i$

$\Pi_{i,t+1} = \Pi *_i$ with $\Pi a_{i,t} < \beta_i, \Pi a_{i,t} > \alpha_i$ (11)

where the expected profits are

$$\Pi a_{i,t+1} = \Pi_{i,t}\left(1 + \lambda_i\left(\frac{\sum_i \frac{X_{i,t}}{\sum_i X_{i,t}} \epsilon_{i,t}\left(1+\Phi\left(\Pi_{i,t}\right)\right)}{\pi} - 1\right) z + \left(\lambda_i - \lambda w_i\right) z\right) \tag{12}$$

It may be very difficult to describe analytically this system (equation [9], [10], [11], [12]), it is easier to describe the motion of the same system with only one sector, in this case the system can be reduced to the following two-variable one, considering $y_t = \frac{\epsilon_t}{\pi} z$ we obtain:

$$\begin{cases} \Pi_{t+1} = \begin{cases} \Pi_t\left(1 + \lambda \cdot y_t\left(1 + \Phi\left(\Pi_t\right)\right) - \lambda w \cdot z\right), \alpha \leq \Pi a_{t+1} \leq \beta \\ \Pi *, \text{ otherwise} \end{cases} \\ y_{t+1} = y_t\left(1 + \Phi\left(\Pi_t\right)\right) \end{cases} \tag{13}$$

where

$$\Pi a_{t+1} = \Pi_t\left(1 + \lambda \cdot y_t\left(1 + \Phi\left(\Pi_t\right)\right) - \lambda w \cdot z\right) \tag{14}$$

This system [13] has only one saddle point equilibrium $\left(\Pi = \Pi^*, y = \frac{\lambda w}{\lambda} z\right)$

Substituting [14] in [13] we can write the loci where thresholds hold:

$$y\alpha\left(\Pi\right) \leq \frac{\lambda w \cdot z + \left(\alpha/\Pi\right) - 1}{\lambda \cdot \left(1 + \Phi\left(\Pi\right)\right)} \tag{15}$$

ceiling threshold.

$$y\beta\left(\Pi\right) \geq \frac{\lambda w \cdot z + \left(\beta/\Pi\right) - 1}{\lambda \cdot \left(1 + \Phi\left(\Pi\right)\right)} \tag{16}$$

floor threshold.

Looking at the phase diagram in figure 1 there are two corner solutions that

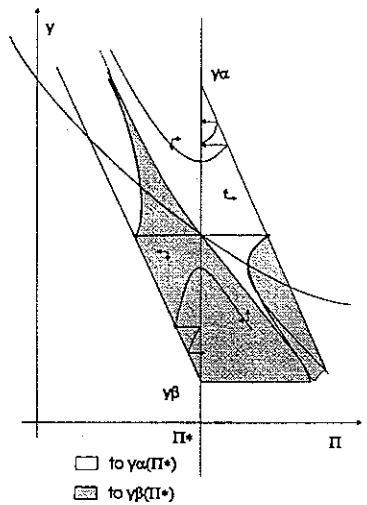


Figure 1: Phase Diagram

are the stable points towards which the system can move

$$y^*_\alpha = y\alpha(\Pi^*) = \frac{\lambda w}{\lambda} \cdot z + \frac{1}{\lambda}\left(\frac{\alpha}{\Pi^*} - 1\right)$$
$$y^*_\beta = y\beta(\Pi^*) = \frac{\lambda w}{\lambda} \cdot z + \frac{1}{\lambda}\left(\frac{\beta}{\Pi^*} - 1\right)$$

The result depends on the starting values of the rate of growth and of profits. In the phase diagram all the points of the dark area are attracted by y^*_β, the other points are attracted by y^*_α.

6. The dynamics in a multi-sector model: a simulation analysis.

When several sectors are taken in account, the number of possible equilibria

increases, it is no longer possible to use the usual tools of analysis[16]. The only way to describe the dynamic is to simulate it. For simulation purposes, let me assume the following simplifications:

- $\Phi(\Pi_{i,t}) = \mu_i \cdot (\Pi_{i,t} - \Pi*_i)$ is the rate of growth of elasticity, since $\Pi_{i,t} \geqslant \beta_i$, $\Phi(\beta_i)$ indicates the maximum obsolescence for sector i; μ_i indicates the impact level of technology on the sector.
- $i = 1...4$, I sort these sectors starting from the one with the highest μ_i to the one with the lowest μ_i. Moreover, I assume that the more a sector is advanced, the higher is μ_i and Verdoorn's (learning) coefficients are and the wider its absolute and relative inertia gaps[17] are.
- The parameters are

Sector i	α	β	μ	λ	λw	$\frac{\alpha-\beta}{(\alpha+\beta)/2}$	Π^*
1	51.8	0.7	0.0015	0.7	0.6	1.947	7
2	20.2	1.3	0.001	0.3	0.6	1.756	5.5
3	11.8	1.2	0.0005	0.3	0.2	1.62	4
4	5.3	2.3	0	0.05	0.2	0.808	3.5

- The starting values of endogena are

Sector i	ε	Π^*	X
1	2	7	20
2	1.5	5.5	10
3	1	4	20
4	0.5	3.5	50

The graph of the rate of growth shows how the economic system changes regimes of growth, jumping from a low equilibrium to a new higher one. Long periods of stability where the rate of growth is constant are broken by a short transition to a new regime. Since the equations describing the system are deterministic, there are no shocks explaining this behavior but only the endogenous dynamic of sectorial profits:

As according to equation [5] and [7], generally profits increase if $y > \frac{\lambda w_i}{\lambda_i} z$;

[16] In particular there are pairs of corner solutions per sector, it is difficult to say if these solutions are all the possible ones or if other dynamics are possible.

[17] Absolute gap is $\alpha - \beta$, relative is $\frac{\alpha-\beta}{(\alpha+\beta)/2}$

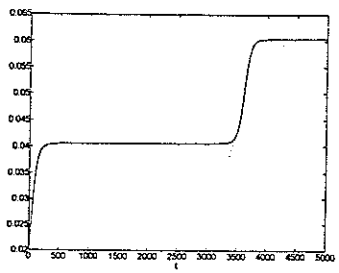


Figure 2: Rate of Growth

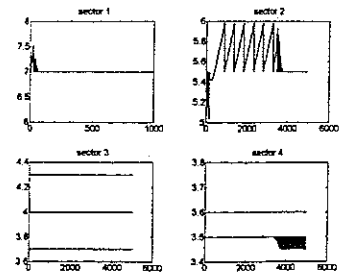


Figure 3: Dynamic of sector profits.

on the contrary, high mark-up values make the expected profits exit the inertia gap, and make the actual profits return to the *normal* level. For some values of the rate of growth, expected profits exit from inertia gap and so agents anticipate their decision, profits and income elasticity of exports become constant. The threshold values for the rate of growth for each sector i can be calculated substituing Π_i^* in equation [12] and considering that $\beta_i \leq \Pi a_{i,t+1} \leq \alpha_i$:

$$y = \frac{\lambda w_i}{\lambda_i} z + \frac{1}{\lambda_i} \left[\left(\frac{\alpha_i}{\Pi_i^*} \right) - 1 \right] \tag{17}$$

is the ceiling threshold,

$$y = \frac{\lambda w_i}{\lambda_i} z + \frac{1}{\lambda_i} \left[\left(\frac{\beta_i}{\Pi_i^*} \right) - 1 \right] \tag{18}$$

is the floor threshold.

Thus the effects of Verdoorn's coefficient is ambiguous: on the one hand, the higher the home coefficient λ_i is and the lower the world one, the higher the growth of mark-up and of profits is. On the other hand a high home coefficient and a low world one reduce the gap within the rate of growth can change without making agents anticipate their decision and obtaining profits which are different from normal value.

Since in sector 3 profits are constant and equal to their normal value and in sector 4 profits have no effects on the elasticity ($\mu = 0$), let me consider the

dynamics of the profits of sector 1 and 2. At the beginning profits grow in the first sector while decreasing in the second, until $y < \frac{\lambda w_2}{\lambda_2} z$ and the elasticity of sector 2 decreases. Since sector 1 starts with the highest elasticity, the region tends to be specialized in this sector, in fact countries tend to be specialized in the sector with the highest elasticity. In spite of this, the sector with the highest elasticity may change; since sectors are heterogeneous the dynamic of profits may stop in one sector but not in others. As in figure 3, when the dynamic in sector 1 has stopped, sector 2 continues making profits. It is due to the speed of growth of the mark-up: the higher the growth rate of income is, the higher the growth of mark-up and consequently of profits is. If profits grow too fast, they often fall out of the inertia gap. A higher rate of growth induces a higher frequency of entry[18] and this stops profits. Then a over-accelerated growth seems to be a constraint for further development since it stops the growth of actual profits, reduces the possibility of technological accumulation and hence reduces further growth.

In the sectors where the profits are at their normal value, elasticity is constant, while it ean change in the other sectors. In sector 2 the increase in the rate of growth of income makes the rate of the growth of mark-up become positive. It makes profits of sector 2 grow and it raises the elasticity of this sector. Even if the elasticity of sector 1 becomes constant, the elasticity of sector 2 continues growing and overtake the elasticity of sector 1. The dotted line in figure 4 is the elasticity of sector 1 that soon becomes constant.

Specialisation consequently coevolves and changes because the sector with the highest elasticity changes

Figure 5 shows the change in specialisation from sector 1 to sector 2. Looking at figure 2, within the periods characterised by a constant rate of growth, the specialisation is stable and the dynamic of the sector in which it is specialized ends; transition periods correspond to structural change and to a change in specialisation. Note that structural change is completely endogenous.

Some exercises can be made to test the effects of a different initial specialisation or of exogenous shocks. Different initial specialisation (better composition

[18] In general it induces to anticipate decisions with higher frequency.

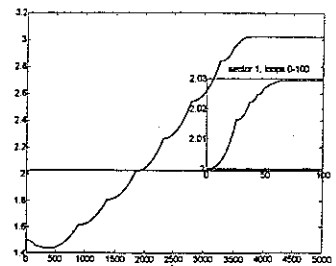


Figure 4: Elasticities of sector 1 and sector 2

of exports[19]) changes the path of the growth rate. In particular, it is possible for a region which starts with better specialisation - i.e. high percentage of exports of sector 1 - to be locked in and not to change its specialisation, moving to a higher regime of growth[20].

Figure 6 shows this lock-in trap: the region that starts with the highest quote of exports in sector 1 starts with the highest growth rate[21]. This situation is not a stable one: the growth rate of region A forges ahead of region B's, in spite of its initial lag.

Because of the higher growth rate of sector 1 the dynamic of the profits of sector 1 in the initial leading country B ends earlier, it does not permit aggregate elasticity to grow enough nor to make the elasticity of sector 2 overtake that of sector 1 (figure 7). In the initial leading country, the elasticity of sector 1 reaches a lower value than in the other region. It explains the lower rate of growth of figure 6. Because of the lower rate of growth, the elasticity of sector 2 decreases and cannot induce a change in specialisation (figure 8). Thus

[19] I simulate two regions starting with the following composition of exports:

i	X_A	X_B
1	20	50
2	10	10
3	20	20
4	50	20

where X_A, X_B are the exports of regions A, B and. The other parameters are the same.

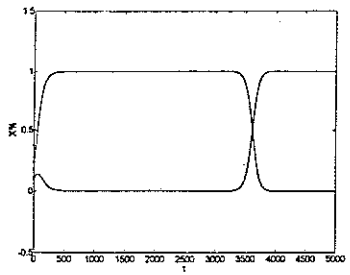


Figure 5: Change in specialisation

the initial leader is locked in a low regime of growth. There are two long-run effects: on the one hand the initial leader remains on a lower regime, on the other hand the lower regime slows the growth of profits of all sectors and it decreases the elasticity of sector 2. Thus the initial leader B cannot invert the decreasing movement of the elasticity of sector 2 and so it cannot change specialisation and jump to a higher regime of growth[22].

7. Conclusion

Considering the feedback from growth to exports, through the link "profits - technology -income elasticity of exports", differences in growth rate and their changes can be explained. Both catching up, forging ahead and falling behind

In the following graphs, region A is the dotted line and it is the region described before, region B the continuous line.

[20] Arthur 1988.

[21] At the beginning $y_A = 2\%$; $y_B = 2.9\%$.

[22] Strong path dependence effects emerge after exogenous shocks as in Fiorillo 1997. The main results of exogenous shocks are:

- opposite shocks do not compensate each other.
- the sequence of shocks changes the path of growth.

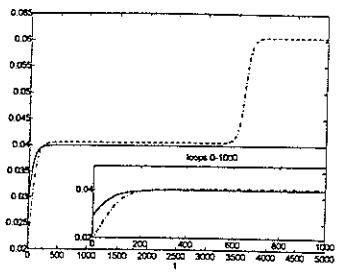


Figure 6: Regimes of Growth in two Regions

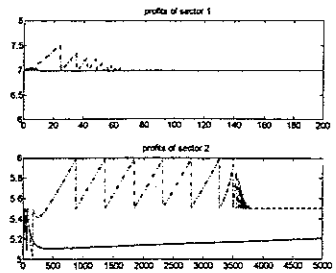


Figure 7: Profits of sector 1 and 2 in two regions

are possible results. Moreover, structural change does not depend on an exogenous shock but it is an endogenous result of the model which has to be considered as a metaphor of the coevolution of the rate of growth and of structure, thus suggesting a way which is consistent with Kaldorian tradition in linking together short-run equilibria or regimes of growth, in a long run evolution. Although there is no effort to calibrate the results to some actual countries or regions, the results in term of endogenization of Thirlwall's law are relevant.

Heterogeneity among sectors and their dynamic allow for the building of a model where growth and specialisation coevolve; sector specialisation determines aggregate growth, while aggregate growth modifies sector specialisation. The economic system converges towards a medium-period macro equilibrium where the rate of growth and sector specialisation are constant. After some periods, the system endogenously shifts towards another equilibrium if the underlying dynamic of sectors drives the system to some critical values.

Traditional aggregate models belonging to Kaldorian traditions are correct and robust enough during the period in which specialisation remains constant. Considering the underlying dynamic of sectors, we can connect in the same model different short-period equilibria, linking them to structural change[23]. These changes cannot be analyzed from the aggregate point of view.

The main result of this model is the presence of endogenous changes in the

[23] Following Setterfield's deep endogeneity (1992, 1993).

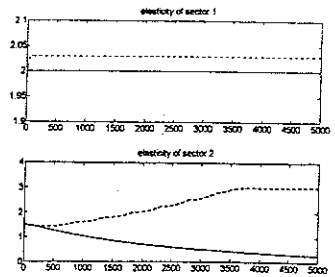


Figure 8: Elasticities of sector 1 and 2 in two regions

regimes of growth. Long periods of stability where specialisation and rate of growth are constant are broken by short transition phases. Specializations are stable until there is a change in the rank of the income elasticities of exports : if a region is specialized in a sector it maintains its specialisation. When the cumulated dynamic of profits changes the rank of the income elasticity of the exports of each sector, there is a bifurcation in specialisation.

Specialisation could be changed only if the rate of growth reaches some critical values. In the model, an early specialisation in a successful sector can make the rate of growth too high and stop the technological investment of profits. This slows further growth and so the elasticity of another sector could not grow so much as to change specialisation, thus a region could incur a lock-in along a low growth regime. The results are strongly path and time dependent.

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