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The cumulative growth model as an alternative approach to the convergence process: Some theoretical and empirical considerations

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resumo

O objectivo principal deste artigo é explicar as diferenças entre três teorias principais que pretendem interpretar o fenómeno de convergência ou divergência do rendimento per capita ou da produtividade entre economias diferentes. A primeira parte descreve três processos diferentes que tentam explicar o fenómeno da convergência real: a teoria neoclássica e a teoria do crescimento endógeno da convergência incondicional e condicional, e a teoria Keynesiana baseada no processo de crescimento cumulativo que prevê a divergência como o resultado mais provável. A segunda parte do artigo explica as fontes da convergência incondicional examinando os estudos empíricos que evidenciam este resultado. A secção 3 analisa as fontes da convergência condicional apresentando estudos empíricos que identificam quais os factores condicionais que explicam esta convergência. A secção 4 comenta a relevância e as limitações das teorias convencionais que explicam a convergencia real. A secção 5 apresenta o processo do crescimento cumulativo que explica o fenómeno da convergência ou divergência, como método alternativo para compreender as diferenças de crescimento entre economias diferentes. A última secção apresenta as conclusões, enumerando as razões que tornam o processo de crescimento cumulativo como o mais relevante para explicar as diferenças dos níveis da vida entre regiões ou países diferentes.

résumé / abstract

Cet article a pour objectif principal d'expliquer les différences entre trois théories principales qui prétendent interpréter le phénomène de convergence ou de divergence du revenu per capita ou de la productivité entre des économies différentes. La première partie décrit trois processus différents qui tentent d'expliquer le phénomène de la convergence réelle: la théorie néoclassique de la convergence absolue ou inconditionnelle, la théorie de la croissance endogène de la convergence conditionnelle et la théorie keynésienne basée sur le processus de croissance cumulative qui prévoit la divergence comme le résultat le plus probable. La seconde partie de l'article explique les sources de la convergence inconditionnelle par l'examen des études empiriques qui mettent en évidence ce résultat. La troisième section analyse les sources de la convergence conditionnelle présentant des études empiriques qui identifient les facteurs conditionnels expliquant cette convergence. La quatrième section commente l'importance et les limitations des théories conventionnelles qui expliquent la convergence réelle. La cinquième section présente le processus de la croissance cumulative qui explique le phénomène de la convergence ou de la divergence, comme méthode alternative pour comprendre les différences de croissance entre des économies différentes. La dernière section présente les conclusions, énumérant les raisons qui font du processus de croissance cumulative celui qui est le plus important pour expliquer les différences des niveaux de vie entre des régions ou des pays différents.

The main scope of this study is to analyse the differences between three main approaches which attempt to explain the convergence or divergence pattern in per capita income or productivity level, among different economies. In section 1 three main theoretical approaches are brought together to explain the convergence phenomenon: the neo-classical and endogenous growth analyses of unconditional and conditional convergence, and the demand orientated approach of cumulative growth, which predicts divergence as the most probable outcome. Section 2 explains the sources of unconditional convergence in the light of the empirical evidence that gives support to this result. Section 3 analyses the sources of conditional convergence making reference to the empirical studies which identify the main conditioning factors which lead to convergence. Section 4 evaluates the relevance and explains the limitations of the conventional approaches to convergence. Section 5 describes the cumulative approach to convergence or divergence as an alternative method for understanding the differences in growth rates between economies. Section 6 concludes, pointing out the reasons which make the cumulative approach to growth the most relevant approach in explaining differences in the living standards of regions and countries.

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1. Introduction: The main theories of convergence[2]

Recently, a large literature on economic growth tries to explain the crucial issue of whether different countries or regions become similar over time. A large number of empirical studies use cross-section or time series methods to analyse whether different economies have converged or not. Convergence between economies[3] is defined as the tendency for the levels of per capita income, or levels of per worker product (productivity), to equalise over time which will happen only if a continuous catching-up process takes place. There are three main theories which predict this convergence pattern of economies.

First, there is the "neo-classical theory" of convergence which argues that due to diminishing returns to reproducible capital, poor countries or regions with low capital/labour ratios have a higher marginal productivity of capital, and therefore, will grow faster than richer ones, given the same saving and investment rates. The conditions of free factor mobility and free trade are essential and contribute to the acceleration of the convergence process through the equalisation of prices of goods and factors of production. The role of the government in such a process is limited to the promotion of market forces and the provision of macroeconomic stability. In this context, the tendency for disparities to decline over time is explained by the fact that factor costs are lower and profit opportunities are higher in poor regions compared to rich regions. Therefore, low income regions will tend to grow faster and will catch-up the leading ones. In the long run, income differences and growth rates will be equalised across regions. In the neo-classical conver- gence framework technical progress is a public good; therefore, all economies will benefit from the exogenously given technical progress. At the empirical level the neo-classical approach to convergence uses and tests the so called hypothesis of "sigma" (σ) convergence which predicts a narrowing dispersion of real per capita income across regions with the passage of time, or the alternative hypothesis of "beta"[4] (β) convergence which identifies a negative relationship between the growth of per capita incomes over a given period and the initial level of income per head across different regions. Some empirical studies based mainly on the concept of "beta" convergence find evidence of unconditional convergence, which is interpreted by the neo-classicists, as a convergence to the same steady - state growth of per capita income or productivity for all regions (Barro and Sala-i-Martin, 1991). The convergence hypothesis of the neo-classical approach is consistent with Solow's (1956) growth theory where growth is determined by the supply of the exogenously given factor inputs, inputs exhibit diminishing returns to scale and technological progress is exogenous. In particular, the simple Solow model assumes that technology is a public good; therefore, all economies have access to the same technology and this eventually leads to convergence. The model predicts that in the long run there will be an inverse relationship between a country's per capita growth of income or productivity and its initial level of income per head or productivity. In the steady state point, all countries will have identical rates of per capita income growth. In the short run an adjustment process will take place towards the steady state path where the poorer countries will exhibit faster growth of their per capita income than the richer ones, since poor countries will have a higher marginal productivity of capital due to a lower capital-output ratio. Convergence is thus the rule in the Solovian growth model and there is no room for a divergent process of per capita output to take place, (Barro and Sala-i-Martin, 1992, Targetti and Foti, 1997).

The story of the neo-classical approach to convergence owing to diminishing returns to capital and the exogeneity of technical progress has been challenged by the theory of endogenous

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3 Economies can be regions or countries.

4 This concept was introduced by Barro and Sala-i-Martin (1992) to distinguish it from "sigma" convergence.

growth which argues that the main forces of convergence may come from the externality effects of R&D expenditure (Romer, 1986), and human capital formation (Lucas, 1988). The theory assumes that all these factors are endogenous to the growth process and offset diminishing returns to physical capital. Regions or countries with more qualified human capital due to higher levels of education, and higher innovation activities will grow faster, so the convergence process is conditional on all these elements. At the empirical level, when human capital and technical progress are introduced into the neo-classical equation of "beta" convergence, the significance level of the parameters improves and the speed of convergence (beta coefficient) increases (Barro, 1991). Accordingly, convergence is not the rule as the neo-classical model predicts but is the exception and only takes place when the poor regions (countries) are able to absorb technical progress emanating from the advanced regions and improve their human capital efficiency and innovation capacity. In these terms, it is more likely to find convergence "clubs" among similar economies and not overall convergence when empirical studies are applied to test for convergence. Consequently, unconditional convergence is more likely to be found among regions or states of the same nation or among similar economies.

The story of the endogenous growth theory has some common elements with the early demand orientated approach to growth which explains the phenomenon of divergence in the light of the "cumulative causation principle" (Myrdal, 1957). According to Myrdal, leading economies have the ability to exploit, sustain, reinforce, increase and accumulate their initial advantages of economies to scale over time, and make it difficult for the lagging countries to compete in the same activities. Therefore, the tendency is for regional disparities to increase if the followers become unable to exploit economies to scale in certain activities and to benefit from technological advantages. The phenomenon of polarisation which Hirschman (1957) first addressed can also be the consequence of this divergence process. Into the same stream of thought (Kaldor, 1957, 1970) argued that the forces which explain the convergence or divergence phenomena depend mostly on the strength of demand (demand-led growth) where exports are the most powerful element (export--led growth). Factor inputs (labour and capital) are assumed to be endogenous and transferred to regions where the demand is strong and not where the prices of inputs are favourable (the neo--classical argument). The special feature of the demand orientated approach is that the growth of productivity is endogenous depending on the expansion of output and this relation exhibits increasing returns characteristics, both static and dynamic (Kaldor,1981), and represents a technical progress function with "learning by doing" properties (Arrow, 1962). The productivity relation, known as the "Verdoorn Law" (Verdoorn, 1949) makes the cumulative causation process of growth circular and virtuous. An exogenous increase of exports increases output through a direct Harrodian foreign trade multiplier effect, making exports the engine of growth[5]. The next effect is on productivity which improves as the result of output expansion (Verdoorn equation), generating substantial dynamic gains in production efficiency, product specialisation, innovation capacity, cost reduction , etc (Kaldor,1975). The reduction in prices is the next consequence as a result of productivity improvement which in turn increases price competitiveness of exports inducing a higher output growth, and the process continues in a circular and expansionary way. According to this approach, there will be a convergence only when poor regions (countries) are able to generate such a cumulative causation growth process by specialising in products with a high elasticity of demand and improving the supply characteristics of exports related to quality, design, confidence, product differentiation, etc. In particular, regions with higher income elasticity of demand of exports relative to the income elasticity of the demand for imports will grow faster (Thirlwall, 1979). When regions are not able to promote such a cumulative growth process by making exports more attractive in the international market they will stay backward and divergence

5 Three main reasons explain the nature of exports as the engine of growth: exports are the component of demand with the smallest import content, this is why exports have a strong foreign trade multiplier effect on income; exports allow for imports especially capital equipment and raw materials which are necessary for economic development; exporting facilitates the flow of technical knowledge which can improve further the growth performance.

will take place. Once again, convergence is not the rule, convergence is conditional depending on the ability of the economies to become more competitive which in turn has much to do with technical progress, innovation ability, capital accumulation and human capital formation. Here is the common element of the "new theory" of endogenous growth and the "demand orientated approach" of the cumulative growth developed earlier.

2. The sources of unconditional convergence

As we explained above, in the neo-classical model convergence is the rule at least in the long run, while divergence is a transitory phenomenon. Backward economies are at an advantage[6] compared to rich countries because of diminishing returns to the accumulation of capital per head. Diminishing returns[7] to capital implies that the rate of return is negatively related to the stock of capital per head so that, other things being equal, economies with a low amount of capital per head are expected to grow faster. The convergence result is tested by using two main approaches: a time series approach which shows that the dispersion of per capita income of different regions decreases over time, and this is the concept of "sigma" convergence based on the coefficient of variation[8]. The second approach, known as "beta" convergence, uses cross section analysis and estimates a linear or a non-linear relationship between the average growth of per capita income or productivity over a certain period and the initial level of income or productivity of different regions. The relation is derived from the standard neo-classical production function with diminishing returns to capital, and exogenous technical progress. The convergence equation can be described as follows:

$$(1/T)\log(Y_{it}/Y_{i0}) = \alpha + \beta \log Y_{i0} + u_{it} \,,\ \alpha>0 \,,\ \beta<0 \quad (1)$$

or

$$(1/T)\log(Y_{it}/Y_{i0}) = \alpha + (1/T)(1-e^{-\beta T})[\log Y_{i0}] + u_{it} \,,\ \alpha>0 \,,\ \beta<0 \quad (2)$$

In equation (1) or (2), Y_{it} stands for real per capita income (or per worker income) of region i at time t, Y_{i0} is the initial per capita income of region i, T is the length of time over which the growth of per capita income is measured, u_{it} is the stochastic error of the equation, α is a constant term[9] representing the steady-state point of convergence which is the same for all regions, and β is the convergence coefficient which is expected to be negative in order to show convergence[10]. According to the neo-classical theory, a negative sign of the β coefficient indicates that poor regions grow faster than richer ones, or, in other words, regions become more homogeneous in their per capita incomes. This is the idea of unconditional or absolute convergence where regions are assumed to converge to the same terminal point, the steady state point, represented by the coefficient α (Sala-i-Martin, 1994). The convergence to the same steady state point implies that the economies do not differ in their levels of technology, investment ratio, saving rates, tax rates and other structures. Therefore, unconditional convergence is more likely to be found among regions of the same country which share a higher degree of homogeneity, a higher factor mobility, similar technologies and the same administrative and legal system.

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6 The idea of the "advantages of relative backwardness" is that poor countries imitate and rich countries innovate. Since imitation is easier and has lower costs, backward countries should enjoy a more rapid growth than advanced countries. Gerschenkron (1962) was the first to express this idea.

7 An interesting argument is that diminishing returns characteristics might also come from the services and education sectors, where it is impossible to raise labour productivity beyond a certain level. Once a country reaches a certain level of services development and education attainment, additional sources to these sectors will not lead to a higher productivity gains. For this argument see Elmslie and Milberg (1996).

8 The coefficient of variation is obtained by dividing the standard deviation of the series by the mean of the sample.

9 α is a function of the steady state growth and technology which are assumed to be the same for all economies.

10 β in equation (2) gives directly the annual speed of convergence.

The concepts of "sigma" and "beta" convergence are complementary since they measure convergence in a different manner and they yield different information. According to Sala-i-Martin (1994, 1996), "beta" convergence is a more interesting concept since it can be used to show whether there exists any convergence pattern among different economies, how fast the convergence process is, whether the convergence is conditional or unconditional, and whether there is partial or total convergence. The same author also shows that "beta" convergence is a necessary but not a sufficient condition for "sigma" convergence. Some of the empirical studies use both concepts of convergence in order to provide a more complete information for the convergence result.

The whole controversy on the convergence issue started from Baumol's (1986) findings of both "sigma" convergence and "beta" unconditional convergence on productivity (GDP per work-hour) among 16 industrial countries, over the long period 1870-1979. Innovation and investment are considered as the main sources of growth in labour productivity exhibiting international public good properties, which however are not included explicitly in the estimated linear equation of convergence. The same author found a weak convergence in output per capita for a small sample of centrally planned economies and no convergence for a sample of less developed countries, suggesting that a convergence "club" process has been taking place. The explanation of the poor performance of the less developed countries lies in the fact that these countries did not benefit much from the public good properties of the innovations and investments of other more developed nations. Different types of product specialisation, lack of education and labour skills prevent the less developed countries from imitating successfully and adopting innovative activities from the leaders.

On the same line of thought, Abramovitz (1986) argued that convergence depends on what he called a country's "social capability" to absorb and exploit successfully more advanced technologies already employed by the technological leaders. According to Abramovitz, social capability is related to technical competence, education level, organisation of firms, and capital accumulation among other structural factors. Using Maddison's (1982) data, Abramovitz also found strong evidence of a catching-up pattern on productivity among 16 industrialised countries over the long period 1870-1979, but the strength of this process varied from period to period. Some other factors, such as capital flows from the leaders to the followers, migration movements, trade and of course flows of applied knowledge are mentioned to be important to the catching-up result found across the industrialised countries, whose relevance, however, is not tested explicitly in the convergence equation.

De Long (1988) has criticised Baumol's results on the grounds of sample selection bias since he uses an *ex post* sample of countries which have successfully developed. In order to use a more consistent *ex ante* sample, he adds seven more countries to Baumol's group and by using a more adequate estimation method in order to avoid specification error bias, he finds little sign of convergence of productivity or per capita income. He concludes that the simple regression equation cannot be used to test for convergence, but he recognises that the forces of convergence exist and everything depends on the capability of nations to assimilate industrial technology, which is a public good.

At the regional level, most studies are limited to searching for unconditional convergence because of the lack of regional data on structural variables. Sala-i-Martin (1996) found evidence of unconditional convergence at a speed of approximately two percent per year when the model was applied to the States of the United States, the Japanese prefectures, and the regions of some European countries. In Europe the evidence for convergence is more controversial and less clear. The hypothesis of unconditional convergence has been tested by Armstrong (1995) among 85 regions of the European Union, over the period 1950-1992. He finds evidence of a slow regional convergence in per capita income (at about 1% per year) for the whole period; a falling convergence rate in the 1970s and 1980s, and no evidence to support the idea of a convergence club between the European regions. On the contrary, Neven (1995) tested σ and β convergence using different groups of regions of the European Community over the period 1975-

-1990. He found strong differences in the pattern of convergence across sub-periods and across subsets of regions in terms of output per head, concluding that the process of convergence among the regions of Europe is unstable. Regions in the south of Europe seem to catch-up in the early 1980s and stagnate thereafter while regions in the north of Europe tend to stagnate or diverge in the first part of the eighties but converge strongly thereafter. He found evidence to suggest that the distinction between the north and the south of the EC is more relevant in the analysis of growth patterns than the distinction between the centre and the periphery. The lack of convergence of the southern regions in the late of 1980s can be partly explained by the lower mobility of labour force in the south than in the north of Europe.

Paci (1997) testing the linear convergence equation (1) found evidence of unconditional convergence in productivity (value added per worker) across 109 European regions over the 1980s, at a slow rate of 1.2% per annum. However, when the convergence equation is estimated using the income per capita variable, no convergence is found across the same regions and over the same period. This inconsistency demonstrates that productivity convergence does not necessarily mean more equality in the standard of living of the European population. It is argued that productivity convergence has been achieved at the expense of increasing unemployment and lower labour participation. Testing the convergence hypothesis at a sectoral level he finds strong evidence of productivity convergence in the industrial and service sectors (although "σ" convergence is constant) and less evidence of convergence in the agricultural sector (and evidence of "σ" divergence). He concludes that the convergence found in aggregate productivity is partly explained by the structural changes in economic activity moving from agricultural activities to industrial and service activities.

Marques and Soukiazis (1999) present some recent evidence on regional convergence (both on "σ" and "β" convergence) for 175 EU regions over the period 1987-1995. They found a slow unconditional convergence in per capita income (in PPP terms) of around 1.3% per annum for the whole sample, but the convergence rate is higher among poor regions (3.8%) than the intermediate regions (2.5%), and no convergence is found between the rich regions. This evidence shows that regions in the EU converge towards a different steady state which depends on their level of economic prosperity, and that structural funds will help more the poor regions to reduce their differences in the standard of living.

McGuinness and Sheehan (1998) found weak evidence of regional convergence in per capita output (0.9% per annum) among 13 UK regions over the period 1970-1995. In terms of σ convergence they found evidence of convergence in per capita income during years of economic expansion and divergence during years of slower economic performance, evidence which supports the idea that regional growth performance follows the growth pattern of the national economy.

Some other studies of regional convergence within a given country confirm the neo-classical prediction of convergence but others not. For example, Coulombe and Lee (1995) found convergence across Canadian provinces from 1961 to 1991, for different measurements of per capita income and output. Their evidence suggests that regional convergence has been reinforced by a favourable change in terms of trade and by government transfers and taxes. Cashin (1995) provides evidence of convergence in real per capita GDP across the seven states of Australia during the period 1861-1991, but the convergence runs at a slow rate of 1.2% per annum. Kangasharju (1998) found regional β convergence across 88 Finnish sub-regions from 1934 to 1993 using taxable per capita income as an indicator of income level. The absolute convergence in Finland runs at about 2% per year in the long run but in the short run is shown to be unstable. On the other hand, Mauro and Podrecca (1994) reject the convergence hypothesis among the Italian regions and give evidence in favour of economic dualism between northern and southern Italy. The same picture is provided by Siriopoulos and Asteriou (1998) when they tested the convergence hypothesis across the Greek regions over the period 1971-1996. They found neither unconditional nor conditional convergence for the Greek case over three sub-periods considered, but they found evidence of the existence of economic dualism across the southern and northern regions of the country. They suggest that the lack of regional convergence is the result of ineffec-

tive investment planning from Greek regional policy and that poor regions do not have previous experience and knowledge which will make them able to establish efficient investments.

Finally, Hofer and Worgotter (1997) found no evidence of absolute convergence across nine Austrian regions and 84 districts. A co-integration analysis of the time series data rejects the hypothesis of an equilibrium relationship between regional and national output. Weak conditional convergence only was found when dummy variables were introduced to account for differences in socio-economic structures between the Austrian districts.

The majority of empirical studies on the convergence issue across countries give little support for unconditional convergence and to the idea that there are automatic forces which lead the economies to converge in their long run path of growth in productivity or per capita income. The unconditional convergence which has been found and the slow catching-up speed, is a special case among homogeneous industrialised countries which form a convergence club or among states or regions of the same nation. Therefore, the idea and the evidence found of several convergence clubs is a serious restriction to the generalisation of the law that poor economies will grow faster and catch up to the technological leaders. Lack of education and the associated skills and differences in productive structure prevent the latecomers from becoming similar to the more successful economies.

At the regional level the evidence is less clear since regional convergence is tested by using different groups of regions, different periods and different definitions and this diversity makes it difficult to compare the results. However, the empirical studies seem to agree that European regions are becoming more similar in their per capita income or labour productivity level (especially within industry), but at a very slow speed. On the other hand, the dispersion of per capita income (σ convergence) across regions has not narrowed significantly. High unemployment and a low labour participation rate in poor regions could be the explanation of this paradox.

3. The sources of conditional convergence

Conditional convergence – an argument brought forward by the theories of endogenous growth - implies that economies converge to a different steady-state point of growth since they have different structures (Barro and Sala-i-Martin,1992). Convergence is conditional to the steady-state growth path which is a function of the differences in technology levels, human capital, investment and saving rates among other structural variables. In the convergence literature, in order to test the hypothesis of conditional convergence, equation (2) of "beta" convergence is extended to include some structural variables, such as the investment ratio, human capital, innovative activity, public expenditure, population growth, trade, and so on. The estimated equation has the following form[11]:

$$(1/T)\log(Y_{it}/Y_{i0}) = \alpha + (1/T)\,(1-e^{-\beta T})[\log Y_{i0}] + \gamma X_{it} + u_{it} \quad \beta<0,\ \gamma\neq 0 \quad (3)$$

Equation (3), is the same as equation (2), but additionally includes X_{it}, a vector of structural variables (as proxies for the steady state) which is believed to influence the average growth of per capita incomes or productivity. In this equation the economies converge if $\beta<0$, and the convergence is absolute if $\gamma=0$ and conditional if $\gamma\neq 0$. The unsatisfactory results found from tests of unconditional convergence led many researchers to search for conditional convergence which is expected to be conditioned on other structural factors, rather than the catch-up effect.

Barro (1991) criticised the "neo-classical" model of unconditional convergence as being unrealistic. He tested the hypothesis of unconditional convergence in a sample of 98 countries over the period 1960-1985 and found no evidence to support the inverse relation between the growth of

11 Mankiw et al., (1992) show in a very comprehensive way how this equation can be derived from Solow's original growth model.

per capita income and the starting level of per capita product. He argued that an important variable is missing from the convergence equation which is human capital, the core variable of the endogenous growth theory. Human capital is essential to the research sector which generates new ideas, new products and contributes to technological progress. The higher the stock of human capital the easier it is for a country as a follower to absorb the new products or ideas generated from the more advanced countries. Therefore, countries with a higher initial stock of human capital are expected to grow faster and catch up more rapidly to the technological leader. Barro provides evidence which shows that the neo-classical hypothesis of convergence is only valid if measurements of human capital are explicitly introduced into the convergence equation. When measures of initial human capital (proxied by school-enrolment rates) are added into the convergence equation the correlation between per capita growth and the initial level of per capita gross product becomes significantly negative across countries, which supports the idea of conditional convergence. On the other hand, the initial amount of human capital and investment rate have significant positive effects on the growth of per capita gross domestic product. Some other conditional factors, such as the ratio of government consumption on gross product, market distortions and political instability influence negatively the convergence pattern. Mankiw *et al.* (1992) also show that the augmented Solow model which takes into account the accumulation of human as well physical capital (and population growth) performs better. When the Solow model is tested for three different groups of countries, a sample of 98 non-oil countries, a sample of 75 intermediate countries and a sample of 22 OECD countries, over the period 1960-1985, no evidence of convergence in GDP per worker is found, except in the case of the OECD countries. This gives support to the idea that unconditional convergence of the Solovian type is only partially valid, for certain countries and certain time periods. However, when the Solow augmented model includes human and physical capital as the additional variables, convergence is found in all samples.

The relevance of the absolute convergence hypothesis has also been questioned by Chatterji (1992) who rejects any automatic mechanism towards convergence. If there was such an automatic mechanism, then it is difficult to explain why disparities between the poor and rich countries still remain. He argued that a negative correlation between growth and the initial level of per capita income or productivity is not a sufficient condition to establish convergence. Using a simple example, he shows that it is possible to find convergence in per capita income or productivity, but the absolute gap between two members of the convergence club can be larger at the end of the period than it was at the beginning. In other words, convergence in growth rates does not necessarily imply convergence in levels of per capita income[12]. He calls this situation "weak convergence" in contrast to the "strong convergence" which requires the existence of a steady state point in which all per capita incomes are equalised. He criticises strongly the neo-classical hypothesis of the exogeneity of technical progress, and as an alternative solution, he elaborates a model where technological growth is endogenous depending on the gap in technology between the follower and the world leader (the technological diffusion model). The model considers the possibility of multiple convergence equilibria (different steady-state points), and therefore allows for the existence of multiple convergence clubs. The existence of two mutually exclusive convergence clubs, one for the rich and one for the poor countries, is possible each of which ends up at a different level of per capita income. Therefore, the disparities between the rich and poor nations can be sustained or even grow. He also assumes that it is possible for some countries to fall into the poverty trap situation, suggesting that in this case a "big push" policy with aid programmes is required from the richer countries in order to help the poor countries to escape from the trap.

The "technology gap" approach is in line with the endogenous growth theory which explains that the slow rate of convergence is the result of differences in technology and the ability to innovate or adopt the existing technology. Technology has some private good characteristics (it is not a public good as in Solow's model) in the sense that it can be excludable to some economies. Convergence will depend on all the efforts, such as investment, education and innovation (R&D,

12 This is consistent with Sala-i-Martin's (1994) explanation, that "beta" convergence is a necessary but not a sufficient condition for "sigma" convergence.

patents), which contribute to narrowing the technology gap between economies (Fagerberg, 1994). A recent study of Sedgley (1998) estimates the convergence hypothesis on growth in real gross product per worker across the USA states. He finds evidence that the technology gap (defined as state gross product per worker as a percentage of the highest state gross product per worker at the beginning of the period) makes a big difference to the growth of productivity, and he surprisingly finds that technology is a private good even across the homogeneous states of the USA. Other structural factors, such as, patenting activities (used as proxy for innovation and technical progress), government expenditures (particularly on health, education and infrastructure) and human capital also have significant effects on state convergence of productivity, and when they are introduced in the estimation the length of time to convergence falls substantially (from 32 to 24 years).

Some other interesting results on the convergence issue are given by Bernard and Jones (1996), where they examine the role of sectors in aggregate convergence for 14 industrialised countries over the period 1970-1987. They show that the aggregate convergence found in labour productivity or multifactor productivity is due to other sectors, especially services, but not to the manufacturing sector which shows little or no convergence. Another study by Elmslie and Milberg (1996), employing an input-output approach, gives an interesting explanation of the convergence or divergence phenomenon which depends on the type of industrial specialisation in goods with dynamic or non-dynamic returns. Countries will succeed in converging to the leader when they are specialising in the production of goods which have "positive-feedback" effects related to increasing returns, learning by doing and technological spill-over properties. Countries which are specialising in goods with "zero-feedback" effects (low productivity specialisation and labour intensive) will fail to converge.

The conditional convergence hypothesis has also been tested in a regional context. Dewhurst and Gaitan (1995) have tested the convergence path among 63 EU regions (NUTS I level) over the period 1981-1991. They found evidence of conditional convergence over the whole period which runs at a slow rate of about 1% per year. The national growth rates of per capita income with a positive effect and unemployment rates in the regions with a negative effect are the main conditional factors which influence significantly the convergence process. Conditional convergence is found to be faster for the shorter period 1987-1991, at about 2% per annum. The growth rates of per capita income among regions are not only related to national growth and unemployment rates but also positively related to the proportion of the region's employment in services. Some other factors, such as the proportion of the regional population of working age, regional population, the participation rate and the proportion of the region's employment in agriculture are not statistically significant. In this study it is shown clearly that the regional convergence path is highly dependent on the national economic performance.

Fagerberg and Verspagen (1996) provide some interesting evidence of conditional convergence across 70 regions in six EU countries, over the period 1950-1990. Convergence in income and productivity levels is found to be stronger up to 1980 and weaker afterwards. The main c onditioning factors which show relevance in the convergence process are innovative efforts and EU investment support while a high share of agriculture and high unemployment are retardant factors. When regions are divided into high, intermediate and low unemployment groups they found evidence of different convergence patterns. In the high unemployment group, catch-up effect is the only explanation of convergence in per capita income. In the intermediate unemployment group, catch-up effect and innovation activity have an important impact on convergence, but EU investment support has not a significant impact. Finally, in the low unemployment group, the catch-up effect is insignificant but investment support from EU and R&D efforts are important factors in the growth of per capita income.

The endogenous growth theory called the attention to the point that convergence in per capita income and productivity level is conditional, associated with endogenous human capital, technical progress and capital accumulation, as opposed to the early neo-classical approach to unconditional convergence, associated with the diminishing returns to capital and where technical progress is assumed to be exogenous.

4. The relevance of the conventional[13] approaches to convergence

Empirical studies in the convergence literature give little support to the neo-classical proposition that poor countries will grow faster than rich ones, and that there are some automatic forces (diminishing returns to capital, same benefits from technology, free factor mobility and trade) which will ensure such an unconditional path towards convergence. The neo-classical approach to general convergence loses its credibility if one makes the following qualifications: (i) the model is not able to explain why leaders change with the passage of time or why some followers before can become leaders later (as is the case of Japan); (ii) the model fails to explain why some poor countries stay poor and rich countries stay rich, without any tendency to converge; (iii) the model does not explain why some countries fell from a fast-growing club into a slower one (Latin American countries); (iv) the model does not explain further why convergence holds for some periods and not for others. The assumptions which the theory makes are also unrealistic. The theory ignores that there are activities that exhibit increasing returns characteristics, such as industrial activities, innovation activities, efforts to improve the human capital performance, and dynamic effects induced by capital accumulation and investment and also by international trade. All these are forces which can create tendencies towards divergence rather than convergence. The hypothesis of technology as a public good and freely available to all countries, ignores that spill-over effects from technology depend on the capacity of the economies to exploit successfully the technological improvements imported from the most advanced countries. Factor mobility, especially of labour, is not perfect as the neo-classical model assumes. Capital and labour movements are limited by the strength of demand and some non-economic factors (institutional impediments, language barriers, personal motives, etc) which can delay or even prevent convergence. The neo-classical approach, by ignoring the demand side of the economy, does not consider that free trade can create balance of payments problems for the less competitive countries which can be a serious impediment to faster growth (Thirlwall, 1979) . All these considerations weaken the idea that backwardness is an advantage for the poor countries which will allow them to grow faster in order to catch-up the more advanced countries. The unconditional convergence which has been found in productivity is a special case among similar economies and it does not prove that there are diminishing returns to capital at work.

Furthermore, the original neo-classical approach tests the convergence hypothesis in terms of productivity and not in terms of per capita income level. The reason is that the convergence equation has been derived from the standard production function approach where labour and not the population is the source of growth. However, as Paci (1997) has shown, productivity convergence does not necessarily imply that the standard of living conditions across economies have converged. On the contrary, disparities in per capita income may have been increased. The reason for this inconsistency is that income per capita is influenced by unemployment and the labour participation rate which are ignored in the productivity convergence approach of the neo-classical type. In other words, productivity convergence can be associated with increasing unemployment and low labour participation which both have a negative impact on the population's prosperity.

On the other hand, there is a plethora of empirical studies which have tested the hypothesis of conditional convergence. In a very ad-hoc manner, the majority of these studies test the significance of the conditional variables added to the convergence equation in order to identify the forces which explain the long run tendency of economies or regions to equalise their levels of productivity or income per head. In the empirical literature other studies criticise the inadequacy of the estimation method which uses a cross section analysis to test for convergence (Quah,1996, Evans and Karras,1996)[14]. In this kind of models there are statistical problems related to multicolinearity,

13 The term conventional is used here to distinguish the neo-classical and endogenous growth approaches from the cumulative causation approach to convergence presented below.

14 Temple (1999) provides a detailed overview on the growth evidence discussing the problems of measuring growth and convergence, the statistical defects which are involved in the cross-section estimation of the convergence equation, and the difficulties of finding an accurate set of structural variables which can explain robustly the convergence pattern.

endogeneity and simultaneity bias as well as measurement or specification errors all of which can affect seriously the robustness of the convergence coefficient and produce misleading results and conclusions on the convergence problem. Klenow and Rodriguez-Clare (1997) argue that considering all these statistical problems the negative coefficient on the initial income variable may not accurately reflect the speed of conditional convergence because some of the control variables contain information about transition dynamics to the steady state point.

The main weakness of all these studies is that, even if they identify correctly the conditional variables which are assumed to contribute to the convergence process, they do not explain formally the mechanism through which the convergence process is generated. No explanation is given of the interaction between the conditional variables and the growth of productivity or per capita income and most importantly to the dynamics which are involved in the convergence process. In the rush to apply country or regional data to test the convergence hypothesis, no effort has been made to explain the complexity of the interaction between structural factors and the growth process, since the former are treated as exogenous. Most importantly, the models applied to convergence in open economies do not consider that growth can be constrained by the balance of payments problems when economies are not competitive in international trade.

5. The cumulative growth approach as the explanation of convergence or divergence tendencies

The demand orientated approach to growth is the alternative approach which criticises strongly the neo-classical generalisation of the convergence phenomenon and the crucial assumptions which ensure such a tendency. In line with Myrdal (1957), Kaldor (1970) questioned the neo--classical predictions that growth rate differences between regions will narrow with trade and free factor mobility, because of diminishing returns to the accumulation of capital and the equalisation of factor input prices. In contrast, and in line with Myrdal's cumulative causation principle, he argued that once a region gains a productivity advantage, the tendency is to sustain and even increase that advantage through the process of increasing returns induced by the expansion of output (Verdoorn's Law), and especially from industrial output. Therefore, countries follow their own national growth path, building their own technological capabilities with little tendency for convergence. The growth model that Kaldor describes is a demand driven model where exports is the most powerful autonomous component of aggregate demand which allows for the expansion of all other components of demand and has direct strong multiplier effects on growth. The increasing returns effects emerging from the relationship between productivity and output growth make the growth process have cumulative and self expanding properties.

Kaldor's ideas of the cumulative causation process of growth were formalised by Dixon and Thirlwall (1975) in a structural model where all the demand forces are brought together in a systematic way. The model involves the following equations:

$g_t = \gamma(x_t)$ $\quad \gamma>0$	growth equation	(4)
$x_t = \eta(p_d)_t + \delta(p_f)_t + \varepsilon(z)_t \quad \eta<0,\ \delta>0,\ \varepsilon>0$	export demand equation	(5)
$(p_d)_t = (w)_t - (r)_t + (\tau)_t$	domestic price equation	(6)
$r_t = r_a + \lambda(g)_t \quad r_a>0,\ 0<\lambda<1$	productivity equation	(7)

In this system all variables are expressed in discrete rates of change through time. In particular, (g) is output growth, (x) is export growth, (p_d) and (p_f) are the growth rates of domestic and foreign prices, respectively, (z) is world income growth, (w) is the growth of money wages, (r) is the growth of labour productivity, and (τ) is 1+% mark-up growth on unit labour costs.

The structural parameters of the system are the following: ($\gamma>0$) is the output elasticity with respect to export growth, ($\eta<0$) is the domestic price elasticity of the demand for exports, ($\delta>0$) is the foreign price elasticity of the demand for exports, ($\varepsilon>0$) is the world income elasticity of the

demand for exports, (r_a) is the growth rate of autonomous productivity and (λ) is the elasticity of productivity growth with respect to output growth (the Verdoorn coefficient) which is assumed to be between zero and unity in order to show increasing returns properties.

Equation (4) expresses Kaldor's idea of exports as the engine of growth. Equation (5) is the export equation with the most important determinants of export demand and thus inversely related to the growth of domestic (export) prices, and positively related to the growth of foreign prices and to the growth of external demand. Equation (6) is the domestic price equation, related to the growth of money wages, productivity growth and the mark up growth on unit labour costs. Finally, equation (7) is the Verdoorn equation, where the growth of productivity (endogenously determined) is positively related to the growth of output.

Equation (7) is very special to the system and responsible for generating the cumulative characteristics and self sustained growth tendency. An exogenous increase in exports (or through the improvement in ε) will increase output and the productivity rate, improving the price competitiveness of exports, increasing further exports and output, and the process will continue to expand in a virtuous way. The region which obtained an initial competitive advantage[15] in the production of goods with a high income elasticity of demand will keep this advantage and will make it difficult for other regions to compete in the same activities. This is the crucial point in the cumulative causation growth models which explains the differences in growth rates between regions, and that divergence can occur between the "centre" and the "periphery" and between industrial and agricultural regions. The openness of the trade between regions can create growth differences which can be sustained or even increase.

Combining equations (4),(5),(6) and (7) we can derive the reduced form equation which gives an expression for the equilibrium growth rate:

$$g_t = \gamma\,[\eta(w_t - r_a + \tau_t) + \delta(p_f)_t + \varepsilon(z)_t] \,/\, (1+\gamma\eta\lambda) \qquad (8)$$

It can be seen from equation (8) that the growth rate of a region is positively related to r_a, z, ε, p_f, and λ and negatively related to w and τ (since $\eta<0$). The model predicts that differences in growth rates between regions can be explained by differences in the values of some crucial structural factors. Countries with a higher income elasticity of demand for exports will grow faster. The income elasticity of the demand of exports captures the supply characteristics of the exported goods, such as quality, design, durability, product differentiation, etc, the so-called non--price characteristics. Price competitiveness can also have some growth effects, which, however, are not so significant as the non-price characteristics: empirical evidence from the estimation of the import and export functions shows that imports and exports are more sensitive to income changes than to price changes. Wage differences can affect the growth performance between economies, since higher wages affect the price competitiveness of exports and can reduce exports and thus growth. Differences in productivity levels are also very important in explaining differences in growth rates between economies. Dixon and Thirlwall (1975) explain that the rate of autonomous productivity growth, r_a, and the Verdoorn coefficient, λ, are functions of the rate of disembodied technical progress and the rate of capital accumulation (autonomous and induced), and also, of the extent to which technical progress is embodied in capital accumulation. Consequently, regions with higher technology and capital accumulation are expected to grow faster in relation to regions which do not posses such advantages[16]. Finally, differences in the foreign trade multiplier effect of exports, γ, will explain differences in growth rates. The higher the foreign trade multiplier effect, the higher the country's growth rate will be. The convergence result will depend on the countries' ability to make their structural parameters as similar as possible.

15 However, this theory does not explain how the initial competitive advantage has been gained.
16 Technical progress and capital accumulation are also the conditional variables which are used to test for conditional convergence in the endogenous growth theory.

This implies, fundamentally, the ability to make regions more competitive by directing productive resources to industrial activities which produce products with a higher income elasticity of demand and exhibit strong increasing returns properties.

The Dixon-Thirlwall model can easily be extended to include a balance of payments equilibrium condition. As Thirlwall (1979) demonstrates, there is a general rule which defines that a country's growth rate (y_B) consistent with a balance of payment equilibrium is given by the Harrod's foreign trade multiplier defined as the ratio of export growth (x) to the income elasticity of the demand for imports (μ), thus, $y_B=x/\mu$. Alternatively, the relation can be expressed as $y_B= \varepsilon(z)/\mu$, where ε is the income elasticity of the demand of exports and z the growth of world demand , or $y_B/z=\varepsilon/\mu$. This last relation has interesting properties, implying that differences in growth rates between two economies are explained by differences in the income elasticity of demand for exports relative to the income elasticity of demand of imports. In other words, a country with a higher income elasticity of demand of exports relative to imports will grow faster without disturbing the equilibrium in the balance of payments. The message of this simple rule is that the growth rate of an economy will depend on its ability to be competitive in the international market. This rule is extremely important when the convergence issues are considered across regions which are very open economies with a high degree of dependence in external trade or across countries with free trade relations. As Thirlwall (1980) explains, regional problems are mainly balance of payments problems.

The Dixon-Thirlwall (1975) model of cumulative growth and Thirlwall's (1979) export-led model have been tested extensively in growth theory[17] but have been ignored in the convergence literature, with few exceptions. Three main reasons can explain this fact: (i) testing the convergence hypothesis in a single equation of the Barro-Sala-i-Martin type is an easy task compared with the difficulties involved in specifying and estimating a complete model of structural equations; (ii) The Dixon-Thirlwall model can not easily be applied in regional analysis because of the lack of data on structural variables; (iii) The Dixon-Thirlwall model is more useful in explaining differences in growth rates across economies than in testing directly the convergence hypothesis.

Interestingly, Targetti and Foti (1997) estimated a modified version of the Dixon-Thirlwall model where they tried to combine the cumulative growth approach and the catching-up theory on convergence. The model they used can be described in the following equations:

$g_t = \alpha + \beta(x)_t \quad \alpha, \beta>0$	output growth equation	(9)
$p_t=\gamma+\delta(g)_t + \mu\ln(GAP)_t + \nu(I/Q)_t \quad \gamma,\mu,\nu>0$ and $0<\delta<1$	conditional convergence equation	(10)
$x_t = \xi + \pi(p)_t + \rho(wp)_t + \sigma(z)_t \quad \xi, \pi, \sigma, >0, \rho<0$	export growth equation	(11)

Equation (9) is the usual Kaldor's equation where the growth of a country's output (g) is governed by the rate of growth of the most potent (exogenous) component of demand, which is the demand for exports (x), with $\beta>0$ representing the elasticity of output with respect to export growth.

Equation (10) is a modified Verdoorn equation which according to the authors represents the conditional convergence equation. Thus, the growth of productivity (p) is positively related to the growth of output (g) with $\delta<1$ representing the Verdoorn effect of dynamic increasing returns. The productivity growth is also positively related to the log of the technology GAP, defined as the productivity ratio between the leader and the follower, with $\mu>0$ the elasticity of productivity growth with respect to the technology gap or the catch-up effect. The productivity growth equation also includes the investment-output ratio (I/Q) as a proxy for capital accumulation and $\nu>0$ measures the sensitivity of productivity growth with respect to this ratio. New investment carries new knowledge which is embodied in new capital goods and new knowledge improves productivity, therefore, ν measures the diffusion effect of technology.

17 See, for instance, Thirlwall (1979), Bairam (1988), McCombie (1993), Atesoglou (1994) , Amable (1993), Soukiazis (1995), among others.

Finally, equation (11) is the usual export equation, where export growth (x) is positively related to the country's productivity growth (p), negatively related to the world productivity growth (wp) and positively related to the growth of world demand (z). In the same equation, $\pi>0$ and $\rho<0$ measure the sensitivity of exports with respect to national and world productivity, respectively, and $\sigma>0$ is the income elasticity of the demand of exports with respect to world income growth.

The above model which integrates the cumulative growth approach and the catching up effects, has been estimated for three different samples, over the period 1950-1988. The first sample covers 9 OECD countries, and using 3SLS estimation the results show strong evidence of the cumulative effects and a clear tendency of productivity convergence towards the leader country, the USA. The second sample covers a group of the main Latin American countries, while the third includes a group of faster growing East Asian countries. The estimation of the conditional convergence equation shows clear signs of convergence in the East Asian group but the catching-up effect is not significant for the Latin American countries. The explanation of these results is that countries will not enjoy a high rate of productivity growth (and thus convergence) if they face restrictions on the growth of demand and if they face low dynamic economies of scale in the production process.

Ledesma (1999) has also developed an extended cumulative growth model where the effects of learning-by-doing, innovation, education and catching-up are integrated into the Dixon-Thirlwall model. The intention is to reconcile the endogenous growth theory and the demand orientated approach[18], explaining the interaction of the cumulative forces and the conditional factors which can lead to divergence or convergence in productivity levels. The structure of the model is the following:

$g_t = \kappa x_t \quad \kappa>0$	output growth equation	(12)
$x_t = \eta(p_d-p_f)_t + \varepsilon z_t + \zeta K_t + \delta(I/Q)_t,\ \eta<0,\ \varepsilon,\ \zeta,\ \delta>0$	export growth equation	(13)
$(p_d)_t = w_t - r_t$	domestic price growth equation	(14)
$r_t = \pi g_t + \lambda(I/Q)_t + \mu K_t + \sigma(GAP)_t\ \pi,\ \lambda,\ \mu,\ \sigma>0$	productivity growth equation	(15)
$K_t = \gamma g_t + \beta q_t + \omega(edu)_t + \psi(GAP)_t\ \gamma,\ \beta,\ \omega,\ >0,\ \psi<0$	innovation equation	(16)

Equation (12) is the usual export induced growth function relating the growth of output (g) and the growth of exports (x) through the Harrod foreign trade multiplier, (parameter $\kappa>0$).

Equation (13) is the augmented demand function of export growth which in addition to the usual determinants related to the growth of relative prices (p_d-p_f) and growth of foreign demand (z) includes two more additional factors: a technology variable to count for innovation (K)[19] and the investment-output variable (I/Q) to proxy capital accumulation. Thus, the elasticity ($\eta<0$) reflects the negative effect of the growth of relative prices on the growth of exports, the elasticity ($\varepsilon>0$) reflects the positive effect of the growth of world income on the growth of exports, the parameter ($\zeta>0$) shows the positive impact of innovation on the growth of exports, and the parameter ($\delta>0$) measures the positive impact of capital accumulation on export growth. The export equation integrates explicitly the price and non – price competitiveness effects. Price competitiveness is measured by the relative price variable and non-price competitiveness is measured by the innovation and capital accumulation variables, both essential for the improvement of the supply characteristics of the produced and exported goods, related to quality, product differentiation, design, etc

Equation (14) in the above model expresses the usual price setting rule where, if it is assumed that mark-up on unit labour costs is constant, the growth of domestic prices (p_d) is determined by the difference between the growth of money wages (w) and the growth of productivity (r).

18 Palley (1996) provides a theoretical framework where he shows how it is possible to incorporate the endogenous growth approach into a Keynesian theory of growth.

19 The ratio of R&D expenditure in the business sector to private investment is used as a proxy for innovation.

Equation (15) is the augmented Verdoorn relation which establishes the increasing returns characteristics and generates the cumulative growth effects. Productivity growth is determined by four major factors. The first factor is the rate of growth of output which establishes the traditional Verdoorn relation with (π<1) measuring the increasing returns effects. The second determinant is the investment-output (I/Q) ratio, taken as a proxy for capital accumulation or embodied technical progress, with (λ>0) measuring the positive effects of capital accumulation on productivity growth. The third factor is the technology variable (K) which captures the innovation effects on productivity growth measured by the parameter (μ>0), while the last determinant is the productivity gap variable (GAP)[20] which captures the catching-up effects on productivity growth given by the positive parameter (σ>0). The higher the differences in productivity level between the leading economy and the followers the higher the opportunities for imitation and diffusion of technology induced from the more advanced countries. Thus, the augmented Verdoorn equation integrates into the cumulative process the conditional forces of the endogenous growth theory which are believed to lead to convergence.

Finally, equation (16) defines the innovation activity relation, where, innovation (K) is positively related to the growth of output (g), to the growth of the cumulative sum of real output (q), (intending to capture learning-by-doing effects) and to the level of education of the working population (edu), but inversely related to the productivity gap (GAP). The higher the productivity disparities between the leader and the followers the lower the capacity of the lagging countries to innovate. The idea is that the innovation activity depends on the level of development. Less developed countries spend less on research and development activities or patenting activities than the advanced countries.

The above model has been estimated successfully for a sample of 17 OECD countries, over the period 1965-1994, by using 3SLS. All the parameters in the structural equations have the expected signs. In particular, the augmented export function shows that capital accumulation and innovation variables are crucial non-price factors in improving export performance. The augmented Verdoorn equation shows strong evidence of increasing returns and catching-up effects in productivity between the OECD countries, but capital accumulation and innovation direct effects are weak on productivity growth. Finally, the most significant effect on innovation comes from education which is the leading factor for convergence in the endogenous growth theory. In general terms, it is shown that the extended cumulative growth model which takes into account the conditional forces of convergence is relevant and that it is possible to integrate the forces of convergence and divergence in the same structural model. The final result will depend on the solution of the reduced form system and the values of the main structural parameters.

Another type of cumulative growth model is used by Amable (1993) which incorporates the interactions between productivity growth, investment, innovation and education in order to explain catch-up and convergence tendencies in productivity. In this model the factors determining the "social capability" concept addressed by Abramovitz (1986) are taken to be endogenous and the cumulative growth properties of the model are reinforced when innovative activity, equipment investment and education are included. The productivity growth model with "social capability" elements can be described in the following set of structural equations:

$$(pg)_t = \alpha + \beta(GAP)_t + \gamma(eq)_t + \delta(prim)_t + \varepsilon(gov)_t \quad \beta, \gamma, \delta, \varepsilon > 0 \text{ or } < 0 \quad \text{productivity equation} \quad (17)$$

$$(eq)_t = \varphi + \kappa(pg)_t + \lambda(pat)_t + \mu(gov)_t \quad \kappa, \lambda > 0, \mu > 0 \text{ or } < 0 \quad \text{equipment investment equation} \quad (18)$$

$$(pat)_t = \omega + \pi(GAP)_t + \rho(sec)_t \quad \pi < 0, \rho > 0 \quad \text{innovation equation} \quad (19)$$

$$(sec)_t = \nu + \theta(GAP)_t + \phi(prim)_t \quad \theta < 0, \phi > 0 \quad \text{education equation} \quad (20)$$

20 GAP is defined as 1-P/P* where P and P* are labour productivity of the follower and the leader, respectively.

Equation (17) relates the productivity growth (pg) positively to the initial technology gap (GAP), where $\beta>0$ measures the catch-up effect which leads to convergence. The higher the initial technology gap, the higher the opportunities for the lagging countries to imitate and assimilate new technical progress from the advanced countries. The share of equipment investment in GDP (eq) is assumed to be the most important variable influencing positively productivity growth, and $\gamma>0$ measures its positive effect. Investment equipment carries embodied technical progress which substantially improves productivity performance. Education level (prim) (proxied by enrolment in primary school) is assumed to have a positive effect on productivity growth (the human capital argument), $\delta>0$, but the effect of the ratio of real government expenditures to real GDP (gov) on productivity growth is uncertain, $\varepsilon>0$ or <0. Government spending especially on infrastructure and innovation will improve productivity, unless it is oriented towards activities which do not promote productivity growth.

Equation (18) is the investment equation, where the share of equipment investment (eq) depends positively on productivity growth (pg), $\kappa>0$, and innovation (pat) (proxied by patenting activity), $\lambda>0$, but the effect of government spending ratio (gov) on investment is again ambiguous, $\mu>0$ or <0. It can be positive when government spending is used to sustain demand (the Keynesian argument) but it can be negative when it induces crowding out effects on private investment. It is important to notice that productivity growth (pg) and equipment investment (eq) are simultaneously determined in this model since a reciprocal influence is assumed to exist between the two variables. Higher investment in new equipment and new processes of production improve labour productivity and higher productivity is an incentive for new investment in machinery and new products. The mutual interdependence of the two variables makes the model have cumulative properties.

Innovation equation (19) relates patenting activity (pat) (taken as an indicator of innovation) negatively to the initial technology gap (GAP), $\pi<0$, and positively to the education level (sec) (percentage of enrolment population in secondary education), $\rho>0$. When the initial technology gap between the lagging country and the technological leader is high, the innovative capacity and the ability to explore the induced spill-over effects are expected to be weak for the follower. On the other hand, the qualification of the labour force is expected to influence the innovation activity positively.

Finally, the human capital qualification is taken to be endogenous in equation (20), where schooling enrolment in secondary level (sec) is negatively related to the level of technology gap (GAP), $\theta<0$, and positively to the level of primary school enrolment (prim), $\pi>0$. The idea is that less advanced countries have a lower percentage of enrolment in secondary education and that one must go first to primary education before entering secondary education.

Amable (1993) estimated the above simultaneous equation system by a full information maximum likelihood method using a cross-section sample of 59 countries over the period 1960--1985. The results confirm the relevance of the model and the estimated coefficients have the expected signs and acceptable significance levels. The positive and highly significant effect of the initial technology gap on productivity growth shows strong evidence of productivity convergence between the countries considered and the technological frontier country, the USA. The mutual interdependence of productivity growth and investment is strong suggesting that a cumulative causation mechanism of growth is at work. Government spending is found to be investment inducing but not productivity promoting. Finally, human capital contributes positively to the improvement of productivity growth and to innovation activity while the initial technology gap has a negative effect on innovation activity and on secondary school enrolment as expected. The structure of the model shows that it is possible to endogenize the concept of social capability and integrate its determinants into a cumulative causation process of growth which allows also for catching-up effects.

6. Conclusions and summary

In this study, an attempt has been made to distinguish three main approaches which explain the convergence or divergence phenomena, both in the light of the theory and the empirical evidence. It is argued that the orthodox neo-classical approach to unconditional convergence can not be taken as a general rule for many reasons. Diminishing returns to capital is not an advantage for poor countries to grow faster, since this result will depend on the "social capability" of lagging countries to adopt, imitate and explore successfully the technical progress emanating from the advanced countries.

On the other hand, increasing returns to scale from other sectors, such as manufacturing, innovation activities and education have externality effects generating dynamic forces which can lead to divergence. Technology is not a public good and freely available to anyone; on the contrary, it can be excludable to some economies. Technology is endogenous and growth induced, depending on the productive structure of the economy, its ability to innovate and exploit increasing returns activities and the level of human capital formation.

Free factor mobility is not a guarantee of convergence through the equalisation of factor prices. Productive factors are endogenously governed by the strength of demand, and when demand is weak there will be no transfer of capital from the advanced economies to the lagging ones simply because of higher profit opportunities nor a transfer of labour from the less prosperous to more prosperous regions simply because of higher wage opportunities.

Neither is free trade a guarantee of convergence, since the more competitive regions can sustain their growth advantages through a cumulative causation process and the less competitive regions can face a balance of payments constraint on growth. So the disparities between regions can be sustained or even increase[21].

At the empirical level, the evidence does not support the unconditional convergence of the neo--classical prediction except in some cases of relatively homogeneous economies. The convergence which has been found is mostly conditional depending on important structural factors of the economy, such as human capital, capital accumulation, innovation and some other institutional factors associated with market conditions and to political and macroeconomic stability.

Conditional convergence is the argument of the endogenous growth theory which tends to rehabilitate the neo-classical approach to convergence by introducing human capital, innovation and investment into the convergence equation. However, the way which is used to find conditional convergence based on a simple regression on the initial level of productivity or income per capita and a set of conditional structural variables on the growth productivity or income per head, suffers from some weaknesses.

In the first place, a single equation is not appropriate to describe the complexity of the interdependence between the structural variables of the economies or to explain the mechanism through which the convergence or divergence path is generated. Secondly, the estimation technique suffers from specification error bias and multicollinearity and also simultaneity bias problems. It is very difficult to isolate and find the pure individual effects of such important structural variables whose interdependence is ignored. Thirdly, it is difficult to restrict the number of conditional factors which can contribute to the convergence result without facing specification error problems.

Finally, the endogenous growth theory does not bring new ideas to the growth literature, since factors such as human capital performance, innovation activity, capital accumulation and technical progress were used in the early cumulative causation models to explain differences in growth rates between countries or regions. This is the reason why some examples of structural cumulative models are presented in this paper as alternative approaches to explain the complexity of the convergence issue. The models are more complete, in the sense that they explain the

21 For these arguments see Thirlwall (1999) who questions the impact of EMU on the reduction of regional disparities.

mechanism through which the convergence or divergence result can be observed. The models involve both convergence and divergence forces and the final result will depend on the reciprocal interaction of the structural parameters of the model. The models refer to the open economy and structural factors which determine international competitiveness are taken into account.

An important difference is that cumulative models are growth models and they are used to explain indirectly the convergence or divergence phenomena as opposed to the neo-classical methodology which recently uses the convergence approach in order to explain the growth performance across different economies. As a policy issue the cumulative models suggest that the convergence result will depend on the nature and strength of factor mobility, the structure of production and type of specialisation, the competitiveness of the economies (mostly non-price competitiveness) and the ability to explore increasing returns activities coming mostly from the industrial and exportable sectors. The difficulties of applying the model in a regional context (due to the lack of data) and the difficulties of establishing the conditions which define the convergence or divergence pattern are some of the weak aspects of the cumulative growth models.

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