# SLOW CONVERGENCE? POST-NEOCLASSICAL ENDOGENOUS GROWTH THEORY AND REGIONAL DEVELOPMENT

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## Abstract

Recently, in economics there has been a major revival of interest in economic growth, and especially in the evidence for long-run convergence in per capita incomes and output between countries. This empirical debate has promoted the development of endogenous growth theory, which seeks to move beyond conventional neoclassical theory by treating as *endogenous* those factors that the neoclassical growth model relegates as *exogenous,* in particular, technological change and human capital. The economists who have been at the forefront of the formulation of endogenous growth theory and the new growth empirics have begun to use long-run regional growth patterns to test and develop their ideas. Their analyses suggest a slow and discontinuous process of regional convergence. This paper considers whether endogenous growth theory can help to explain this finding. It argues that endogenous growth theory has some important regional implications, but also some limitations when applied to a regional context. It advocates an exchange of ideas between endogenous growth theory and the more descriptive focus on 'indigenous' growth that is now popular in economic geography.

**Keywords:** Endogenous growth, regional convergence, human capital, technology, externalities.

# SLOW CONVERGENCE? POST-NEOCLASSICAL ENDOGENOUS GROWTH THEORY AND REGIONAL DEVELOPMENT

## 1. Introduction

The study of the capitalist space economy has traditionally been dominated by two opposing views as to the expected long-run trajectories of regional development. The first, rooted in neoclassical equilibrium economics, holds that provided there are no major barriers to the operation of market processes, in an integrated national space economy there are strong pressures leading to the general *convergence* of regional incomes over time. Regional disparities can only be short-run phenomena, since such disparities will set in motion self-correcting movements in prices, wages, capital and labour, which restore the tendency towards regional convergence. One of the earliest and most influential statements of this view was Borts and Stein's (1964) classic study of regional development in the United States. Using the coefficient of variation they found clear empirical evidence for the dispersion of state incomes to decline over time, and argued that this was in large part due to transfers of labour and capital between states and a convergence in state economic structures. A similar conclusion was reached by Williamson (1965) from his analysis of the evolution of regional income differences in a number of countries. He found that as development proceeds regional incomes initially diverge (he likewise used the coefficient of variation as an indicator of dispersion), but then converge as countries move into the advanced stages of economic development.

According to the second scenario, there are no necessary reasons why regional growth and incomes should converge, even over the long run. To the contrary, regional *divergence* is the most likely outcome. Thus the models of regional growth advanced by writers such as Perroux (1950, 1955), Myrdal (1957) and Kaldor (1970; 1981) predict that regional incomes will tend to diverge because if left to their own devices, market forces are spatially disequilibrating and economies of scale and agglomeration lead to the cumulative concentration of capital, labour and output in certain regions at the expense of others:

uneven regional development is self-reinforcing rather than self-correcting. Whether and at what point there are limits to this regional divergence process will depend on the emergence and strength of 'counteracting tendencies', such as the build up of congestion diseconomies in the leading (core) regions, of growth 'spillover effects' from the leading regions to the lagging regions, and of governmental fiscal transfers or policy aid directed at low income, depressed areas. However, while these countervailing processes may keep regional divergence in check, they are considered unlikely to be sufficient to promote regional convergence.

The Marxist accounts of uneven regional development that became popular amongst geographers during the 1970s and early-1980s challenged both of these two views. Epitomised for example by the writings of Harvey (1982), Massey (1984) and Smith (1984), these Marxist-oriented theories viewed regional economic evolution as neither convergent nor divergent, but essentially as *episodic*. While regional economic development is inherently and necessarily uneven, as a result of the imperatives driving profitable capital accumulation, a particular pattern of unevenness is not historically immutable or ineluctable. Rather, the geography of economic growth is periodically restructured as the rhythm and nature of capitalist development change. More specifically, the accumulation crises that from time to time punctuate the course of capitalist development promote the search for new spatial, technological and social 'fixes', and lead to new configurations of regional relative growth and decline. In theory, it would be possible to observe regional convergence during one historical phase of regional development but divergence in another phase. Although there were some attempts to link Marxist models of uneven regional development and regional cumulative causation models of the Myrdal-Kaldor type (for example, Holland, 1976), the focus of Marxist regional theory was more on the dynamics of periodic 'spatial restructuring' than on the long-term trajectories of regional growth.

Since the mid-1980s, this shift away from a concern with the long-run evolution of the space economy within geographical studies of

regional development has continued. Increasingly, interest has centred on the so-called 'new industrial spaces' and growth regions that are allegedly leading the contemporary transition of the advanced countries into a new, 'post-Fordist', era of globalised economic accumulation and regulation. Marxist approaches have given way to neo-Marshallian and transaction cost theories of regional economic agglomeration and growth. While these new models have certainly shed some interesting light on the technological, institutional and social foundations of economic growth in these 'new' regions, the fortunes and prospects of 'old' industrial spaces and areas have been largely ignored (Gertler, 1992; Cooke, 1995). As a consequence, understanding and charting the development of (a nation's) regional system as a whole has in effect been subordinated to the analysis of a particular sort of archetypal region - the exemplars of post-Fordist 'flexible specialisation' - regardless of where these are found. Although one of the implications of this focus would seem to be that significant income inequalities have opened up between the new and old industrial spaces, the emphasis is firmly on understanding the contingent conditions of regional success rather than on the long-run evolution of the entire regional economic system.

It is perhaps ironic, therefore, that while geographers' interest in the measurement of the long-run evolution of regional systems has waned, economists have been busy reviving their interest in long run economic growth. After having languished in the early-1960s, since the mid-1980s long run growth has re-appeared back on the economists' research agenda. An important stimulus for this revival has been renewed interest in the empirics of growth, and especially in the evidence for long-run convergence in per capita incomes and output between nations. This empirical debate has in turn promoted the re-examination and re-orientation of growth theory. The thrust of this new endeavour has been to escape the straight jacket of conventional neoclassical theory by treating as *endogenous* to the growth process those factors that the neoclassical growth model relegates as *exogenous*, in particular technological change and human capital. Hence the label *endogenous growth theory* is commonly used to refer to this new approach. This endogenous growth theory has in

turn stimulated further interest and controversy over the convergence issue. Of particular significance for economic geography and regional economics, these empirical and theoretical developments have important implications for the study of long run regional growth trajectories. Indeed, some of the economists who have been at the forefront of the formulation of endogenous growth theory and the new growth empirics have begun to use regional growth patterns to test and develop their ideas. A reassessment of regional growth patterns and the usefulness and applicability of endogenous growth theory to the analysis and explanation of regional development would thus seem apposite. At the same time, recent advances in, and evidence from, economic geography provide a valuable means of evaluating the claims and predictions of endogenous growth theory. These twin motivations form the aims of this paper.

First, we review the new empirics of regional growth, and in particular the evidence for regional convergence. Next we turn to a discussion of the main elements of the new 'post-neoclassical' endogenous growth theories that have been advanced to account for the observed patterns of convergence between countries. These theoretical ideas are then evaluated for their usefulness in accounting for the trends in regional income convergence within advanced economies described in Section 2. Although endogenous growth theory highlights the key role of human capital, technology and increasing returns in regional development, there are important limitations to the ability of endogenous growth models to incorporate the full complexity of these factors in real regional contexts.

## 2. The New Empirics of Regional Convergence

Over the past decade, empirical issues have played a key role in the rapidly expanding debate over economic growth. Indeed, theoretical work on endogenous growth has been stimulated in large part by the apparent inability of the standard neoclassical growth model to explain some important features of cross-country income and growth trends. This research has in turn spurred the proliferation of empirical work on cross-national and cross-regional convergence (for useful

reviews see, for example, Chatterji, 1992; Canova and Marcet, 1995; de la Fuente, 1995; Galor, 1996; Barro and Sala-i Martin, 1995; Sala-i-Martin, 1996).

Essentially, attention has focused on two concepts of convergence: β-convergence and σ-convergence. So-called β-convergence in a cross section of economies (countries or regions) is said to exist if there is a negative relationship between the growth rate of per capita income and the initial level of per capita income in the base year of the period over which growth trends are being analysed. Empirically, β-convergence is usually estimated by running a cross section 'growth regression' of the form

$$(1/T)\log(y_{it+T}/y_{it}) = \alpha - \beta\log(y_{it}) + \varepsilon_{it} \qquad (1)$$

where $y_{it} = Y_{it}/Y_t$ is per capita GDP in the i-th economy (country or region) relative to the average for the sample of economies under investigation, $(1/T)\log(y_{it+T}/y_{it})$ is the annualised rate of growth of (relative) per capita GDP in the i-th economy over the study period between t and t+T, and $\log(y_{it})$ is the logarithm of relative per capita GDP in the i-th economy in the base year t. If $0<\beta<1$, the data set is said to exhibit absolute β-convergence: there is a tendency for per capita GDP to equalise across economies. The value of β measures the speed of the convergence process.

A group of economies (countries or regions) is said to be characterised by so-called σ-convergence if the dispersion (variance) of their relative per capita GDP levels tends to decrease over time, that is if

$$\sigma_{yt+T} < \sigma_{yt} \qquad (2)$$

where $\sigma_{yt}$ is the standard deviation of $\log(y_{it})$ at time t. The concept of σ-convergence can easily be shown to be closely related to that of

absolute β-convergence by rewriting the basic growth regression in discrete time, corresponding for example to annual data, as

$$log(y_{it}) = \alpha - (1-\beta)\, log(y_{it-1}) + \varepsilon_{it} \qquad (3)$$

and taking the variance of both sides, so that

$$\sigma^2_{yt+T} = (1-\beta)^2\, \sigma^2_{yt} + \sigma^2\varepsilon \qquad (4)$$

In other words the existence of β-convergence will tend to generate declining dispersion or σ-convergence. However, since the latter also depends on the variance of the error terms or 'shocks', $\sigma^2\varepsilon$, this implies that although the long-run steady state dispersion falls with β (the strength of the convergence effect) it rises with the variance of the disturbance term. Thus even if there is absolute convergence, the long run steady state dispersion may be positive.[1] Moreover, if the initial dispersion is below this long-run steady state value, income dispersion may rise over time even though there is β-convergence. Thus the existence of β-convergence is a necessary but not sufficient condition for σ-convergence.

There have been numerous attempts to measure the speed of cross country β-convergence. In an early work, Baumol (1986) used Maddison's (1982) historical series on GDP for 13 advanced countries for 1870-1979 and found strong evidence of convergence in the post World War II period. This finding was criticised by Romer (1986) and DeLong (1988), however, on the grounds that it referred only to a set of similar countries all of which were rich *ex post* and hence biased towards convergence, whereas the analysis should have included an *ex ante* sample of countries which in 1870 were likely to have industrialised. If the sample of countries is expanded to include developing and undeveloped nations, the evidence for convergence disappears: there is no consistent tendency for the poorer countries to grow faster than, and hence to catch up with, the richer, and no tendency for the cross national dispersion of per capita GDP to

decline over time (De Long, 1988; Baumol and Wolff, 1988). Several recent analyses (for example, Dowrick and Nguyen, 1989; Barro, 1991; Dowrick and Gemmell, 1991; Barro and Sala-Martin, 1992; Chatterji 1992; Mankiw, et al., 1992; Barro and Sala-i-Martin, 1995; Canova and Marcet, 1995; Sala-i-Martin 1996) confirm that only when attention is restricted to the set of richer OECD countries is there some support for absolute convergence. As Barro (1991) concludes

> The hypothesis that poor countries tend to grow faster than rich countries seems to be inconsistent with cross-country evidence, which indicates that per capita growth rates have little correlation with the starting level of per capita product.

This has prompted two main developments of the basic convergence regression. The first is the idea of *club convergence*. This, as the term suggests, is the hypothesis that only countries that are similar in their structural characteristics and which have similar initial conditions will converge to one another. Thus the richer OECD countries may form one convergence club, the developing countries another, and the underdeveloped yet another. There need be no convergence between these clubs, and hence the broad inequalities between the different club sets may persist or even increase so that the cross-country income distribution becomes polarised (see, for example, Canova and Marcet, 1995; Galor, 1996). Chatterji (1992) has developed an extended version of the convergence regression to test for the possibility of club convergence.[2] He finds clear evidence for two growth clubs: one consisting of 45 high income nations with per incomes converging on those in the USA, and another comprising 64 less developed countries converging on a different and considerably lower long-run per capita income level.

The second reformulation of the standard β-convergence model has been to allow different economies to converge, not to a common steady state (equalisation of incomes) but to their own long-run steady-state income relativities. This concept is known as *conditional*

*convergence* (Sala-i- Martin, 1991; Barro and Sala-i-Martin, 1992; Mankiw et al, 1992), because convergence is conditional on the different structural characteristics or 'fundamentals', of each economy, such as its preferences, technologies, rate of population growth, government policy, etc. Different structural characteristics imply that different countries will have different steady-state relative incomes. Hence the prediction is that the growth of an economy will be a function of the gap that separates it from its own steady state. To test for conditional convergence, therefore, it is necessary to hold constant the steady state of each economy. There are essentially two ways of doing this empirically. One solution is to introduce structural-type variables that proxy for the steady state into the 'growth regression', that is

$$(1/T)\log(y_{it+T}/y_{it}) = \alpha - \beta \log(y_{it}) + \text{'other variables'} + \varepsilon_{it} \qquad (5)$$

If $0<\beta<1$ once the other regressor variables are included, then the economies in question are said to display *conditional* β-convergence. Barro (1991), Mankiw *et al* (1992) and Barro and Sala-i-Martin (1995) find strong cross-country support for the conditional convergence hypothesis, although it should be noted that this evidence is to a large extent also consistent with the club convergence hypothesis as well.

An alternative approach is to restrict the analysis of convergence to sets of economies for which the assumption of similar technology, institutions, tastes, etc. is not unrealistic. Members of a given set might then be expected to converge to the same steady state (same per capita income). Hence similar economies should display absolute β-convergence. It is in this context that economists have begun to show considerable interest in the question of regional convergence within countries. They argue that the regions within a nation are much more likely to share similar structural characteristics than are different nations, so that regional systems may be expected to show much greater evidence of long-run absolute convergence. In the view of Barro and Sala-i-Martin (1995) for example,

> Although differences in technology, preferences and institutions do exist across regions, these differences are likely to be smaller than those across countries. Firms and households of different regions within a single country tend to have access to similar technologies and have roughly similar tastes and cultures. Furthermore, the regions share a common central government and therefore have similar institutional set-ups and legal systems. This relative homogeneity means that absolute convergence is more likely to apply across regions within countries than across countries (p.382).

They add that factor mobility is also likely to be higher across regions than between countries, and that legal, cultural, linguistic and institutional barriers are smaller between regions within countries than between countries.

Barro and Sala-i-Martin (1991, 1992a, 1992b, 1995) have tested for absolute convergence of regional per capita incomes in number of countries.[3] In Sala-i Martin (1994), and Barro and Sala-i-Martin (1995), these authors examine regional per capita incomes for the 48 US states for the period 1880-1990, and for the 47 Japanese prefectures for the period 1930-1990 and 1950-1990, per capita GDP for 90 regions across eight European countries (Germany, France, the UK, Italy, the Netherlands, Belgium, Denmark and Spain) between 1950-1990, and per capita incomes for the 10 Canadian provinces between 1961-91. In all cases they find clear evidence of long-run regional convergence. The dispersion of regional per capita incomes declines steadily over time. Moreover, the speed with which regions of different countries converge to their respective national means (absolute β-convergence) is remarkably similar, about 2 percent per annum (see Table 1).[4] This rate of *absolute* regional convergence is identical to the rate of *conditional* national convergence Barro and Sala-i-Martin (1995) find for large samples of developed and developing countries. Finally, for the USA, Europe and Japan they

find that the speed of regional convergence is unstable through time, and that there have been periods when it has it has declined, in particular since the mid-to late-1970s.

Armstrong (1995) has also carried out extensive analyses of regional convergence in 62 and 169 European regions for 1975-1993, 48 US states over 1963-1986 and 1977-1991, and the Australian states and territories for 1953-91 and 1977-1993. Like those of Barro and Sala-i-Martin, his results also suggest there has been considerable variability in the speed of convergence over different periods of time. In the case of the US, he found regional incomes converged at an overall rate of 2.33 percent from 1963 to 1986. However, this varied greatly, from a convergence rate of 3.6 percent over 1963-71 and 1971-75 to regional *divergence* of 0.40 percent per annum between 1975-81. Similarly for Australia, the findings suggest regional income convergence of about 1 percent per annum for the whole 1953-91 period but *divergence* since the late-1970s. The European results follow a somewhat similar pattern. Absolute convergence across the NUTS1 regions of the EU is estimated to have occurred at about 1 percent per annum between 1975 and 1991: much of this slow convergence was attributable to between-country effects rather than within-country trends. For the smaller NUTS2 regions, the annual rate of absolute convergence was only 0.4 percent per annum. At both geographical scales, the speed of β-convergence slowed down considerably after 1981.[5] Indeed, for both the American and European regions, Armstrong finds evidence that convergence fluctuates with the economic cycle, being greater in boom periods than during recessionary phases. Armstrong also tests for possible regional convergence clubs, but finds little support for this hypothesis, even in the European case, where it has often been argued that a major split exists between the dynamic northern growth regions and the economically peripheral Mediterranean areas. These results contrast somewhat with the study of trends in per capita GDP amongst the UK counties over the period 1977-91 by Chatterji and Dewhurst (1996). They provide evidence of three convergence clubs amongst the UK counties, and while like Armstrong they also find that the speed of regional convergence varies with the economic cycle, the relationship is the opposite direction: convergence appears

to be fastest during periods of slow national growth rather than during national booms. A further aspect of Armstrong's study is particularly significant, however. For both the US and Europe there is clear evidence of spatial autocorrelation of regional growth rates: fast growth regions are spatially clustered with other fast-growth regions, and similarly slow-growth regions tend to be geographically grouped.[6]

It should be noted that other economists have questioned these estimates of regional convergence, and the methods by which they have been obtained. Thus Evans and Karras (1996) have found that per capita incomes amongst US states do not display absolute convergence but rather converge to different long run levels, reflecting significant state 'fixed effects' (which they ascribe primarily to persistent differences in technlogy. Quah (1993) has argued that, in any case, the growth regression approach has an inherent statistical bias towards yielding a convergence coefficient of 0.02, that is of two percent per annum. He also criticises this approach for not utilising the full information on the regional income distribution as a whole, and suggests an alternative procedure that focuses on the changes in the regional distribution through time and, in a similar way to Armstrong, on its spatial autocorrelation properties (Quah, 1994a,b; 1996). Like Armstrong he also finds evidence of geographical clustering of fast-growing and slow-growing regions within Europe. From a somewhat similar position, Canova and Marcet (1995) argue that by assuming a common rate of convergence for all regions and ignoring the heterogeneity of the space economy, the growth regression model seriously underestimates the rate of regional convergence.[7] They use an alternative Bayesian approach and claim that instead of showing very slow absolute convergence, the European regions show quite rapid conditional convergence. They therefore reject the contention that regions are converging to an identical steady state and insist that the main determinant of a region's steady state position is in fact its position in the initial distribution of income.

A number of key points can thus be drawn from these recent studies of regional growth empirics. First, while there is evidence of long-run

absolute β-convergence of per capita incomes across regions in the advanced economies, the rate of convergence appears to be very slow, at most 2 percent per annum and often even less. The rate of 2 percent per annum that seems to typify the US implies it takes 35 years for an initial regional disparity in per capita income to be halved, while the rate of 1 percent found in Europe implies a half-life of about 70 years.[8] These slow rates of convergence are much less than would be expected from a neoclassical view of the regional growth process, and therefore raise fundamental questions over the validity of that model. For example, the conventional assumption in the standard neoclassical growth model that capital's share in total income is equal to one third, implies a convergence speed of about 6-7 per cent per year. In order to make the model consistent with the regional convergence estimates in Table 1, the capital share would have to be as high as three-quarters or more. Second, the slower speed of convergence amongst the European regions compared to that across US states (where it is hardly rapid), possibly reflects the less economically, socially and institutionally integrated nature of the European space economy compared to that of the US. Third, there does not appear to be any consistent evidence of polarisation of regional growth patterns into distinct convergence clubs. However, fourth, there does seem to be significant spatial clustering of regions with similar growth rates. This spatial clustering suggests that spillover effects (of labour, capital, technology and other influences on growth) are geographically localised. Finally, regional convergence does not appear to be a simple monotonic process, but rather seems to vary over time. In particular, most of the advanced countries show a similar sharp slowdown in the speed of regional convergence and an increase in regional income dispersion since the mid-1970s. Most authors invoke 'exogenous shocks' to account for these 'deviations'. Thus Barro and Sala-i-Martin (1995) attribute the recent convergence slowdown in Europe to the uneven regional impact of the early-1970s oil price hike, that in the US to the impact of Reagan's economic policies, and that in Japan to the exceptional growth of Tokyo during the 1980s. Whether this appeal to ad hoc exceptional events is sufficient, or whether the reversal in dispersion over the past two decades signals a

more fundamental structural or systemic change to the process of regional growth remains an open issue.

## 3. Post-Neoclassical Endogenous Growth Theory

Much of the revival of interest amongst economists in regional growth patterns stems from their relevance to new endogenous theories of economic growth. The term 'endogenous growth' refers to a body of economic modelling which emerged during the 1980s, and which was, in part, a critical response to the canonical neoclassical model of economic growth (see Solow, 1956). Output in this neoclassical model is given by the production function

$$Y = TK^{a}L^{b}(a + b) = 1;\ 0<a<1 \qquad (6)$$

where $T$ represents the level of technology, and is often called Total Factor Productivity (TFP), $K$ refers to physical capital and $L$ to labour. This function has constant returns to scale and each factor of production shows positive but diminishing marginal productivity. An increase in investment has only a temporary effect on growth and runs into diminishing returns and, in the long run, growth is independent of investment. The model's basic proposition is that the rate of growth of an economy over the long run is equal to the rate of growth of the labour force plus the rate of technological improvement. The growth of income per head is proportional to the growth of TFP which in turn reflects the rate of technological progress. However, technological improvement is not explained by the model and, in this sense, growth is *exogenous*. If technology is universally available and there is no factor mobility, then, as a consequence of diminishing marginal productivity, the model predicts a strong tendency to income equality and a convergence of steady state growth rates across countries and regions. If factor mobility is permitted this prediction is reinforced as capital and labour should move to where they are scarce, thus equalising rates of return.

During the mid-1980s, several problems with this neoclassical model were 'rediscovered'. Attempts to measure the relative contributions of

the different factor inputs to productivity growth found that the growth of inputs could only account for a limited share of the growth of output and a substantial 'residual' had to be allocated to TFP. In addition, the prediction of converging per capita incomes appeared increasingly at odds with the lack of evidence for international convergence noted in the previous section. Another problem for the neoclassical model was the fluctuating strength of the convergence process even within the industrialised club of countries (Abramovitz, 1986).[9] Furthermore, not only does the standard neoclassical model fail to explain why convergence in per capita incomes has not materialised, or at least has been very slow and limited, across the world, it also appears to be incapable of showing why some countries have been able to grow for decades with no apparent tendency to slow down despite rising capital-labour ratios (Boltho and Holtham, 1992).

One response to some of these problems was to augment the neoclassical production function with a measure of human capital *(H)* so that

$$Y = TK^{a}L^{b}H^{c} \quad (a + c) < 1 \qquad (7)$$

For instance, Mankiw *et al* (1992) show that the inclusion of human capital reduces the speed of convergence but that returns to capital nevertheless diminish in the long run.[10] It has also been argued that the *conditional convergence* found in studies of country growth trends, as summarised in Section 2, is a basic property of the neoclassical model (Barro and Sala-i-Martin, 1994). The augmented model predicts conditional rather than absolute convergence: only when national differences in savings and population are controlled for can convergence be identified.[11]

Endogenous growth theory represents a more radical response to the shortcomings of the conventional neoclassical model.[12] In general, endogenous growth models postulate that investment and increasing returns are central to growth.[13] However, there are two different types of endogenous growth theory which envisage different sorts of

increasing returns (Table 2): *endogenous broad capital* models and *endogenous innovation* models (Crafts, 1996). Endogenous broad capital models can be further separated into two sets: those which simply show capital investment as generating externalities, and those which emphasise human capital and relate technological change to 'learning by doing' and 'knowledge spillovers'. The second type, endogenous innovation growth theory has been labelled Schumpeterian because it emphasises the returns to technological improvements arising from deliberate and intentional innovation by producers.[14] In the remainder of this section we review these three different classes of models.

The first type of endogenous broad capital model modifies the conventional production function to include externalities to investment, so that

$$Y = K^{a+x}L^{b}\ (a+x\ ) = 1 \qquad (8)$$

where $x$ represents externalities or social returns which result in constant rather than diminishing returns to investment. For example, Romer (1986) argues that investment in capital stock generates 'learning by doing' (see Arrow, 1962) and 'spillovers' of knowledge and that, through these externalities, technology becomes a 'public good'. In this way, technological progress is made endogenous to the growth process. One implication of this approach is that investment in physical capital equipment is strongly correlated with, and causally related to, growth (De Long and Summers, 1991). Another implication of the model is that large countries should always grow faster than smaller ones and that cross-country growth patterns will show a lack of convergence.[15] However, several criticisms of these models have been influential. High rates of fixed capital accumulation appear to *follow from*, rather than precede, periods of rapid growth (Blomstrom *et al,* 1996). Moreover, one of the major problems of this type of capital model is that, unrealistically, technological change is pictured as the side-effect of other activities rather than the result of deliberate choices and actions by agents (Romer, 1994; Crafts, 1995).

Thus a second series of endogenous models portray technological progress as the result of research and education (R and E) and introduce human capital into the production function. Hence

$$Y = K^a L^b H^c \ (a + c = 1) \qquad (9)$$

where the returns to human and physical capital combined are constant.[16] In this model, investment in human capital generates spillover effects which increase the productivity of both physical capital and the wider labour force (Lucas, 1988). It is assumed that human capital is acquired intentionally by individuals because it leads to higher real wages. Each generation of workers assimilates ideas passed on by the preceding generation so that there are no diminishing returns. The model implies that income differentials between countries will be persistent. Another variant asserts that external increasing returns from human capital arise from on-the-job training or learning by doing in employment (Lucas, 1988). This opens up new possibilities for interactions between international trade and economic growth. Countries, in this model, produce goods suited to their human capital endowments but in doing so they accumulate more skills by producing what they are already good at producing. Thus comparative advantage will be intensified and an initial pattern of production may become 'locked in' with variable rates of output growth across countries (see also, Stokey, 1991).[17] However, these human capital models continue to face the key question which besets all the broad capital models, namely whether it is convincing to show returns to capital as constant or increasing rather than diminishing. A series of studies has produced evidence that returns to even broad capital are in fact diminishing in the long run (Mankiw, *et al,* 1992; Levine and Renelt, 1992; Islam, 1995). This problem is one of the reasons why attention has shifted to explicitly technological models.

In Schumpeterian endogenous growth theory, purposive and profit-seeking improvements in technology are the main force behind rising standards of living. Rather than abolishing TFP, Schumpeterian

models seek to explain it. Typically, the incentive for firms to undertake research and development is the possibility that new products may earn temporary monopoly profits (Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1993). According to these models, imperfect competition allows firms to capture sufficient profits to cover the costs of R and D; by developing a new product which is slightly higher up 'the quality ladder' firms can capture the rents hitherto enjoyed by the producers of previous generations of the product. These innovations subsequently become the intermediate inputs for other producers so that they determine the overall rate of growth. The production function underpinning this model is thus

$$Y = CK^{a}L^{b}D^{d}(a + b + d) = 1 \qquad (10)$$

where $C$ is a constant and $D$ is an index of the creation of intermediate goods which embody innovative progress. $D$ increases with the amount of labour allocated to R&D, and it is assumed that this labour is used with constant returns as a result of the spillover effects of increased technological knowledge. In general, growth depends on the balance of costs and benefits of research and is therefore influenced by the allocation of resources to innovation, the size of markets, the productivity of labour involved in research, and the degree of market power enjoyed and expected by innovators. As we will see, there are numerous points of contention in this analysis.

The implication of these endogenous innovation models is once again divergence in cross-country relative rates of growth and patterns of cumulative advantage and disadvantage. However, these predictions are complicated by the need to take account of processes of *technology transfer* and *diffusion*. Recent technological approaches have built upon the distinction between processes of product innovation and processes of diffusion and imitation through which these innovations are assimilated into production and made profitable. Rapid growth is function of both access to new technological ideas and the diffusion of these ideas through the productive structure (Romer, 1993). It may well be that different countries exhibit different

'social capabilities' to absorb and apply new technologies (Abramovitz, 1986). However, if imitation is cheaper than innovation then a process of club convergence will occur between interdependent economies as discoveries occur in a 'leading edge' economy and then are imitated, relatively quickly, in 'follower' economies (Barro and Sala-i-Martin, 1995). Thus, assuming technology transfer, endogenous innovation models, like augmented neoclassical models, can also generate patterns of club and conditional convergence (Gould and Ruffin, 1993; Barro and Sala-i-Martin, 1994). There is, therefore, increasing interest in the ways in which trade, by disseminating new ideas and increasing the incentive for innovation, may increase the rate of technological progress and hence growth (Grossman and Helpman, 1991; Rivera Batiz and Romer, 1991; Ben David, 1993).[18] Young (1991), for example, argues that the effects of trade depend on the patterns of specialisation which they create. He suggests that the development of new products exhibits a cyclical pattern. Innovations are gradually assimilated and made profitable through processes of learning by doing and that while this continues increasing returns exist. However, there is a limit to the amount of improvements yielded by learning and once these limits are reached diminishing returns set in. The effect of trade thus depends on whether it causes countries to specialise in industries and sectors where there is scope for technology spillovers, or whether it encourages specialisation in labour-intensive, low-technology industries.

The growing interest in how spatial flows of goods and ideas shape the distribution of economic growth is not the only reason why these endogenous models are of potential significance to economic geography. The emphasis placed upon increasing returns raises the issue of whether and to what extent these returns are geographically based. Furthermore, by highlighting the increasing returns stemming from different types of investment these models have provoked a considerable debate on the effects of government policies on economic growth. As Crafts writes "A general implication of the new growth economics is that institutions and policy may have stronger effects on the growth rate than would have been predicted using the traditional neoclassical model" (1996, page 41). Two main and

overlapping areas of policy debate have been stimulated by the new theories. The first focuses on fiscal policies, public infrastructure and political stability. The second concentrates on the scale of resources and the incentives of technologically innovative sectors. In the first area, for instance, Rebelo (1991) has argued that policy regimes with high tax rates lessen the rate of return in the private sector and thus lead to a slower rate of capital accumulation and hence growth. Barro (1991), on the other hand, distinguishes education as a positive determinant of growth in contrast to different measures of political instability and market distortions which act as hindrances. While disentangling the relative impacts of different policy factors is difficult empirically, "One fact seems to be clear however: publicly induced disarray is not associated with large rates of economic growth" (Sala-i-Martin, 1994, p. 746). However, many of these studies are based on aggregate regression analyses and need to be treated cautiously. Levine and Renelt (1992) find that most of the identified linkages are statistically unstable; when other conditioning variables are changed the results also change.[19] Easterly and Rebelo (1993) find that investment in transport and communication infrastructure is consistently correlated with growth but that the evidence on the relations between tax rates and economic growth is "disturbingly fragile".[20] The second type of policy debate has focused on the resources and incentives made available to technologically innovative sectors and the appropriability of returns to innovation. Overall, the implication of the Schumpeterian models is that subsidies and tax relief to promote R and D, effective patent systems, trade liberalisation and steps to divert skilled labour into R and D may all lead to higher growth rates. While these debates may contain some valuable lessons for regional policy, the theoretical implications of endogenous growth theories for regional development need to be assessed carefully before any such lessons can be drawn.

## 4. Endogenous Regional Development

Most of the major perspectives on economic growth have generated their own approach to understanding regional development. As we have seen, endogenous growth theory has been developed with mainly international differences in mind, but despite this, there is a growing interest in the regional and urban implications of endogenous growth theories. The fact that rates of regional income convergence are very slow even within countries suggests that endogenous growth theory may also be of relevance to the question of uneven regional development. Thus, a recent review of regional convergence concludes that "Perhaps the greatest methodological challenge of all ..... is to adapt the concepts and techniques of new growth theory to a regional context" (Armstrong and Vickerman, 1995, page 19). As yet, there have been few explicit attempts to make this adaptation and formulate regional endogenous growth models although there are signs that this may be changing (see Benabou, 1993; 1996; Bertola, 1993; Cheshire and Carbonaro, 1995; Sala-i-Martin, 1994). Without doubt, the development of endogenous growth theory reopens, and extends, the debate on processes on cumulative causation in regional development. While the idea of cumulative causation has long been familiar in economic geography, many would argue that it has never been fully incorporated into regional models (Armstrong and Taylor, 1993). Endogenous growth theory may well provide the opportunity to do just this, as well as shedding light on the endogenous limits of cumulative tendencies. The slow rate of regional convergence identified in Section 2, and the tendency to find spatial clusters of high and slow-growth regions, suggests that the key growth processes highlighted by the new growth theories either operate differentially over space or produce uneven development as part of their routine operation. In this section we start to consider the spatial dimension of these processes by addressing three overlapping themes: the significance and possible spatial consequences of increasing returns and externalities; the role played by endogenous human capital development in regional economies; and the importance of both technology innovation and technology transfer.

As we argued in Section 3, endogenous growth theory is based on the existence of increasing returns and positive externalities. There is, of course, a long tradition of using externalities and increasing returns in urban and regional analysis to explain the localisation and agglomeration of production. Indeed, in recent years there has been a renewed interest in the spatial significance of externalities (Phelps, 1992). Economic geographers have used types of Marshallian external economies to explain the rise and success of new industrial districts and, it has been argued that, the spatial clustering of firms in leading industries reinforces their competitive advantage (Scott, 1988; Porter, 1990). In addition, there has also been a resurgence of interest in the pecuniary economies which are produced by the agglomeration of firms from different industries in urban locations (Krugman, 1991). Together these types of increasing returns imply that regional development is highly path dependent; temporary conditions and shocks, as well as historical accidents, may have permanent effects as patterns of specialisation, of economic success or economic backwardness, become 'locked in' through external and self-reinforcing effects. The implication of endogenous growth theory is to underline the spatial significance of increasing returns and to suggest that there are other types of externality, particularly in human capital development and technological leadership, which also act to 'lock in' patterns of industrial specialisation. It implies also that the regional specialisations induced by trade may be the basis of cumulative relative advantages and disadvantages. To date, however, the new growth theory has given inadequate attention to the spatial dimensions of the externalities which it utilises. Typically it is assumed that spillovers are perfectly mobile within national industries and sectors, even internationally. We need to know much more about the specific geometries of many of the envisaged externalities and spillovers, especially whether they exhibit a distance decay profile, whether they are concentrated within cities and regions and how far and in what ways they become socio-institutionally embedded in specific locational contexts. In short, endogenous growth theory highlights the need for more regional research into increasing returns and, moreover, it suggests that these returns are likely to be found in the realms of human capital and technological development.

Conventionally, human capital has received insufficient attention in studies of regional development. Although in recent years, economic geography has recognised the social role of labour in the production process, the geographical study of human capital development remains underdeveloped, so far relatively little study has been directed to issues of skills, learning and training. However, the endogenous human capital models clearly have possible regional applications. Lucas (1988) himself argues that the agglomeration of producers and wholesalers in relatively costly city locations can only be explained in terms of 'external' human capital effects, that is group interactions, larger than the immediate family, which raise individual productivity.[21] Partly as a consequence of such arguments, there is an emerging interest in the relationships between human capital and local economic performance. The focus of this is typically on the local skill base and the importance of training, as human resources are far less mobile than capital and are a key constituent of the *indigenous* potential and competitiveness of localities and regions.[22]

One set of human capital models emphasises that, in the context of socio-spatial segregation, human capital formation is group activity involving externalities which make inequality more persistent and give rise to local poverty traps. These externalities include the ability of local communities to provide financial resources for education and the series of rules, norms and peer effects described as "social capital" (Benabou, 1993; 1994). In this view, investment in human capital is a local public good so that the more that local agents invest in obtaining high skills, the easier it becomes for others to do so. Durlauf (1994) also argues that neighbourhood spillover effects, combined with income-based segregation, transmit economic status from one generation to the next. These spillovers include the capacity for local revenue sourcing, the productivity of levels of education investment, labour market networks and connections, the degree of observed payoffs to investment in education and peer-group effects in local schools. Most of these arguments have been developed on the basis of

US neighbourhood experience, but similar cumulative effects may be apparent at regional scales and in other settings.

Another set of models highlights the possible connections between spatial variations in human capital and differences in productivity levels and growth. It has been argued that the educational profile of the workforce is one of the factors underlying inter-urban and regional differences in productivity growth (Mullen and Williams, 1990; Ke and Bergman, 1995). If groups of highly skilled and educated workers are concentrated in an area then they will be more likely to swap ideas in random meetings and this sharing of knowledge will boost the rate of technological improvements in an industry (Rauch, 1993). According to Bradley and Taylor (1996), localities with a poor socio-economic infrastructure and poor economic performance also tend to be marked by a poor educational performance.[23] This, in turn, has adverse long-term effects on economic development and on the socio-occupational mix of localities. In their view, the interaction between educational system and economic performance produces a process of cumulative causation and regional divergence so that both spatial patterns of wealth-creation and deprivation are self-perpetuating. Regional differences in real wage returns to investment in education and training would play an important role in this interaction, and Bennett *et al* (1995) find evidence that there are differences in these rates of return across the regions of the UK. Once again, path dependence is important here, as regions which have traditionally specialised in low skill assembly work, or sectors where returns to education are low, would suffer cumulative disadvantage in comparison with high-skill, economically dynamic regions.

These models mean that the migration of labour, and especially skilled and professional labour, has profound significance. In contrast to neoclassical approaches, which see labour migration as an equilibrating force in regional development, it is more likely that labour migration is *selective* and that the migration of better-educated, highly skilled workers is regionally disequilibriating, in that it benefits destination regions at the expense of the areas of origin. In many of the models, the migration of educated and skilled labour into areas

which already have a high proportion of such workers in their socio-occupational mix is a key mechanism reinforcing differential regional growth and prosperity (Bradley and Taylor, 1996). In contrast to the benefits received by the receiving areas, the source regions tend to be left with less-skilled, less enterprising and more poorly educated workers, so that their relative human capital disadvantages are intensified. In one of the few attempts to construct a model of localised growth along endogenous-theoretical lines, Bertola (1993) makes labour migration a key component of his model. Capital and labour tend to migrate to prosperous regions and create and sustain increasing returns in these areas which lead to permanent inter-regional income inequalities. This discussion also suggests that geographical spillovers of externalities and increasing returns are largely confined to neighbouring areas. Together these dynamics form the basis of a possible explanation of the spatial clustering of growth regions discussed in Section 2.

Another possible explanation of this clustering lies in the fields of technological transfer and spillovers so that it is important to consider whether the Schumpeterian endogenous models can be adapted for a regional context. There is a good deal of background information which underlines the need to add a spatial dimension to the endogenous technology models. First, there is copious evidence that R and D activities themselves tend to cluster spatially in key regions, and there is a vast literature on the underlying causes of the localisation of high-technology industry (see, for example, Malecki, 1991; Hall and Markusen, 1985; Storper, 1992; Thwaites and Oakey, 1985; Todtling, 1991).[24] Many of the explanations focus on factors which relate to human capital, such as the presence of pools of skilled labour and the propinquity of universities and government research establishments, but rarely adopt an explicitly human capital perspective. Second, a smaller but highly significant literature suggests that technology transfers and spillovers are to some extent spatially localised. Adducing the spatial contours of technological diffusion and adoption is far from straightforward. However, using the US Small Business Administration database, Acs, Audretsch and Feldman (1993) find that more than 80 percent of innovation in US

manufacturing in the early 1980s occurred in just eleven states and was highly correlated with R and D expenditure by private industry and universities in those states. They suggest that small firms are able to access and exploit knowledge created by R and D in university laboratories and large corporations. Further, Audretsch and Feldman (1994) find that industries where spillovers are most important (i.e. where R and D and skilled labour are most important) are more spatially clustered than industries where spillovers are less significant. Likewise, Jaffe *et al* (1993) compare the geographical locations of patent citations in the USA with those of the cited patents. They find that citations to domestic patents are more likely to come from the same states and metropolitan areas where the cited patents are located. Others have identified a regional pattern to the diffusion of product innovations and a tendency for regional externalities to shape the adoption of innovations, whereby firms use other firms in a region to learn about and to learn to use new technology (see, Antonelli, 1990) . For example, several studies have shown that firms in the peripheral regions of the UK are slower to adopt new innovations than their competitors, in the same industry, in the South East of England (Thwaites, 1982; Alderman and Davies, 1990).

The immediate effect of endogenous innovation growth theories is to reopen the debate on whether regional technological differences play a causal role in regional patterns of growth. Earlier studies which found little evidence of technological progress and diffusion as causes of regional differences in productivity growth within the US may well have been premature in their dismissal of the impact of technology. These studies were typically based on fairly crude statistical indicators (see for example, McCombie, 1982: Hulten and Schwab, 1984). More recently, it has been argued that, in some cases, regional spillovers of technology do raise regional productivity levels (Antonelli, 1994). However, there are clearly some problems in applying recent endogenous models to these regional issues. First, the models imply that a high regional rate of innovation will depend on the presence of oligopolistic firms as this ensures a market incentive for R and D. It also depends on the presence of a skilled labour force devoted to research and participation in extra-regional and international trade.

The association of innovation with oligopoly is problematic, however, as some studies have found that in some high-technology districts, small firms, often formed by 'breakaway' personnel, are significant innovators (Smith, *et al,* 1993) . Monopoly may also result in the disappearance of the stimulating effect of inter-firm competition (Geroski, 1994). Moreover, the association of innovation with oligopoly obscures the fact that spillovers across a *diversity* of firms in different sectors may be more important to technological and productivity growth than the spatial specialisation of single industries or sectors (Jacobs, 1969; Glaeser *et al,* 1992). Some of the existing perspectives on regional technological change, such as those derived from the product cycle analogy, attempt to construct a more historically dynamic approach to this issue. For example, in Markusen's (1985) profit cycle theory, technologically dynamic regions start with a fairly competitive stage, in which externalities are important, but then progress to a more oligopolistic stage as their products mature and technology diffuses to other areas. Similarly, some long-wave approaches argue that the innovation sector is competitive at the beginning of a 'technological long-wave', but gradually becomes oligopolistic. Such possible changes are ironed out by the endogenous innovation models which fail to historicize the relationship between corporate context and innovation.

On the other hand, one of the strengths of the endogenous innovation models lies in their recognition that innovation is inseparable from application, so that it is not assumed that products appear in a final and finished form and follow a predetermined path.[25] Whereas product cycle analogies emphasise the diffusion of production, usually in response to labour costs, the endogenous innovation models highlight the diffusion and absorption of product and process innovations as being central to growth. The notion of the social capability of firms to absorb, apply and learn from innovations occupies a key place in these models. However, this capability itself appears to be exogenous and very little is said about how such capability is determined and how it evolves through time. It may well be that social capability is an integral part of varied 'regional technological regimes'. In the US, for example, it has been found that within given industrial sectors,

different regions occupy different positions in production technology (capital/output and labour/output) space, and further that these differences are relatively stable through time (Rigby and Essletzbicher, 1996). At present we know very little about the causes of these regimes; about how and in what ways they are related to capital vintages, sunk costs, social externalities, foreign direct investment and public sector activities.

It is clear that endogenous innovation models raise more questions on these issues than they can answer. In examining regional technological trajectories, it is important to recognise that technological innovation is deeply embedded in organisational features and corporate systems (Dosi, 1992), so that it would be a mistake to think that these trajectories can be fully explained by formal equilibrium-type models. One consequence of the organisational embeddedness of technology is that technological leadership is unlikely to translate directly into manufacturing productivity (Broadberry, 1994). Similarly, the mechanical stylized tendencies of endogenous innovation models are unable to fully account for the formation and reproduction of high-technology districts and regional clusters. In the first place, a wide range of geographical work on the characteristics of these districts demonstrates that the forms of these agglomerations are shaped by the national technology regimes in which they occur. These regimes include a wide range of social and institutional features which structure the incentives and opportunities for R and D (Lundvall, 1992). In addition, while geographical work has emphasised that local positive externalities are indeed central to high-technology districts, these externalities are dependent on the existence of various types of networks. In particular, inter-firm and social networks based on co-operative, reciprocal and high-trust relations which involve the sharing of risks and information are seen as crucial (Hansen, 1992; Storper and Harrison, 1991, Storper, 1993).[26] If these networks break down for any reason then the evidence suggests that local technology districts may decline precipitously (Saxenian, 1991; Glasmeier, 1991). The underlying limitation of endogenous models is their reliance on formal equilibrium models which pay no heed to the social and

institutional contexts which shape the operation of the growth processes (Skott and Auerbach, 1995). This reliance also means that the models continue to assume that actors are perfectly rational and fully knowledgeable of alternative choices and the consequences of their decisions (Boyer, 1993), so that the effects of cultural interpretations on the direction of technological change are erased from the analysis.

The fact that high-growth regions, on occasions, lose their momentum and suffer problems of relative economic decline poses problems for endogenous growth approaches in general. In emphasising cumulative positive feedbacks the models convey an inadequate sense of the obstacles and barriers to further growth which frequently arise.[27] One of the reasons for this is that the models treat externalities in a general and abstract manner and, in relating them to the *rate* of technological progress or economic growth, they do not consider the actual *direction* or trajectory of these processes. But by obstructing changes of direction in a region's technological or growth trajectory, certain types of increasing returns may in fact engender the onset of relative regional decline. As Arthur (1989) argues, once a user has opted for a particular technology then increasing returns may encourage other users to replicate this choice and accidental initial events may have long-term consequences. However, this may result in these users being 'locked in' to an inefficient technology. If a regional economy became locked in to an inefficient technology then it would of course be highly vulnerable to competition. As Frankel (1955) once argued, the 'interrelatedness' of the different parts of an economic system (be it a firm, region or nation), will increase the costs of changing any one part of that system. Thus increasing returns may in some senses become a force for inertia. Such effects are ignored by the endogenous growth models. If there are limits to the advantages to be gained from learning by doing with an individual product (Young, 1993) then regional prosperity will in part depend on the ability of regions to escape 'lock-in' and to absorb new classes of innovations. Moreover, not only do endogenous growth models say little about the possible relative decline of individual regions, they also have difficulty explaining the periods when aggregate trends to regional

convergence seem to break down. In this respect , they may therefore have little to say about the recent trend of regional divergence that have characterised most Western countries since the mid-1970s (section 2). The implication of endogenous models is that during these phases those forces which limit cumulative divergence, such as technological diffusion, are much weaker. However, there is a need for much more research into why this might be so, and precisely what happens to the growth processes during these periods.[28]

## 5. Conclusion

To retrace our argument a little, the new empirics of regional convergence in the industrialised world reveal a rate of regional convergence which is much slower than the rate proposed by orthodox neoclassical models. This implies that there continues to be a need for alternative theoretical accounts of regional growth and its underlying dynamics. Endogenous growth theory offers some scope in this direction as the evidence suggests that the key factors stressed by endogenous growth theory - increasing returns, human capital and technology - develop unevenly across the space economy and are locally and regionally differentiated. However, as we noted earlier, endogenous growth theory is based on the contention that the main factors underlying economic development should be understood as internal to an economic model of the growth process. This is clearly different to the way in which the term *endogenous development* has recently been used in economic geography and regional studies. Increasingly, both theoretical and policy contributions to these disciplines emphasise the re-discovery and re-emergence of local and regional economies. The argument is that the transformation from 'Fordism' to 'post-Fordism' is creating scope for the re-birth and promotion of localised endogenous economic development. Thus Garofoli (1992), for example, argues that a shift towards more flexible production systems has allowed some regions to benefit from 'development from below', a self-centred style of diffuse industrialisation which is mainly controlled by actors within the local area. He calls this 'endogenous development' and, in his view this involves the local capacity to promote social learning,

entrepreneurship and innovation and to develop local productive interdependencies. Although this is not a closed regional strategy, nevertheless it is premised on a high degree of local autonomy (see also, Hilpert, 1991). A similar theme of endogenous development weaves its way through much of the literature on the so-called 'new industrial districts', which are seen as archetypal exemplars of endogenous development based on agglomerations of (typically small) locally-originating businesses, and locally-based networks of trust, co-operation and competition, all held together by locally-based institutions, customs and conventions (Harrison, 1992; Storper, 1995).

In these accounts, therefore, the term endogenous development is used in a manner which is synonymous with 'locally-based'. Indeed, the term is very close to the idea of *indigenous development* which has come to dominate local economic and regional policy thinking (see for example, Campbell, 1990; Chisholm, 1990; Stohr, 1990; Bennett *et al,* 1990). Almost invariably this concept is used to refer to policies aimed at stimulating local enterprise, small-firm growth, and technological innovation, although it has recently been widened to include the development of a 'flexible' and highly-trained local labour force. The underlying logic of such policy prescriptions is that in the same way that successful growth regions and industrial districts appear to owe their dynamism to their indigenous resources and capabilities, so the revival and development of old and declining regions and localities will depend on building and harnessing the indigenous enterprise and resources within these areas. In many of these discussions, the terms endogenous and indigenous development are used interchangeably. However, while endogenous growth theory supports an emphasis on increasing returns, human capital and technology, it also implies that indigenous and endogenous are not synonymous. Endogenous growth theory makes the key factors to growth, including human capital, technology and externalities, internal to the production function, not to local or even national economies. On the contrary, the theory underlines the importance of national and international (global) flows of goods and knowledge. Trade, for instance, is shown to be vital to patterns of specialisation, and hence to the way in which externalities develop, as well as to the

diffusion of technology. Similarly, a key element in human capital development is the system of national education and a receptiveness to foreign innovations and new ideas. The implication is that those who advocate indigenous development should be wary of neglecting the larger scale and extra-local connections and flows highlighted by endogenous growth theory. In this respect, this theory reinforces the criticism that indigenous local economic development policy can be inadequate, and that of itself it is unlikely to be sufficient for the regeneration of economically lagging areas (Armstrong and Taylor, 1993). In this respect also, endogenous growth theory offers scope for explaining and explicating some of the ways in which the contemporary globalisation of economic activity is related to the development of local and regional economies. As the recent experience of many of the 'new industrial districts' and geographical high technology complexes show, while globalisation may well promote the simultaneous localisation of economic activity, it also places limits on the meaning and scope of purely indigenous local development.

Yet, at the same time, endogenous growth theory could benefit from the idea of indigenous development emphasised by economic geographers. For the evidence does suggest that some of the key elements of growth - increasing returns, human capital formation and technological progress - have a significant and causal localised dimension. The fact that external economies, skilled labour and technological innovation all seem to be spatially clustered within nations indicates that geography is fundamental to the growth process. Some economists now seem to have appreciated this: for example, both Krugman (1991, 1995) and Porter (1990; 1992) recognise that the forces of growth and accumulation develop unevenly across the regions of a national economy and that this geographical unevenness in turn has a major influence on national growth, trade and competitiveness.[29] Furthermore, the growing focus in economic geography on the role of institutions in shaping regional development also has important potential implications for endogenous growth theory. An increasing number of economists have acknowledged the importance of institutions for the economic performance of nations

(for example, North, 1990; Porter, 1990). This is part of a new 'institutionalist' perspective that recognises that the institutional structure of a national economy is crucial to the framework of contacts, inter-firm networks, circulation of knowledge, and administration of markets that underpins a country's technological development. Thus far endogenous growth theory has not absorbed much of this new institutionalism, yet it would seem to be of central importance for understanding how the growth process is directed, encouraged or constrained. But, in addition, economic geographers have begun to show how the 'thickness' and form of institutions are not uniform across a nation but vary between regions and localities, with direct consequences for the growth performance of different areas (Amin and Thrift, 1994). Thus there appears to be a significant local indigenous dimension to the institutional bases of economic growth, and this would need to be incorporated into any endogenous-theoretic perspective on regional development.

Endogenous growth theory undoubtedly offers some possible explanations of global-local interactions and the dynamics of regional growth, most of which revolve around the proposed connections between increasing returns, human capital and technology. However, thus far, the development of endogenous growth economics has been overwhelmingly theoretical and there is a lack of empirical support for its key contentions. This problem is even more pronounced at the regional level. The extent to which regional applications of the theory are successfully realised will depend on the path followed by the future development of the theory itself. On the one hand, if future work becomes purely obsessed with the formal derivation of complex growth equations and with constructing ever more complex regressions of growth on 'conditioning variables', it is likely that growth debates will once again be preoccupied with measuring the statistics of convergence and lose sight of the underlying issues and processes.[30] On the other hand, if the possibilities and questions raised by the endogenous models are used to guide more informal and empirical enquiry, then their potential significance for regional research is likely to be more promising. This will depend on the successful combination of different styles of analysis, and in

particular the exchange of ideas between the new growth theory and more contextualised, historical studies which are sensitive to the details and specificities of particular places (Crafts, 1994; Romer, 1993).[31] As is so often the case when economists turn their attention to regional development, the recent interest by the new growth theorists in regional convergence has thus far failed to take *geography* and *place* seriously. It is not sufficient for the new growth theorists to analyse regional growth patterns within countries merely because they offer a more 'controlled' test of their models: this of itself provides few insights into the processes of regional development. Rather, the new growth theory needs to be properly 'spatialised', not only in the sense of recognising that the growth mechanisms emphasised by the theory operate unevenly across space but also in the sense of recognising that those mechanisms are themselves spatially differentiated and in part geographically constituted.

## Notes

1. More specifically the steady state dispersion is given by
   $\sigma^*y = \sigma 2\varepsilon / [1-(1-\beta)2]$

2. Essentially his procedure uses successive powers of $log(y_{it})$ as additional variables in the basic 'growth regression' to test for the existence of multiple steady states to which different countries groups of countries are converging.

3. Most authors, including Barro and Sala-i-Martin , actually use a non-linear version of the 'growth regression' as the basis of their empirical work, namely

   $$(1/T)log(yit+T/yit) = \alpha - [(1-e-\beta T)/T]\ log(yit) + \varepsilon it,t+T$$

   where εit,t+T is the average of the error terms between t and t+T. This is preferred to the straightforward linear growth regession because it allows convergence to be asymptotic and for the speed of β-convergence to be compared directly across historical periods of different length without having to use transformations.

4. Similar estimates have been produced by other studies including Japan (Shioji, 1993), China (Rivera-Batiz, 1993), Canada (Coulombe and Lee, 1993), Australia (Cashin, 1995), Sweden (Persson, 194) and Germany (Keller, 1994).

5. This result is supported by Dunford's (1993) more descriptive study of regional disparities in the EU. Dunford finds that the regional dispersion of GDP per capita increased in most of the EU member states during the 1980s. Unfortunately, however, Dunford does not estimate growth regressions of the sort used in the regional growth empirics literature. Instead, he regresses regional growth rates (over 1977-89) on the *end of period,* rather than initial, levels of regional per capita GDP. It is difficult,

therefore, to reconcile his results with the work being discussed here.

6. Armstrong deploys a range of spatial autocorrelation procedures to test for the presence of geographical clustering of the unexplained residual regional growth rates from his growth regressions.

7. Canova and Marcet (1995) correctly point out that by pooling data for all the geographical areas in the system being studied, the growth regression approach assumes that the underlying convergence generating process is identical across space, when in reality it is likely that the rate of convergence will vary from region to region. Other critiques of the use of the linear regression technique in cross-country growth analyses suggest that it hides multiple steady state regimes which are locally stable among subsets of countries (Durlauf and Johnson, 1995; Bernard and Durlauf, 1995).

8. The 'half-life' or time required for one half of the initial deviation of relative regional per capita income from its steady state value to be eliminated is given by $H = ln2 / -ln(1-\beta)$

9. It is clear that the 'Golden Age of Capitalism' between 1950 and 1973 was the era of most rapid convergence in per capita incomes and it is difficult to explain this using only the basic neoclassical model (see Crafts and Toniolo, 1995).

10. Mankiw et al use the approximate percentage of the working-age population in secondary school as a proxy of the rate of human capital accumulation.

11. Islam (1995) uses a panel data technique and concludes that convergence is rapid when individual "country effects" are removed from the estimations. His results also suggest that the level of total factor productivity varies considerably even within

the OECD countries. He notes a close correlation between schooling and the level of technology and suggests that this arises because education encourages technology transfer.

12. Endogenous growth theory is a radical response in the sense that it introduces increasing returns to the production function. Buchanan and Yoon (1994) provide a useful collection of articles showing the origins of thinking on increasing returns and their current return to popularity. However, there are, of course, even more fundamental critiques of the neoclassical production function. Scott (1989) for example dismisses the concept of the production function on the grounds that capital inputs fail to take account of the rate of obselescence and in this respect Scott's dismissal echoes that of Kaldor (1985).

13. The centrality of increasing returns to the new growth theories is reminiscent of the development theory of Myrdal (1957), Hirschman (1958) and others, which envisaged a tendency towards cumulative causation and divergence, and of the demand-led models of cumulative growth and increasing returns described by Kaldor (1985). However, this earlier work tended tended to be less abstract and mathematical and more descriptive than the endogenous theories. According to Romer (1993) and Krugman (1995), recent advances in the formal modelling of imperfect competition have facilitated a rescue of some of the insights of the earlier tradition. In this view, mathematical modelling has allowed the detailed specification of how growth processes and mechanics 'work'.

14. See Van de Klundert and Smulders (1992), Gould and Ruffin (1993) and Boltho and Holtham (1992) and Crafts (1996) for useful surveys of the new growth models.

15. Romer (1986) also noted that, under this model, a small change in policy, such as a slightly increased tax rate could have a large effect on growth.

16. This also led to Rebelo's (1991) endogenous growth model, $Y=A\tilde{K}$ ($A$ is a constant and $\tilde{K}$ represents a composite of $K$ and $H$).

17. Lucas (1993) uses a variant of this model to explain the rapid post-war economic growth of some of the East Asian NICs.

18. However, none of these processes are inevitable as domestic producers may, of course, be unable to survive foreign competition.

19. Although they do find a robust relationship between average growth rates and the share of investment in GDP this investment share is robustly correlated only with average share of trade in GDP and not with a range of broad fiscal indicators nor with a large assortment of other political indicators.

20. Easterly *et al* (1993) also point out that while educational conditions and political stability variables across different countries tend to be empirically persistent, variations in relative growth in output per worker tend to be much more inconsistent. They argue that this inconsistency is better explained by random shocks transmitted through trade than by policy variables.

21. He argues that "It seems to me that the 'force' we need to postulate account for the central role of cities in economic life is of exactly the same character as the 'external human capital' I have postulated as a force to account for certain features of aggregative development" (1988, page 38).

22. In fact the terms *endogenous* growth and *indigenous* growth have been taken as synonymous in many recent regional studies. However, we argue later that this is mistaken and that the confusion of the terms can lead to misleading policy implications.

23. Bradley and Taylor's conclusion is based on a statistical analysis of the interaction between educational provision, socio-economic profile and economic performance in the English local education authority areas.

24. The situation may well be different in smaller countries such as the Netherlands where Kleinknecht and Poot (1992) find that technological innovation is fairly evenly distributed across the regions.

25. These are among the most problematic assumptions made by product cycle approaches to regional technological change (see Taylor, 1986).

26. Some authors prefer to describe local socio-institutional relations as forming a 'milieu' which may be conducive to entrpreneurialism and innvation (Maillat, 1991; Castells, 1989).

27. A similar problem besets Kaldor's approach to regional growth, which also emphasised increasing returns in the form of economies of scale and the Verdoorn effect. Kaldor's model generates 'too much cumulation' and does not give due weight to the barriers to continued accumulation which can emerge (Gordon, 1993). Gertler (1986) also found that regional capital investment in the US is a unpredictable and discontinuous process which does not simply conform with cumlative causation.

28. One suggestion is that it may be possible to link endogenous models to long-wave ideas and that the transition from one long-wave to another results in periods of divergence (Crafts, 1996a). However, this is a tentative proposal which lacks detailed specification at the moment.

29. This reflexive relationship is a recurring central theme in Krugman's work. For a review and evaluation of Krugman's 'geographical economics', see Martin and Sunley (1996).

30. Gertler (1988) argues that this is precisely what happened to the earlier work on convergence which flourished and then faded.

31. In Romer's (1993) words, "The best bet, no doubt would be collaboration between model-builders and those who use informal methods, to compromise between one side's need for definiteness and the other side's sense of complexity" (page 52).

# TABLES

**Table 1:** The Empirics of Regional Convergence: Summary of Some Major Studies (Rate of β-Convergence Estimated from Growth Regessions for Periods Shown)

| Study | US States | Japanese Prefectures | European Regions (NUTS1) | European Regions (NUTS2) | Canadian Provinces | Australian States |
|---|---|---|---|---|---|---|
| **Barro and Sala-i-Martin (1995)** | 1870-1990: β= 0.027<br>1920-1930: β= -0.014<br>1940-50: β= 0.043<br>1960-70: β= 0.024<br>1980-90: β= 0.001 | 1930-90: β= 0.027<br>1930-55: β= 0.035<br>1955-90: β= 0.019<br>1980-85: β= -0.001 | 1950-60: β= 0.018<br>1960-70: β= 0.023<br>1970-80: β= 0.020<br>1980-90: β= 0.010 | | | |
| **Sala-i-Martin (1994)** | 1870-1990 β= 0.017 | 1955-1990 β= 0.019 | 1950-90 β= 0.015 | | 1961-91 β= 0.024 | |
| **Armstrong (1995)** | 1963-86 β= 0.023 | | 1950-60: β= 0.012<br>1960-70: β= 0.025<br>1975-93 β= 0.006 | 1950-60: β= 0.016<br>1960-70: β= 0.027<br>1975-81: β= 0.008<br>1981-93 β= 0.002<br>1975-93: β= 0.003 | | 1953-91: β= 0.009<br>1977-93: β= -0.017 |

**Note:** All of the above studies use the non-linear version of the basic growth regression given in footnote 3.

**Table 2:** A Typology of 'New' Growth Theories

| **Type of growth theory** | **'Engine of growth'** | **Convergence?** |
|---|---|---|
| Endogenous broad capital | Capital investment, constant returns through knowledge spillovers | Cumulative divergence but shaped by government spending and taxation |
| Intentional human capital | Spillovers from education and training investments by individual agents | Dependent on returns to investment, public policy and patterns of industrial and trade specialisation |
| Schumpeterian endogenous innovation | Technological innovation by oligopolistic producers<br>*with technological diffusion, transfer and imitation | Multiple steady states and persistent divergence<br>*Possible club convergence and 'catch up' |
| Augmented Solow neoclassical | Physical and human capital, exogenous technological progress universally available | Slow and conditional convergence - within clubs of countries with similar socio-political structures |

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