ISEG ECONÓMICAS

Departamento de Economia

Manuel Mira Godinho and
Ricardo Pais Mamede

Technological Convergence in Europe: What Are the Main Issues?

WP 8/1999/DE/CISEP

Working Papers

ISSN Nº 0874-4548

UNIVERSIDADE TÉCNICA DE LISBOA

Instituto Superior de Economia e Gestão

Technological Convergence in Europe: what are the main issues?

Manuel Mira GODINHO*
Ricardo Pais MAMEDE*

*CISEP and ISEG, Technical University of Lisbon
Rua Miguel Lupi 20, 1200 Lisboa, Portugal

1999-05-26
Preliminary Draft

Abstract

This paper puts forward a basic model of technological catching up. This model represents an attempt to systematise the most relevant factors that, from a perspective of less-favoured regions in Europe, affect the prospects for technological catching up. This process is conceptualised as an interaction between three major factors: the endogenous capabilities accumulated in the less advanced regions; the possibilities these regions have to free ride the knowledge spilling over from the more advanced regions; and, finally, the local conditions that may improve or hinder the development of capabilities and the absorption of externally-produced knowledge.

This paper builds on ongoing research part of the Converge Project - "Strategies and policies for systemic interaction and convergence in Europe", funded by the TSER Programme/DGXII. It was prepared for presentation at the ESST network Annual Scientific Conference, May 29-30 1999, EPFL, Lausanne, Switzerland.
The e-mail addresses of the authors are respectively mgodinho@iseg.utl.pt and rpmamede@iseg.utl.pt .

1. Introduction

Two sorts of questions justify the interest in studying convergence among the European regions. First, the political-institutional process of integration in the EU. Since its very beginning, the European Union has had the harmonious growth of standards of living and social well being among its member countries and regions as an aim. The reduction of interregional disparities has been explicitly targeted by active community policies since the middle 1980s. The increase in structural funds allocations was parallel with the EU enlargement (Portugal and Spain joined in 1986) and the deepening of the integration process, that has followed the publication of the Single European Act, the setting up of the Single Market and the implementation of the Monetary and Economic Union and the recent introduction of the Euro. Cohesion within the Union is an aim concerned with keeping the existing disparities at politically and socially tolerable levels.

The second question concerns the fact that the intensification of the integration process – with the extensive trade liberalisation and the factor mobility, and the increasing co-ordination of monetary and fiscal policies – has brought along old debates in economic theory on convergence. Namely, the impact of economic integration on productivity, employment, and unemployment disparities. Recent contributions from different research programs help to understand the mechanisms, factors and barriers to convergence among regions. Particularly, special attention is being paid to the process of technological competence accumulation, and its importance for development in economies where productive knowledge is recognised as an increasingly relevant factor.

The concept of "convergence" became ambiguous from the moment it was used to refer to the nominal criteria underlying the implementation of the European single currency. "Nominal convergence" was meant as a basic condition for the successful implementation of the Monetary Union. In the present text, convergence refers instead to the approximation between countries/regions in what concerns living standards, employment opportunities and social conditions (i.e., the so-called "real convergence").

The integration process has been implemented on the assumption that it will bring about increased economic efficiency, as a result of both the elimination of trade barriers, production specialisation, and the opportunity to exploit economies of scale. Nevertheless, it is recognised that an increase in overall growth in the EU area will not necessarily lead to a decrease in the inter-regional disparities (on the contrary, it can be associated with a widening of the gap). In a sense, the structural policies in the EU correspond precisely to the recognition that problems of production adaptation (especially in the less developed and depressed regions) can arise as the integration process intensifies.

Thus, we are interested in analysing the recent trends in economic convergence among European regions, and in understanding the mechanisms behind this evolution. The evaluation of the main factors and barriers which presently shape the convergence process – taking into account the policies and strategies of the relevant actors - will help us to forecast the possible future developments.

In line with these interests, we will be presenting next a short summary of the main themes and findings which have been present in the extensive literature recently produced about convergence in Europe and elsewhere. Then, on the third section, we will put forward a simple model of technological catching up. Our argument in that model is that the process of technological catching up should be seen as an interaction among factors related with the demand and supply of knowledge in both the advanced and less advanced regions. The potential knowledge spillovers and the capabilities available for absorbing them are the main elements, together with the local contextual conditions, accounting for the trends of technological convergence. The fourth section will be dedicated to the presentation of some very preliminary results of our empirical explorations. This work is being carried out with the intention of verifying whether the framework put forward in the previous section represents an adequate conceptualisation of the technological catching up process. Finally, we will present a conclusions section, where the perspectives for further research will be considered.

2. Main themes and findings in the "convergence literature"

This section is dedicated to a very brief presentation of the main themes and findings in the extensive literature about economic and technological convergence. This is a difficult task, since this field has been growing very rapidly in recent years. We look first at the theoretical literature and afterwards at the empirical studies which have been produced about the inter-regional convergence trends in Europe.

2.1. Theoretical debate on convergence/divergence

There has been a long debate in economic theory on whether economic integration among countries/regions brings about convergence or divergence in income levels.

As known, traditional neo-classical trade theory forecasts the convergence among integrated, non-separated by trade barriers, economies. This occurs for two reasons. On one hand, factor mobility eliminates income differentials – labour will migrate to the regions with higher wages, capital will flow to the regions with lower wages (where profit opportunities are higher); both movements represent equilibrating tendencies in income levels. Even in the absence of factor mobility, free trade will assure the most efficient specialisation in production (according to factor endowments), leading to convergence[1].

Traditional growth theory also predicts convergence. In this context, the reduction of the gap is explained by the assumption of decreasing returns to capital. The less developed economies (with a lower capital intensity) will experience faster productivity growth for identical investment levels. Capital will be attracted by higher returns and this will fasten income per head convergence.

[1] These conclusions depend crucially on the usual restrictive assumptions of the neo-classical theory, namely perfect competition and the homogeneity of production factors.

A different approach to the issue of catching up, is the "technology gap" perspective put forward by Posner (1961) and others. Inspired by Schumpeter, this view ascribes a central role to technology, portraying economic growth as the combined result of innovation and diffusion, with the former tending to increase technological gaps, and the latter reducing them. In consonance with the historical perspective put forward by Gershenkron (1962), backwardness is seen as a potential in itself — countries facing a technological gap may benefit from the technology developed in the leading countries through imitation, increasing their rate of economic growth and converging towards the world frontier without incurring similar development costs.

Opposite views have been expressed by those who emphasise the tendency for divergence of income levels during processes of economic convergence. Myrdal (1957) and Kaldor (1957) rejected the idea that integration tends to eliminate income differentials, introducing the concept of "cumulative causation". They note that when adjustment to income disparities occurs through labour migration from less developed to richer regions, this causes changes not only in supply conditions but also in aggregate demand. Therefore, the poorest regions will experience a reduction in demand, which will benefit the richest ones (where the total labour force will raise). The market dimension in the latter will therefore grow, attracting further investments, causing additional labour inflows, and so on. The integration process will thus reinforce the lead of the advanced regions.

The empirical verification that income gaps between some world regions persisted (and were even widening), while other regions were converging (the most obvious example is the convergence of income per head between the US, Europe and Japan, in the post-war period), brought consensus to the idea that convergence is conditional to the presence of particular factors. In a much-quoted paper, Abramovitz (1986) re-formulates the "catching up hypothesis" put forward initially by Gershenkron, pointing out that the main requirement for a country to catch up successfully is associated with the existence of a "social capability". This relates to flexibility and acceptance/willingness for change among the agents of the development process. The idea of "conditional convergence" can also be found in the New Growth Theory literature, where the negative association between the growth rates in the long run and the initial levels of income per head, depends on the introduction of additional factors – namely, education rates or R&D expenditures.[2]

Other sceptical perspectives regarding the possibilities of rapid catching up were put forward in the 1980s by authors close to neo-Schumpeterian and evolutionary views. For example, Pavitt (1985) analysing the post-World War II technological catching up of Japan and some European countries toward the "best-practice" levels of the US, stressed that "the international patterns of technological convergence... reflect long-standing international patterns of technological accumulation in the assimilating countries" (p. 15). In sum, catching up was portrayed by Pavitt as a long-term endeavour, resulting primarily from a path-dependent process of sequential accumulation of technological knowledge.

One argument that favours the divergence perspective is the existence of static and dynamic economies of scale. It is argued that economic growth causes a reduction in unit costs associated with large-scale production. Furthermore, industrial development is associated with dynamic aspects such as learning-by-doing, the development of specific capabilities and know-how, opportunities for communicating ideas and experiences, or the possibility for an increasing differentiation in production processes or the specialisation of human activities. Both sorts of scale economies will favour the more advanced regions.

On the other hand, economic geography emphasises the presence of economies of agglomeration, which influence the location decisions of individual firms towards specific industrial centres. In the Marshallian tradition, the factors which are accounted for those agglomeration economies include labour market pooling, supply of intermediate goods and knowledge spillovers.

---

[2] Other factors considered as influencing convergence perspectives include political stability, State intervention, market distortions or international trade.

Therefore, according to Shepley & Wilmot (1995, p.51), it is possible to assume that economic development in less developed regions participating in an integration process, proceeds in one or both of two ways: (i) by capital accumulation and technological catch-up, often spurred by a flow of capital, technology and management skills from richer areas; and/or (ii) via labour migration to an existing concentration of capital, an industrial core. If the first effect dominates there is convergence, while if the second prevails further polarisation will occur. The balanced presence of both effects means that *per capita* incomes will converge, but the absolute importance of the core may well increase. One should note, furthermore, that the presence of obstacles to any of the two referred mechanisms – capital accumulation and technological catch-up, and migration – will slowdown the pace of convergence in income per head.

The relative weight of each of those mechanisms is related to the logic that lies behind the location decision of individual firms in each region. The presence of trading costs (such as trade barriers, transportation costs, exchange rate risks) will deter the dispersion of economic activity among regions. In this sense, the European Single Market (and other aspects of economic integration), the improvements in transport and communication infrastructures, and the technological advances in information and telecommunication industries, tend to benefit the dispersion of economic activities and, consequently, convergence. On the opposite direction, scale and external network economies, and accumulated technological expertise, might benefit the concentration of production activity in core regions. This will raise employment and attract labour, leading to a larger market that will attract further investment, and so on, reinforcing the privilege conditions of the regions in comparison to less developed ones.

It is, therefore, the interaction between demand, trading costs and scale and agglomeration economies, what determines the degree of concentration in different industries (and, generally, the dynamics of convergence/divergence between regions).

Table 1. Theoretical Debate on Convergence/Divergence, A Possible Interpretation

Unconditional Convergence	Conditional Convergence	Divergence
▪ Traditional neoclassic trade theory - factor mobility - regional division of labour ▪ Traditional growth theory - decreasing returns to capital - capital flows ▪ Technological gap (Gershenkron, 1962) - technological backwardness as a potential in itself	▪ Abramowitz (1986) - 'social capabilities' - technological proximity ▪ Neo-Schumpeterian/Evolutionary approaches - path-dependent accumulation of technological knowledge - partial tacitness and specificity of economically useful knowledge	▪ 'Cumulative causation' (Myrdal, 1957; Hirshman, 1957) - capital attracts labour - labour increases demand - demand attracts capital ▪ Regional economies of scale - Static - dynamic (learning by doing, development of specific know-how, ...) ▪ New economic geography - Agglomeration economies (labour market pooling, supply of intermediate goods, knowledge spillovers)

2.2. Empirical evidences about regional convergence in the EU

The European economies have been going through several changes, which strongly influence the mechanisms, factors and barriers that induce and limit regional economic convergence. Besides the effects of the integration process, the evolution of regional economies in the EU has been affected by recent technological changes – pulled by the diffusion of information and communication technologies – and by the transformations in Eastern Europe. Thus, we should start by analysing the recent trends in regional convergence in Europe.

Several studies have been done in recent years evaluating the evolution of income disparities between the EU regions (Abraham & van Rompuy, 1995; Amstrong, 1995; Barro & Sala-i-Martin, 1992; Fagerberg, Verpagen & Caniells, 1997; Neven & Gouyette, 1995). Unfortunately, we cannot conclude unequivocally about the observed trends. This is due to the fact that the authors consider different sets of regions in their analysis (taking into account the available data for different time periods), and use diverse methods to evaluate the pace of convergence. Generally, there seems to be a consensus on the fact that there was a strong economic convergence in Europe in the post-war period until the beginning of the 1970s. From here to the middle 1980s there was a slowdown in the pace of convergence, or even an inversion of the trend towards divergence. Since then, regional convergence has been weak or absent.

Behind these general trends, one can observe a diversity of convergence patterns between different sets of regions. Economic convergence between the Northern regions was apparently faster than between these regions and the Southern ones.

The slowdown in the pace of convergence is not related to the exhaustion of the potential for catching-up in productivity. As several studies have noted, disparities within Europe are still much wider then the ones observed in the US or Canada. The lower labour mobility in Europe (stemming from cultural and language barriers, that limit the possibilities of such mobility working as an adjustment mechanism), is often referred to as one relevant factor explaining these differences.

All the studies mentioned above have in common the fact that they try to evaluate regional convergence using income per head as the relevant variable. Some authors limit their work to describing the evolution of disparities in average income (or productivity). Others introduce explanatory variables (such as R&D expenditures, or unemployment rates), assuming – in the context of their models – a linear relationship between these variables and the results in terms of economic convergence. The complex interactions between the process of accumulation and development of technological competencies, and general economic growth, are usually overlooked. Caniells (1996) gives one step in the direction of understanding those interactions in her study on technological convergence in the EU. Based on the levels of corporate expenditure in R&D, she points out to the existence of a significant heterogeneity in technological development levels within the EU. Furthermore, it is shown that population density and the levels of economic activity are positively related to the intensity of corporate R&D. These results seem to give support to the theories of imperfect diffusion of technologies and to the processes of "cumulative causation".

3. A simple model of technological catching up

In this section a simple model of technological catching up will be put forward. The purpose of this model is to consider what are the main factors accounting for the processes of technological convergence or divergence among different regions and what are the relationships between those factors. Technological catching up is only one aspect of the broader processes of economic development and convergence between different spatial units, albeit it has certainly been one critical component of those processes and also one which importance is set to increase much further in the future. From the perspective of the regions aiming to develop and catch up a full understanding of the processes behind the dynamics of technological catching up has a significant normative interest.

In the past, the processes of technological diffusion were slow and took years, or even large decades, to proceed from the central innovative regions to the more remote regions in the "periphery". As communications developed and contacts across regions got more frequent, the pace of technological change in the less advanced regions could be intensified. Today, with the development of a large array of means of instant communication, the potential of dissemination has been increasing to new levels. However, the acceleration of technological change in the most recent decades may be jeopardising the possibilities of catching up, as the most advanced regions tend to invest more in innovative activities to keep ahead of their competitors. Moreover, the dynamics of polarisation, associated with the external economies of local networks in the innovative regions, may help to enhance further the gap that separates these regions from the less advanced ones.

In order to model the process of technological catching up one needs to understand the interactions between the supply of new knowledge, which occurs predominantly in the more advanced regions, and the demand for that knowledge. Most of the attempts to understand the processes of economic and technological convergence have centred predominantly on supply factors, namely in terms of R&D and other related innovation expenditures, leaving out of the analysis framework factors related to the absorptive capabilities of the less advanced, recipient, firms and regions. In the era of the new economy, based on the production, distribution and use of increasing amounts of knowledge and information, one must consider fully the supply and demand factors in the technology diffusion processes, as well as the contextual factors affecting the prospects of dissemination.

Therefore, in line with this argument, the simple model that will now be put forward aims to stress three aspects, which are critical for the prospects of technological catching up. We will represent the potential for technological catching up of region (or country) i by TC_i. That potential is represented in equation 1 as a positive function of three variables:

$$TC_i = t\,(C_i, FR_{ij}, E_i) \qquad (1)$$

where C_i stands for the capabilities of regions i, FR_{ij} for the possibilities of region i free-riding the knowledge produced in region j, and E_i for the environment (or "context") in which firms in region i are operating.

We will now turn to each one of these three variables aspects, to understand their meaning and the way they interact and operate. First, we have the capabilities variable C_i. It represents the accumulated capabilities regionally available. These capabilities stem basically from past and present investments in intangible and tangible technological assets. We may consider here investments in R&D and in other innovation-related expenditures, as well as investments in the local development of qualifications and in gross fixed capital formation (GFCF). In equation 2 variables R_i, I_i, Q_i and K_i stand respectively for the rates of investment on each of those elements in relation to GDP. The role assigned to the variable K_i is to represent the learning effect associated with the acquisition of new capital goods. We assume, therefore, that greater investment rates in these variables will facilitate technological change in the economy. Finally, there are two additional variables in equation 2, which stand for the orientation of R&D: first the ratio of business expenditure in R&D in relation to total GERD (B_i), and second the ratio of applied versus basic research expenditures (A_i). We also assume a positive relationship between those two variables and the overall level of technological capability in the economy.

$$C_i = c\,(R_i, I_i, Q_i, K_i, B_i, A_i) \qquad (2)$$

The fact that we are assuming the sources of capabilities to be diverse, instead of concentrating exclusively on the R&D variables which have been favoured by a number of catching up studies in recent years, means that this model may also be useful to interpret what is happening in regions dominated by sectors of lower R&D intensity. As it is known, in most of the European regions aiming to catch up with the leading regions, these are precisely the sectors that prevail in the local economic structures. In addition to that, the fact we are portraying the technological capabilities as deriving from a diversity of sources, means that we are considering a broader definition of the technology variable, that goes beyond the strictly technological knowledge related to product and process engineering. We consider technological knowledge as also encompassing some specific competencies related to the overall logistics of production and distribution, marketing, and organisational and managerial aspects. Such a broader definition may be more operational in terms of the analysis and interpretation of the catching up patterns.

We will now turn to the second variable in equation 1, FR_{ij}. This is a central variable in the model we are presenting since it establishes the link between the knowledge produced in the most advanced regions and its absorption in the less advanced regions. It represents the capacity of a less advanced region i to free ride any spillovers generated in the more advanced region j. Nevertheless, FR_{ij} may also be understood inversely, as FR_{ji}, as the capacity of the more advanced regions to free ride the knowledge produced in other, less advanced, regions. Even though this process did not have relevance in the past, it seems to be happening now at much higher rates. With the increasing networking of scientific activities, the freely-available basic knowledge produced by the partners located in the less advanced regions, tends to be fully understood only in the nodes of the network, located in the central, core regions. Only these regions have the capacities needed to integrate and bring to practical uses the partial knowledge developed in (and funded by) the less advanced regions. However, as our perspective is that of the i-type regions, we will concentrate for the moment only on the ij version of the FR variable. We will see (equation 3) that FR_{ij} depends on seven different variables.

$$FR_{ij} = f\,(D_{ij}, C_i, E_i, SO_j, Z_{ij}, X_i, F_i) \qquad (3)$$

The first variable D_{ij}, which we admit to be negatively associated with FR_{ij}, stands for the geographical distance between region i and region j. This assumption is in line with the research that has indicated geographical distance to be an important factor explaining the capacity of firms to absorb and to benefit from knowledge spillovers generated elsewhere. Based on the analysis of patent citations, Jaffe, Trajtenberg and Henderson (1993) have shown for the US that citations are more likely to come from the same state as the cited patents when compared with a "control frequency". Also for Europe, similar results have been reached by Maurseth and Verspagen (1998), in the sequence of the recent publication of patent series by the European Patent Office. These authors have concluded that the results of research carried out locally, as seen by patterns of patent citations, tend to be used more frequently by local firms than by firms located in other regions. Besides that, a similar pattern is found for citations between regions of the same country. These results, which consider knowledge spillovers in terms of patent citations, are similar to the ones observed in case-studies of certain innovative areas and clusters, where the potential of locally generated spillovers seem to decay swiftly as geographical distance increases.

The second variable in equation 3 is C_i, the endogenous capabilities of region i. In equation 2 above we presented the factors which were more relevant in determining those capabilities. We need to clarify now that much of those capabilities might be seen more in the sense of adoptive rather than innovative capabilities. We are assuming that most R&D performed in peripheral regions is directed towards the generation and improvement of skills that may help organisations to understand and adopt successfully the new technology originated in the core, central regions. This is one reason why the rate of patents granted to firms in the less-favoured European regions per unit of expenditure is much lower than in the more innovative regions.[3] In sum, we admit a positive relationship between the C_i values and the capacity to decode the knowledge spilling over from the innovative locations. Our argument is that C_i and FR_{ij} are complementary rather than alternative means of catching up. We do not accept the view that regions may decide for the free riding option, as an alternative to invest domestically in innovation, since no effective free riding may occur in the long-term if a minimal degree of innovative capabilities is not present.

Next we have E_i, which generically may be seen as standing for the contextual conditions which affect organisations operating in region i. We will come back to this variable, when dealing with equation 5 below. For now we may only assume that an adequate technological infrastructure may facilitate the transfer of knowledge from external sources to internal users.

The fourth variable SO_j in equation 3 represents the knowledge spillovers generated in region j. This is one of the most important variables in this model, since the capacity of rapid advancement of region i depends very much on the dimension and diffusion patterns of those spillovers. We will therefore go into more detail about it below, in equation 4.

The last three variables in equation 3 refer to aspects related to the external economic relations of region i. First we shall consider Z_{ij}, which represents the pattern of specialisation of region i in relation to that of region j. This may also be seen as a variable of inter-regional distance, in this case a technological rather than geographical distance. The econometric research that has analysed extensively the existence and magnitude of spillovers has used variables standing precisely for a combination of geographical and technological distance (Griliches 1994). We admit with this variable that a specialisation

[3] There certainly exists a threshold in terms of intensity of R&D investment separating the R&D performing regions between those with a poor performance in terms of innovation and the ones showing a strong innovative performance. The analysis of this threshold, namely in terms of patents granted, may be

in similar sectors will improve the free riding capacities of region i with regard to region j. The variable that comes next is X_i, the degree of openness of region i in terms of external trade. It is our assumption here not only that the demand and competitive pressures of external trade are important elements when accounting for convergence patterns (Thirlwall 1999), but we are particularly assuming that the opportunities of contact and learning brought about by external trade will facilitate a closer observation of innovation. This in turn will enhance the free riding opportunities. Finally, the last variable in equation 3 is F_i, that represents the ratio of FDI in relation to total investment in region i. The interpretation of this variable is similar to the previous one, with the exception that the learning opportunities are in this case brought closer yet to the firms of region i.

Before turning to the last element of equation 1 (E_i), we will focus our attention in S_j, a variable that appeared in the previous equation. As stated above, this variable is related to the spillover potential of region j. The kind of spillovers which we are looking for here are the ones which have been referred to as "pure" (Griliches 1994) or "knowledge" spillovers (Jaffe 1998). These kind of spillovers differ from "market spillovers" (which arise primarily in the transaction of certain inputs as capital goods, an aspect that is related to variable K_j above) and also from "network spillovers" (dynamic economies of scale, related to certain aspects of variable S_i that will be treated below). Equation 4 summarises our argument in relation to this matter. First of all, the spillover potential is assumed to be higher if the region has invested more in R&D and in the development of other complementary sources of knowledge. If that is the case, capabilities C_j will show the necessary maturity to bring about significant innovations. Secondly, that potential will decline steeply if the region is equipped with the necessary mechanisms to protect its innovations (Pt_j). Of course firms in region j are interested in maximising their own private returns on investments in knowledge creation and will try to improve the protection environment. However, it is known that appropriability mechanisms have a very relative effectiveness and vary strongly with the technological and sectoral

an interesting topic for further research, since it may represent a critical point in the process of convergence and catching up.

composition of the economies (Levin et al. 1987, Pavitt 1984). This is the reason why we introduce the variable Z_j in equation 4, which is meant to describe the pattern of sectoral specialisation.

$$S_j = s\,(C_j, Pt_j, Z_j) \qquad (4)$$

We will concentrate now on the third and last component of equation 1, that refers to the contextual conditions which frame the catching up potential of region i. In addition to the endogenous capabilities C_i and of the possibility FR_{ij} to absorb technology produced elsewhere, it is necessary to consider the immediate environment E_i in which firms operate as an essential element in improving (or eventually inhibiting) the operation of the former two previous components of equation 1.

$$E_i = e\,(S_i, P_i) \qquad (5)$$

Equation 5 shows E_i as a function of two different variables, S_i and P_i. S_i is standing in the model for a set of very different elements, which have generally been considered under the concept of "system of innovation". The systemic elements we are considering here include firstly the intensity and quality of interactions among the different agents operating in the economy and have some role in the production, distribution and use of technology. Secondly they include the norms and institutions framing the processes of innovation and technological change. Finally, elements associated with history and the past trajectories of the region, namely in terms of knowledge accumulation, are also considered in this variable. In relation to the variable P_i in equation 5, which refers to the characteristics of the population in region i, it has the intention to portray certain aspects, which have been partially covered by the systems of innovation approach. The reason we are introducing it now, however, is that there are some specific features that we wish to stress autonomously. In addition to the attitudes and the culture shared by both individuals and organisations in the region, which influence the propensity to innovate and accept change, there are other geographic and demographic characteristics of the population that may affect very significantly innovation prospects. It has been suggested that the more densely populated regions in Europe are the ones showing a better innovative performance (Caniells 1996). Moreover, it has also been suggested that regions with higher rates of activity of the whole population in the workforce and with higher levels of female and youth activity are more innovation prone than the European average (Rodriguez-Pose 1999). These aspects, which are related to the local social structure, together with other elements of political and legal nature, may be interpreted as shaping what has been referred to as the "social capability" needed as a precondition for catching up (Abramovitz 1986).

In relation yet to equation 5, it should be said that by inserting the S_i variable in our model we are not necessarily assuming that any systemic pattern of innovation and technological change may exist in the less advanced regions. On the contrary, we are aware that the building up of linkages and of the interactive patterns similar to the ones existing in the regions where innovation systems exist, ought precisely be seen as a strategic aim in the catching up efforts of the less advanced regions. The evaluation of the maturity of such linkages and interactions is, therefore, a step needed to understand the catching up potential of the i-type regions.

We left out of this analysis so far some factors of general order which frame the current processes of technological convergence, but which are critical to consider the question of whether the prospects for catching up in the next decade or so will increase or, on the contrary, will decrease. These factors include both what may be called as a change in the dominant "technological regime" and the process of economic globalisation, which we have been observing recently. We will now turn to these factors, before presenting some preliminary results of our empirical research.

It has been widely pointed out the changing nature of technological progress in the most recent years, particularly with the emergence and wide diffusion of IT-related technologies. A decade ago Freeman and Perez (1988) introduced the concept of a new techno-economic paradigm to characterise the changes that were arising in connection with the emergence of the "new technologies". More recently, the literature produced within the context of the OECD working groups (OECD 1996) has started using the concept of knowledge-based economies. Another concept that has started to be used very widely in the last couple of years, the ”new economy”, tries to summarise some of the aspects encompassed by the former ones. From the wide range of matters covered by the literature focusing on the change of technological regime, there are three aspects we would like to point out which may have profound, positive or negative, consequences for the catching up regions we are analysing here. With this we do not intend to provide answers but rather to raise questions for further consideration.

The first one is the intensification of innovation itself. The acceleration of technological change and the systematic use of innovation to keep ahead of competitors may be making convergence prospects more difficult for regions aiming to catch up. The efforts of large global corporations to rationalise their own R&D structures (Kramer et al. 1998) may be hampering any possibilities to bring about the desired dissemination effects. The second aspect to be considered is the possible trend for a relative raise in the codified component of technological knowledge. The wide use of the IT-related technologies may be helping this trend. If that is the case, the public good nature of technology will increase in the near future, what will help the less advanced regions to accomplish their free-riding aims. However, these developments ”also imply more change in the knowledge stock due to higher rates of scrapping and obsolescence, which will put greater burdens on the economy’s adjustment abilities" (OECD 1996, p. 232). This leads us to our third point, which is precisely about the possible strategies more advanced regions may be putting forward to compensate for the increasing footloose nature of technology. The debate on the revision of patent law in America and the wide range of alternatives that have been considered (Thurow 1997), show a will for an improvement of protection mechanisms. US firms and taxpayers seem to be increasingly worried with the widening gap between the social and private rates of return to R&D carried out domestically, particularly when much of the social benefits seem to be spilling over abroad. Even though some calls have come from academic circles to keep unchanged mechanisms that have shown effective in the past, allowing for the free circulation of basic research results and keeping the available protection for privately produced innovation (Nelson and Romer 1996), the efforts of the US government to impose intellectual property regulations through the WTO may mean that catching up regions elsewhere will feel increasing difficulties in the near future.

4. Some preliminary results

In this section we present some very preliminary findings stemming from the observation of available data sets.

In order to observe the evolution of income disparities in Europe, we started by estimating the coefficient of variation of GDP per head for the EU15, in the period 1960-1995. We used the OECD historical data. As can be seen in Figure 1 presented in the Appendix, there was a clear convergence among the EU countries until the middle seventies, when an opposite trend set in until the middle eighties. Since then, and until 1995, convergence seems to be happening again, although this trend is not quite clear.

We take the period since the middle 1980s as our reference for the regional analysis. The source used here is the Eurostat's REGIO database. This source presents some limitations in what concerns availability of data on both some relevant variables (e.g., data on innovation is limited to R&D expenditures and personnel; or, data on education attainment), and time periods (e.g., the possibility to analyse the evolution of innovation variables over the whole period is very limited), particularly for some regions.

The evolution of regional convergence in what concerns GDP per head can be observed in the figures 2 to 5 included in the Appendix. Two samples of regions (NUTS1) were considered, one containing 73 regions for the period 1991-1996, and the other including 58 regions over the period 1985-1996[4]. Furthermore, we analysed two kinds of convergence. On the one hand, the coefficient of variation denotes the overall dispersion among the regions considered. On the other hand, β convergence explores the correlation between the initial level of GDP per head and the rate of growth in a given period for a group of regions (when the correlation coefficient is negative it indicates that convergence is occurring).

[4] We always exclude from our analysis the regions: pt2, pt3, fi2, and fr9, because of data unavailability. The same reason led us to exclude from the analysis 15 other regions for periods before 1991.

For the time period between 1985 and 1996 (58 regions), we have no clear evidence of convergence in income levels. The coefficient of variation (Figure 2) does not present a clear trend and the analysis of β convergence (Figure 4) leads us to a similar conclusion. When we consider instead the period 1991-1996 (73 regions), the signs of convergence in regional GDP per head are more evident. The impact of including the 5 Eastern German regions in the sample (they are not part of the 58 regions of the other group) is obvious when looking at the respective graph (see Figures 3 and 5).

5. Some conclusions and directions for further research

As it was pointed out in section 2, the patterns of economic convergence (or divergence) among different regions depend on the interaction of a significant number of factors. A large number of the most recently carried out studies tend to concentrate on a limited number of variables – namely those related to R&D expenditure – to account for the empirically observed convergence trends. However, setting aside factors such as the demand forces, trade costs, or agglomeration economies represents an oversimplification when the objective is to understand and explain such complex processes.

In this paper we have put forward a basic model of technological catching up. This model represents an attempt to systematise the most relevant factors that, from a perspective of less-favoured European regions, affect the prospects for technological catching up. We conceptualise this process as an interaction between three major factors:

- the endogenous capabilities accumulated in the less advanced regions;
- the possibilities these regions have to free ride the knowledge spilling over from the more advanced regions;
- and, finally, the local conditions that may improve or hinder the development of capabilities and the absorption of externally-produced knowledge.

Next in the paper we presented some preliminary findings stemming from the empirical observation of available data sets. Most of the information available in Europe at the regional level is relatively recent and most series show problems of continuity. We expect in the future to improve and complete the available quantitative and qualitative information in order to test the assumptions and the relationships we identified in our catching up model (Section 3.). The results we have so far seem to confirm the trends that have been highlighted by other recent studies about inter-regional convergence in Europe.

There are also several questions that we will try to address in our future research, namely those related to the impact of both changes in the dominant "technological regime" and the process of economic globalisation on the catching up prospects of the less-favoured regions. We also intend to address other factors, related to the social, political and legal structures in the EU regions, as well as aspects regarding the effectiveness of the regional policies implemented by both national and regional governments and the European Commission.

References

Abraham, F., & van Rompuy, P. (1995). Regional Convergence in the European Monetary Union. Papers in Regional Science, 74(2), 125-142.

Abramovitz, M. (1986). Catching up, forging ahead, and falling behind. Journal of Economic History, Vol. XLVI, No.2, June, pp. 385-406.

Amin, A., & Tomaney, J. (1995). The challenge of cohesion. In A. Amin, & J. Tomaney (eds.), Behind the Myth of European Union (pp. 10-47). London: Routledge.

Armstrong, H. (1995). Convergence among regions of the European Union, 1950-1990. Papers in Regional Science, 74(2), 143-152.

Barro, R.; Sala-i-Marti, X. (1991). Convergence across States and Regions. Brooking Papers on Economic Activity, 1, 107-182

Begg, I. (1995). Threats to cohesion. In A. Amin, & J. Tomaney (eds.), Behind the Myth of European Union (pp. 110-124). London: Routledge.

Caniels, M. (1996). Regional differences in technology - theory and empirics. MERIT Working Paper . Maastricht.

Fagerberg, J. (1987). A technology gap approach to why growth rates differ. In Research Policy, vol. 16, No.2, pp. 87-99.

Fagerberg, J., & Verspagen, B. (1996). Heading for divergence? Regional growth in Europe reconsidered. Journal of Common Market Studies, 34(3), 431-448.

Fagerberg, J., Verspagen, B., & Caniels, M. (1997). Technology gaps, growth and unemployment across European regions. MERIT Working Paper . Maastricht.

Gerschenkron, A. (1962). Economic Backwardness in Historical Perspective. Cambridge, Massachusstes: Harvard University Press.

Griliches, Z. (1992). The search for R&D spillovers. Scandinavian Journal of Economics, 94 (supplement), pp.29-47

Hirchman, A. (1957). A Strategy for Economic Development. Yale University Press.

Jaffe, A.; Trajtenberg, M.; Henderson, R. (1993). Geographic localization of knowledge spillovers as evidenced by patent citations. Quarterly Journal of Economics, August, pp.577-594

Kaldor, N. (1957). A model of economic growth. Economic Journal (December)

Levin, R.; Klevorick, A.; Nelson, R.; Winter, S. (1987). Appropriating the returns from industrial research and development. Brooking Papers on Economic Activity, 3, 783-831

Maurseth, P.; Verspagen, B. (1998). Knowledge spillovers in Europe and its consequences for systems of innovation. MERIT Working Paper 2/98-024. Maastricht.

Myrdal, G. (1957). Economic Theory and Underdeveloped Regions. Duckworth.

Nelson, R.; Romer, P. (1996). Science, Economic Growth, and Public Policy. In Smith, B.; Barfield, C. (eds.), Technology, R&D, and the Economy (pp.49-74). Washington, D.C.: The Brookings Institution

Neven, D., & Gouyette, C. (1995). Regional Convergence in the European Community. Journal of Common Market Studies, 33(1), 47-65.

OECD (1996). The Knowledge-Based Economy. In Science, Technology and Industry Outlook, Chapter 5. Paris: OECD.

Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. Research Policy, vol. 13, pp. 343-373.

Pavitt, K. (1985). Technology transfer among the industrially advanced countries: An overview, in Rosenberg, N. and Fristack, C. (eds.) International Technology Transfer: Concepts, Measures and Comparisons. New York: Praeger.

Perez, C. and Soete, L. (1988). Catching-up in technology, in Dosi, G., K. Pavitt and L. Soete (eds.). The Economics of Technical Change and International Trade. London: Harvester Wheatsheaf.

Posner, M.V. (1961). International trade and technical change. Oxford Economic Papers, Vol. 13, pp. 323-341.

Rodriguez-Pose, A. (1999). Innovation prone and innovation averse societies: economic performance in Europe. Growth & Change, 30(1), pp.75-105

Romer, P. (1986), Increasing returns and long-run growth. Journal of Political Economy, Vol. 94, pp. 1002-1037.

Romer, P. (1990). Endogeneous technological change. Journal of Political Economy, Vol. 98.

Sala-i-Martin, X. (1996). Regional cohesion: evidence and theories of regional growth and convergence. European Economic Review, 40, 1325-1352.

Shepley, S., & Wilmot, J. (1995). Core vs. Periphery. In A. Amin, & J. Tomaney (eds.), Behind the Myth of European Union (pp. 51-82). London: Routledge.

Smith, B.; Barfield, C. (eds.) (1996). Technology, R&D, and the Economy. Washington, D.C.: The Brookings Institution.

Solow, R. (1956), A contribution to the theory of economic growth, in *Quarterly Journal of Economics*, Vol. 70, pp. 101-121.

Thirlwall, A. P. (1999). Factor mobility, trade and 'regional' economic differences in the European union: what story should we tell our grandchildren? Lecture at the Technical University of Lisbon. 14th January 1999, Lisbon.

Thurow, L. (1997). Needed: a new system of intellectual property rights. Harvard Business Review, September-October, pp.95-103

Vernon, R. (1966), International investment and international trade in the product cycle, in *Quarterly Journal of Economics*, 80, 191-207.

Annex - Some Statistical Evidence

Figure 1. Coefficient of variation of GDP per head in the EU countries (at 1990 prices and exchanges rates)

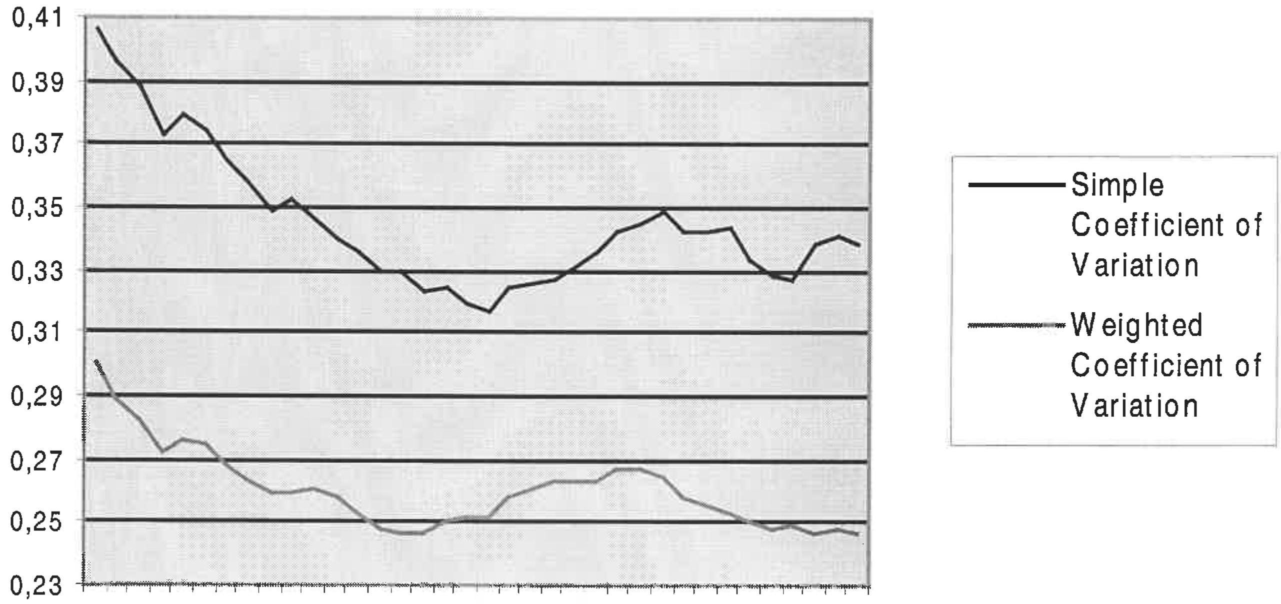


Figure 2. Coefficient of Variation of GDP per head (PPS)
(58 EU Regions - NUTS1)

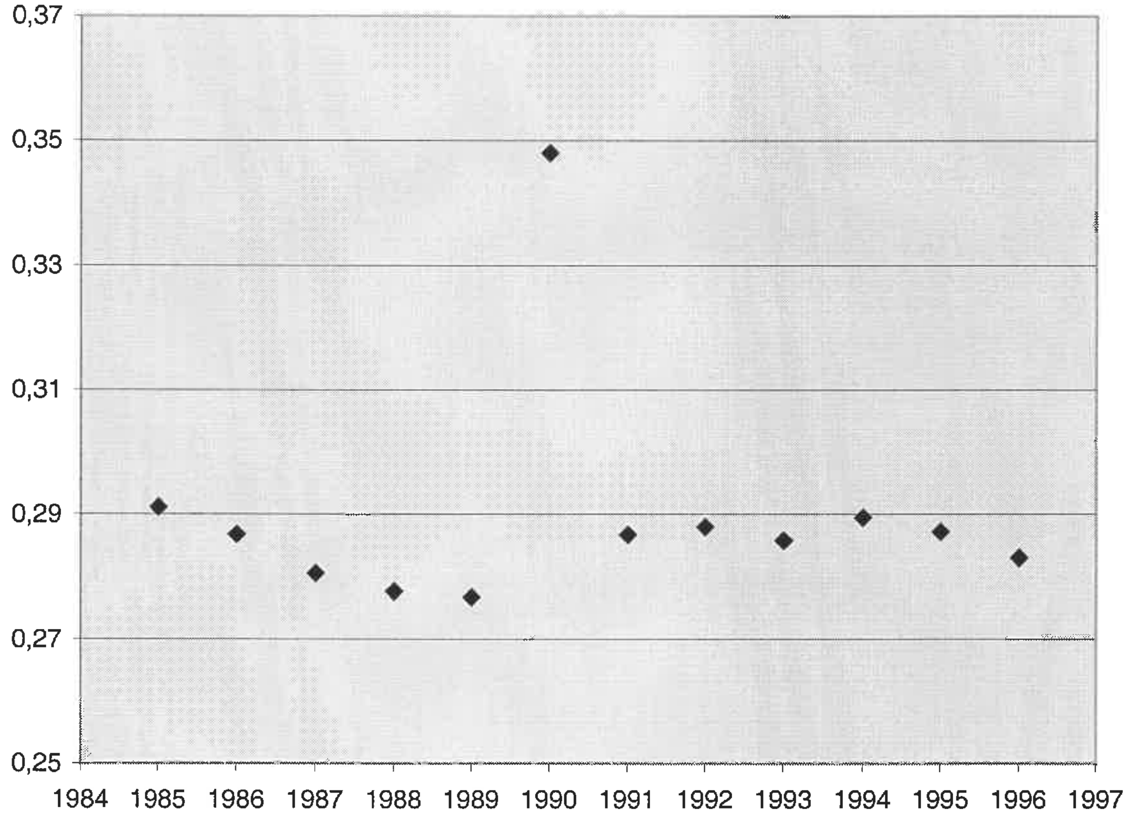


Figure 3. Coefficient of Variation of GDP per head (PPS)
(73 EU regions - NUTS1)

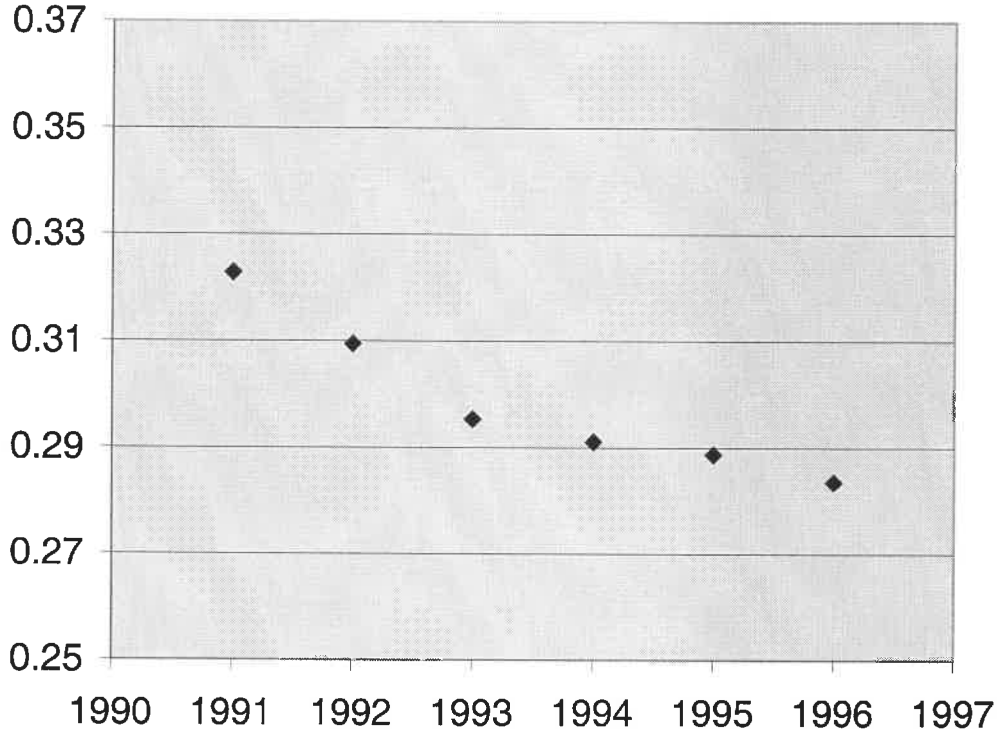


Figure 4. Beta Convergence in GDP per head (PPS) in 1985-1996
(58 EU regions - NUTS1)

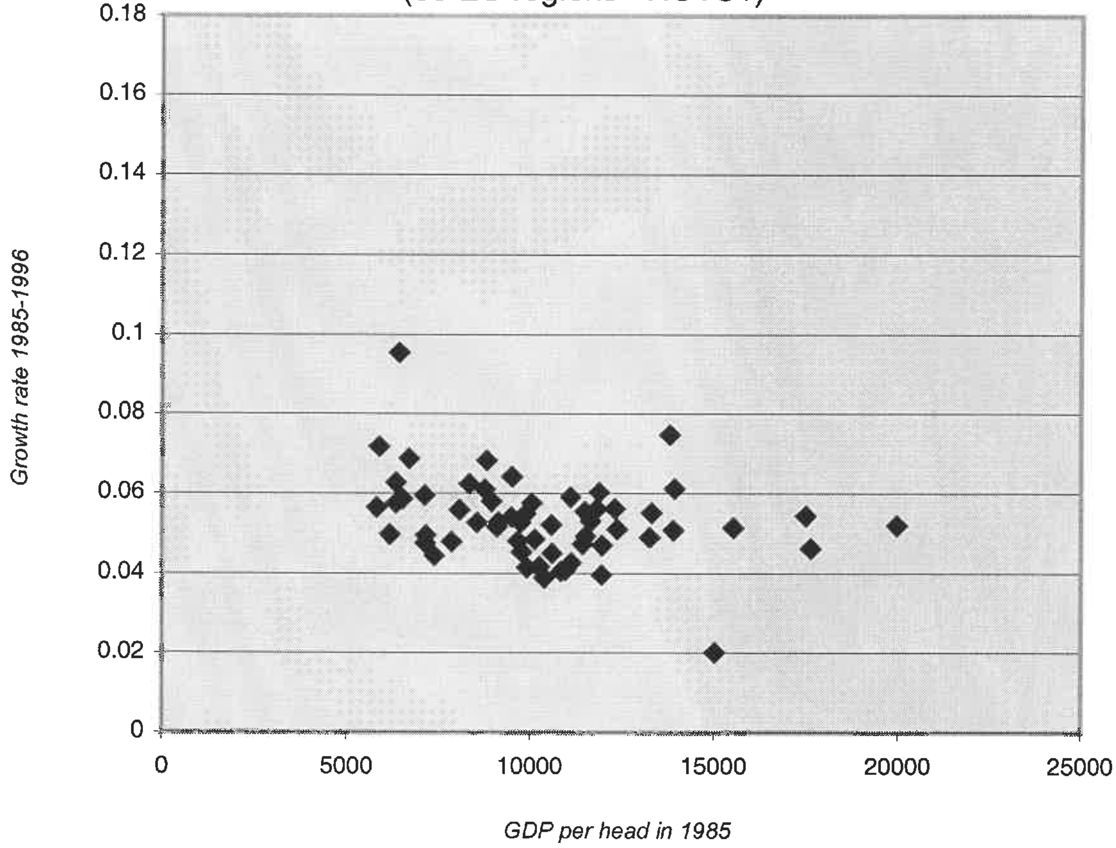
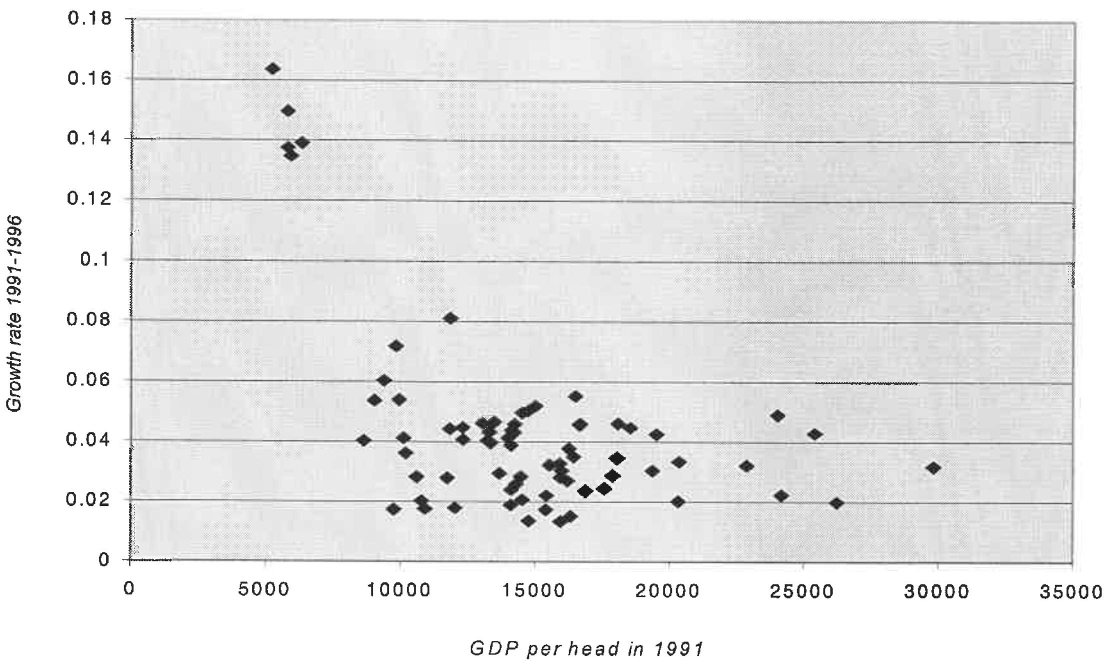


Figure 5. Beta Convergence of GDP per head (PPS) between 1991-1996
(73 UE regions - NUTS1)



Regression Results

(concern , respectively, "Figure 4. Beta Convergence in GDP per head (PPS) in 1985-1996 (58 EU regions - NUTS1)" and "Figure 5. Beta Convergence of GDP per head (PPS) between 1991-1996 (73 UE regions - NUTS1)")

	Beta convergence 1985-1996	**Beta convergence 1991-1996**
n	58	73
B_0	0,0648 (13.617)	0,09442 (9.449)
B_1	-0.0000011 (-2.507)	-0.00000348 (-5.355)
R^2 adj.	0.101	0.288

Departamento de Economia

ISEG/UTL
Rua Miguel Lupi, 20, 1º • 1249-078 Lisboa
Tel.: (351-1) 392 28 10 Fax: (351-1) 392 28 028
depeco@iseg.utl.pt • http://www.iseg.utl.pt