XII ENCUENTRO DE ECONOMÍA PÚBLICA

3 y 4 de FEBRERO de 2005

TITULO DEL TRABAJO:

CONVERGENCE ACROSS EU MEMBER STATES: EVIDENCE ON THE EFFECTS OF EDUCATION INVESTMENT AND FISCAL POLICY.

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Abstract: Despite the notable increase in the literature dealing with economic convergence among the Member States of the EU, the debate concerning the significance of this process is still open. This present paper contributes new evidence, broadening the model developed by Mankiw, Romer and Weil (1992) through the incorporation of the role of goverment, following Bajo's work (2000). The convergence equation, the cornerstone of this study, is estimated employing data panel techniques and deals with the most important problems pointed out in specialized literature. Our findings suggest that European convergence is a slow and discontinuous process, in which human capital has played a key role as a source of convergence, attaching importance to the educational policy developed in different European countries.

JEL: 040, R11, E62
Keywords: Conditional Convergence, Fiscal policy, Public Sector, European Union.

1. Introduction

The concern of the European Member States for advancing in the convergence process has brought about an increase in public resources favoring this process. This budgetary effort has been frequently justified by the effects that economic integration may bring about in those States with lower income although, in practice, the debate concerning the capacity to reduce existing disparities remains open. The different methodologies, time periods and groups of regions and countries taken into consideration have given rise to results that, in general, are not especially conclusive. Even so, there is a certain consensus as to the fact that a convergence process among European economies took place in the fifties and, especially, in the sixties, while from then on, stagnation was registered and economic divergence increased. However, there is no clear evidence as to recovery after the eighties or to the role public policies played in these results[1].

Up until now, the majority of the studies dealing with convergence in the European Union have taken as a point of reference the region, due to the fact that it is the focal point of the current policy of cohesion and convergence in the heart of the European Union. The Sapir Report (European Commission, 2003) introduced a substantial change in the design of European policies because it was aimed at solidarity among states rather than regions and it gave more importance to the analysis of the whole of the Member State economies. In the context of a European Union consolidated with 25 State Members, it is more interesting to demonstrate the aggregate behavior of these countries as to convergence, making it necessary to change the unit of reference for this analysis.

In this context, the aim of this paper is to estimate the convergence equation associated with a growth model such as the one proposed by Mankiw *et al.* (1992) which includes both public and human capital. With the model in question, public sector size is included, allowing us to derive a convergence equation in which the activity of this sector is characterized from two different aspects, since investments carried out as well as tax policy

[1] Since Barro and Sala-i-Martín's work (1991), there has been a considerable increase in the number of empirical studies attempting to contrast the existence of convergence among regions and countries. For a summary of the most outstanding findings, see Armstrong (2002) or De la Fuente (2000).

decisions put into practice are taken into consideration[2]. These estimations will allow us to broaden the evidence concerning the conditioning factors of convergence which are, at the same time, among the main public policy instruments developed in European countries. The estimations are carried out with a panel of European Union Member States from 1980 until 1997. Following Islam (1995), the hypothesis of conditional convergence is contrasted, taking into account the existence of stationary heterogeneous states by means of the consideration of non-observable fixed effects in the convergence equation and the use of data panel statistical techniques. On the other hand and with the objective of avoiding endogeneity biases in the conditioning variables employed, the model is estimated using the instrumental variable method. In addition and aiming to contrast the robustness of the results obtained and broaden the evidence concerning this process, the model is extended to include, under alternative specifications, a variable which reflects the technological gap among European countries.

This outline of the analysis might be included in the most traditional research dealing with convergence and it has given rise to a great deal of literature, but not without criticism[3]. The main advantage over former studies is the use of a homogenous data base for the fifteen Member States, covering the years 1980-1997. This period shows the greatest increase in resources intended to equal the economic conditions among European countries. In addition, studies on European convergence incorporating variables related to tax policy decisions are scarce. In this paper, several different factors referring to public sector size and activity in European economies are analyzed.

The remaining part of the paper is organized as follows. In Section 2 we shall present the theoretical model from which the convergence equation used in the subsequent empirical analysis is derived. Section 3 contains the results obtained after estimating the different specifications of the neoclassical model for European countries during the period 1980-1997. The following Section will discuss different alternative specifications which incorporate a term that represents the technological catch-up effect among European countries. Finally, the main conclusions are presented.

[2] The relation between tax policy and growth has been analyzed in several studies, such as, for example, Barro (1997), Easterly and Rebelo (1993) or De la Fuente (1997) all of which highlight the difficulty of adequately contrasting this complex interrelationship.
[3] For a systematic criticism of this methodology, see Quah (1995, 1996)

2. Theoretical Framework.

In this paper we have used the neoclassical growth model, based on the specifications presented by Mankiw, Romer and Weil (1992) and Bajo (2000) in order to derive the convergence equation resulting when public capital and human capital are included. The point of departure is a Cobb-Douglas production function with constant scaled performance characterized by a technology that increases labour efficiency and which is equal in all countries. In this analysis we consider that there are three types of capital in the economy: private capital, public capital and human capital. The production function is:

$$Y_t = K_t^{\beta} G_t^{\alpha} H_t^{\gamma} (AL_t)^{1-\alpha-\beta-\gamma} \qquad (2.1.)$$

where Y_t represents aggregate production; K_t, private capital; L_t, employment; G_t, public capital; H_t, human capital and A, the level of exogenous technology. It should be pointed out that the production function shows decreasing scale performance in the accumulable factors, $\alpha + \beta + \gamma < 1$, allowing us to analyze the behavior of this economy in a stationary state, as well as to empirically solve the corresponding convergence equation. The neoclassical growth model assumes that the number of effective labour units A(t)L(t) grows at the rate (n+g)[4]. On the other hand, it is assumed that a constant share of income is saved and invested S(ed) and that this rate of investment is given exogenously.

Defining k_t' as the relation private capital-labour $\frac{K_t}{L_t}$, g_t' as the relation public capital-labour $\frac{G_t}{L_t}$ and h_t' as the relation human capital-labour $\frac{H_t}{L_t}$, we can define the movement equations for the three production factors:

$$\dot{k}'_t = (1-\tau) S_k k_t'^{\beta} g_t'^{\alpha} h_t'^{\gamma} - (n+g+\delta) k'_t \qquad (2.2a)$$

$$\dot{g}'_t = \tau S_g k_t'^{\beta} g_t'^{\alpha} h_t'^{\gamma} - (n+g+\delta) g'_t \qquad (2.2b)$$

[4] A(t) y L(t) grow exogenously at rates g and n, respectively:
A(t) = A(0)*e^gt
L(t) = L(0)*e^nt

$$\dot{h}'_t = S_h k_t'^{\beta} g_t'^{\alpha} h_t'^{\gamma} - (n + g + \delta) h'_t \qquad (2.2c)$$

where a dot above the variable denotes differentiation with regard to time, S_k represents the rate of savings in relation to income, S_g y S_h are the fractions of income invested in public and human capital, respectively, and τ refers to the size of the public sector[5]. The rate of depreciation δ is the same for the three types of capital.

Dividing each one of the equations of expression (2.2.) by the variable whose dynamic they represent, the growth rates of accumulable factors in efficiency units are obtained:

$$\gamma_k = \frac{\dot{k}'_t}{k'_t} = (1-\tau) S_k k_t'^{\beta-1} g_t'^{\alpha} h_t'^{\gamma} - (n + g + \delta) \qquad (2.3a)$$

$$\gamma_g = \frac{\dot{g}'_t}{g'_t} = \tau S_g k_t'^{\beta} g_t'^{\alpha-1} h_t'^{\gamma} - (n + g + \delta) \qquad (2.3b)$$

$$\gamma_h = \frac{\dot{h}'_t}{h'_t} = S_h k_t'^{\beta} g_t'^{\alpha} h_t'^{\gamma-1} - (n + g + \delta) \qquad (2.3c)$$

This system of equations allows us to obtain the intensity expressions of private, public and human capital in efficiency units in a stationary state (indicated by *). Thus, equalling the three expressions in (2.3.) to zero, the following is obtained:

$$k'^{*} = \left[\frac{S_h^{\gamma} S_g^{\alpha} S_k^{1-\alpha-\gamma} \tau^{\alpha} (1-\tau)^{1-\alpha-\gamma}}{(n + g + \delta)} \right]^{1/(1-\alpha-\beta-\gamma)} \qquad (2.4a)$$

$$g'^{*} = \left[\frac{S_h^{\gamma} S_g^{1-\beta-\gamma} S_k^{\beta} \tau^{1-\beta-\gamma} (1-\tau)^{\beta}}{(n + g + \delta)} \right]^{1/(1-\alpha-\beta-\gamma)} \qquad (2.4b)$$

[5] Barro (1990) considers that the only source of public income is an income tax with a rate which is constant and equal to τ. Thus, the government budget restriction is as follows:

$$g_t = \tau y_t = \tau k_t^{\beta} g_t^{\alpha}$$

Therefore, $\tau = \frac{g_t}{y_t}$, where it may be deduced that the tax rate should be equal to the weight of the public sector in the economy.

$$h^{'*} = \left[\frac{S_h^{1-\alpha-\beta} S_g^{\alpha} S_k^{\beta} \tau^{\alpha} (1-\tau)^{\beta}}{(n+g+\delta)} \right]^{1/(1-\alpha-\beta-\gamma)} \qquad (2.4c)$$

Substituting (2.4.) in the production function and taking logarithms, we obtain the level of income per effective labour unit in a stationary state:

$$\ln\left(\frac{Y_t}{L_t}\right)^* = \ln A_0 + g_t - \frac{\alpha+\beta+\gamma}{1-\alpha-\beta-\gamma}\ln(n+g+\delta) +$$
$$+ \frac{\beta}{1-\alpha-\beta-\gamma}\ln(S_k) + \frac{\alpha}{1-\alpha-\beta-\gamma}\ln(S_g) + \frac{\gamma}{1-\alpha-\beta-\gamma}\ln(S_h) + \qquad (2.5)$$
$$+ \frac{\alpha}{1-\alpha-\beta-\gamma}\ln(\tau) + \frac{\beta}{1-\alpha-\beta-\gamma}\ln(1-\tau)$$

Equation (2.5.) shows that income in a stationary state depends positively on the rates of capital investment (private, public and human) and on the variables that refer to the weight of the public and private sectors, τ y (1 - τ), while the variables that measure the growth rate of labour in efficiency units and stock depreciation have a negative influence.

Following Mankiw *et al.*, it is assumed that g y δ are constants and that A_o reflects not only technology but also endowments of resources, the climate, institutions, etc., which can differ among countries, leading us to consider $\ln A_0 = a + u_t$, where a is a constant and u_t is a specific shock corresponding to each country. Therefore income per capita in a stationary state is shown as follows:

$$\ln\left(\frac{Y_t}{L_t}\right)^* = a - \frac{\alpha+\beta+\gamma}{1-\alpha-\beta-\gamma}\ln(n+g+\delta) + \frac{\beta}{1-\alpha-\beta-\gamma}\ln(S_k) +$$
$$+ \frac{\alpha}{1-\alpha-\beta-\gamma}\ln(S_g) + \frac{\gamma}{1-\alpha-\beta-\gamma}\ln(S_h) + \qquad (2.6.)$$
$$+ \frac{\alpha}{1-\alpha-\beta-\gamma}\ln(\tau) + \frac{\beta}{1-\alpha-\beta-\gamma}\ln(1-\tau) + u_t$$

Subsequently, taking logarithms and differentiating with respect to time, we can derive the convergence equation:

$$\frac{\ln y_t - \ln y_{t-T}}{T} = \frac{(1-e^{-\lambda_t})}{T} a - \frac{(1-e^{-\lambda_t})}{T} \ln y_{t-T} - \frac{(1-e^{-\lambda_t})}{T} \frac{\alpha+\beta+\gamma}{1-\alpha-\beta-\gamma} \ln(n+g+\delta) +$$
$$+ \frac{(1-e^{-\lambda_t})}{T} \frac{\beta}{1-\alpha-\beta-\gamma} \ln(S_k) + \frac{(1-e^{-\lambda_t})}{T} \frac{\alpha}{1-\alpha-\beta-\gamma} \ln(S_g) +$$
$$+ \frac{(1-e^{-\lambda_t})}{T} \frac{\gamma}{1-\alpha-\beta-\gamma} \ln(S_h) + \frac{(1-e^{-\lambda_t})}{T} \frac{\alpha}{1-\alpha-\beta-\gamma} \ln(\tau) + \quad (2.7)$$
$$+ \frac{(1-e^{-\lambda_t})}{T} \frac{\beta}{1-\alpha-\beta-\gamma} \ln(1-\tau) + u_t$$

where $\ln y_{t-T}$ is the logarithm of income for the effective labour unit in the initial period and $\lambda = (n+g+\delta)\cdot(1-\alpha-\beta-\gamma)$ refers to the speed towards the stationary state. The convergence equation (2.7.) will allow us to analyze not only the degree of proximity in productivity levels of different economies towards their own stationary state (conditioned convergence), but also the role played by the analyzed variables in this process. We should highlight the fact that equation (2.7) includes several factors referring to the public sector: the participation over the income from public investment (S_g), the weight of the private sector $(1-\tau)$, and the relative participation of the public sector τ. In this way it will be possible to analyze the influence that tax policy decisions exert on the convergence process in income levels per effective labour unit of different economies towards their own stationary state.

3. Empirical evidence: An analysis of conditional convergence for European Union Member States.

With the convergence equation developed in the above section, we can better understand the behavior of European economies, analysing whether the growth rate of each country is inversely related to the distance that separates it from its own stationary state. Moreover, this neoclassical analysis of convergence offers the possibility of enriching the model with the objective of determining which variables, in addition to private capital and labour, explain the convergence mechanism. In this paper we have carried out estimations of the conditional convergence equation, using slightly different specifications, allowing us to broaden available evidence and analyse the influence of different public policy instruments as possible conditioning factors in this process.

The estimations of the convergence equation were carried out using a data panel for the fifteen Member States of the European Union during the period 1980-1997. Table 1 presents a description of the variable used as well as the statistical source. Most of data used in this paper were taken from the NewCronos Database (Eurostat), which offers on CD-ROM information concerning the series of Gross Value Added, investments by sectors (1990 PPS) and labour. The expenditure on education series, expressed in 1990 PPS, was taken from OCDE Publications.

Table 1. Definition of Variables and Sources Used

y_{it}	Per active worker Gross Value Added (GVA) (1990 PPS). Source: NewCronos. Eurostat.
S_{kit}	Ratio of private investment over GVA (1990 PPS). Source: NewCronos. Eurostat.
S_{git}	Ratio of public investment over GVA (1990 PPS) Source: NewCronos. Eurostat.
S_{hit}	Ratio of public expenditure devoted to education over GVA (1990 PPS) (proxy to human capital) Source: OCDE.
g	Exogenous technical progress rate whose value has been fixed at 0.02.
τ	Ratio of tax resources collected by government over the GVA[6]. Source: NewCronos. Eurostat.
n_{it}	Average growth rate of active population. Source: OCDE.
δ	Rate of capital depreciation to the three types of capital considered. Its value is fixed at 0.05.

The model estimated is presented in equation (2.7.). Table 2 presents the results obtained with five specifications of this model[7]. In addition to private capital (Model I), human capital (Model II) and, alternatively, public capital (Model III) are included. Next, both variables are incorporated together and are estimated for the entire period (Model IV) as well as for sub-periods: 1980-1985 (Model IVa), 1986-1992 (Model IVb) and 1993-1997 (Model IVc), in order to detect possible changes in the convergence process between member states. Finally, in the empirical implementation of Model V, fictitious temporal variables are included in order to capture the effect of the cycle.

[6] To measure the tax rate, the ratio of all the income of the public sector over the product is employed. We make use of this criterion because in the model there is only one tax rate on all earned incomes and capital of the agent. We have therefore aggregated personal taxes (mainly income tax), indirect taxes on firms, taxes on firm profits and, finally, national insurance contributions. In this way, the tax rate approaches the concept of the tax burden of the economy.

[7] The derivation of the convergence equation for the different specifications considered in this section has been omitted. They are presented in detail in Álvarez y Delgado (2004).

In the estimations carried out, we have dealt with the two main sources of inconsistency presented in empirical studies on convergence: correlated individual effects and endogenous explanatory variables. As to the former, all the estimations carried out show statistic F high enough to accept the hypothesis that there are typical and observable characteristics of countries that influence their rate of growth and this justifies the use of data panel techniques. In addition, we contrasted the possible existence of correlations between the observable effects and the explicative variables, using as a point of departure the contrast based on Hausman's contribution (1978). The values reached by this statistic support the use of a fixed effects model; that is, the intra-group estimation of the model, as shown in Table 2[8].

On the other hand, the possible existence of endogeneity biases in the conditioning variables makes it advisable to estimate by instrumental variables over the model transformed in orthogonal deviations[9]. The extended Generalized Method of Moments (GMM), estimator proposed by Arellano and Bover (1995) considers further orthogonality conditions based on lagged differences as instruments for the equation in levels, allowing for the generation of an optimum group of instruments to obtain efficient and valid estimations of the coefficients of the convergence equation. In addition and employing the Wald contrast, the combined significance of the model can be observed. Furthermore, the residues show no correlation problems and we have made use of the covariance matrix proposed by White (1980), allowing us to carry out robust inferences even in the presence of heteroskedasticity[10].

The results obtained when the different variables analysed are included, both separately and jointly, significantly improve the estimation of the standard conditional convergence equation (Model I). The convergence rate is observed as significant, although limited in Models III and IV (with annual values ranging from 1.2 to 1.4 %),

[8] As is customary in empirical work on economic convergence, the results in Table 2 are obtained imposing the restriction that the sum of the coefficients on the demographic variables, the private investment rate, the public investment rate and the expenditure in education rate is equal to zero.

[9] Due to the difficulty of encountering adequate instruments, we have followed Arellano´s approach (2002) in order to transform the model in orthogonal deviations, thus providing estimations equivalent to that of the intra-groups in order to transform the model into orthogonal deviations which provide estimations equivalent to that of intra-groups and enables us to consider the outdated variables as instruments.

[10] The estimations in this study have been carried out using the DPD package, programmed by Arellano and Bond (1998).

which would indicate the existence of stationary states to which European economies are slowly converging. In Models II and V, convergence speed is practically nil and insignificant. This result is along the same lines as certain alternatively focussed studies, which do not show evidence supporting the convergence hypothesis in Europe (Esteve and Pallardó, 1997, or González, 2003, with certain examples). The importance of the period analysed on results is often argued. We therefore considered it worthwhile to base estimations on different periods so that variations in the dynamics of the process could be observed. Results coincide with available empirical evidence, showing that the convergence process became stagnant in the eighties, although appears to have recovered at the end of the decade and intensified until 1993, reaching an annual convergence rate of 3.2 % in the last sub-period studied (1993-1997). The increase in the economic convergence rate during the mentioned period could indicate that the resources used to balance economic conditions between Member States have started to work, therefore endorsing the public policies undertaken in Europe.

Estimations carried out also enable certain conclusions to be drawn on the influence of particular variables relating to public intervention, which have gradually been included in this analysis: public supply of infrastructure and education, tax burden. Firstly, the analysis performed suggests a negative influence of public investment on European countries' growth rates, although non-significant in many of the estimations made. It is only from 1980-1985 when empirical evidence supports public investment having a favourable impact. Despite the fact that these results question the role of public capital as a growth-determining factor, it is not an uncommon result in analyses carried out in different European countries. (González-Páramo *et al*., 2003, Sturm and de Haan, 1995). The implementing of such investment based on redistribution criteria in Member States could explain the null or negative effect this variable has on economic growth.

Another result worthy of mention concerns education costs, showing a positive and significant effect on growth in the estimation relating to the overall 1980-1997 period. Human capital has traditionally been considered a determining factor in economic growth, although from an empirical point of view, there are numerous difficulties in contrasting the role played by human capital as a production factor. In general, results appear to be sensitive to the specification used as well as to the human capital unit of

measurement and sample period[11]. In this sense, the lack of significance of human capital shown by estimations relating to sub-periods could indicate the need to consider a sufficiently long period of time in order to enable effective measuring of human capital on growth.

The role played by private investment is positive and significant, as predicted by the theoretical framework of Models I and II, in which tax burden effects on the accumulation of private capital are not taken into account $(1-\tau)$. However, when this variable is incorporated, results become non-significant (and in certain cases negative) in the majority of estimations. This could be partly due to the problem of multi-colineality[12], given that both variables cover issues relating to private sector investment capacity. Despite the lack of significance of the private investment variable, the percentage of income available for capital accumulation, after tax (variable $(1-\tau)$) is in fact positive and significant, in accordance with the theoretical model proposed. This result could also suggest that a substantial part of the private capital effect on growth is channelled through a reduction in the importance of the public sector, thus indicating that public and private capital are complementary. Finally, the temporary dummies incorporated into Model V are not significant, which suggests a lack of relevance of economic cycles on European economic growth.

[11] For surveys of this literature and discussions about data quality and the importance of the sample period, see De la Fuente *et al*. (1996), De la Fuente *et al.* (2002) and Sosvilla-Rivero and Alonso Meseguer (2003).
[12] The difficulty in empirically analysing taxation effects due to multi-colineality problems has been dealt with by previous studies (Easterly and Rebelo, 1993).

TABLE 2. Estimation of Convergence Equation. 15- EU (1980-1997). (Dependent Variable: $\ln(y_{it} / y_{i,t-1})$).

FIXED EFFECT PANEL DATA MODEL								
	Model I	**Model II**	**Model III**	**Model IV**	**Model IVa**	**Model IVb**	**Model IVc**	**Model V**
$\ln(y_{i,t-1})$	0.00031(0.076)	-0.00024(-0.056)	-0.012 (-1.54)*	-0.014 (-1.94)**	-0.019 (-1.12)	-0.017 (-1.58)*	-0.032 (-1.69)**	-0.0072(-0.96)
$\ln(S_{kit}) - \ln(n_{it} + g + \delta)$	0.0075(1.57)*	0.0077(1.61)*	-0.0097(-0.75)	-0.0048(-0.54)	-0.029(-1.73)**	0.036(1.57)*	-0.00076(-0.049)	0.0024(0.32)
$\ln(S_{git}) - \ln(n_{it} + g + \delta)$			-0.0017(-0.35)	-0.0013(-0.28)	0.017(1.59)*	-0.014(-1.59)*	-0.0061(-0.57)	-0.00092(-0.201)
$\ln(S_{hit}) - \ln(n_{it} + g + \delta)$		0.00065(0.35)		0.0047(1.76)**	0.0104(1.26)	-0.001(-0.24)	0.0016(0.096)	0.0052(1.54)*
$\ln(1 - \tau_{it})$			0.022(1.69)**	0.018(2.15)**	0.035(1.83)**	-0.0028(-0.15)	0.033(1.24)	0.0304(1.404)*
Test F ind. effects	F(14,238)=5.37	F(14,237)=5.19	F(14,236)=5.24	F(14,235)=5.05	F(14,70)=1.76	F(14,85)=3.83	F(14,49)=5.15	F(14,219)=5.42
Hausman test	$\chi^2(2) = 12.64$	$\chi^2(3) = 13.29$	$\chi^2(4) = 13.39$	$\chi^2(5) = 14.14$	$\chi^2(5) = 16.99$	$\chi^2(5) = 16.93$	$\chi^2(5) = 14.86$	$\chi^2(5) = 17.46$
Wald Sig. dummies test								20.64 (G.L.=16)
Wald Sig. test	268.64(G.L.=2)	267.54 (G.L.=3)	275.16 (G.L.=4)	309.51 (G.L.=5)	273.604 (G.L.=5)	122.25 (G.L.=5)	356.074 (G.L.=5)	6.89 (G.L.=5)
Self-corr. 1st level	1.048	1.020	1.143	0.938	-2.836	2.054	3.380	1.027
Self-corr. 2nd level	1.711	1.660	2.063	1.602	-0.541	-1.303	2.158	1.693

G.L. = degree of freedom. T- statistic in parentheses.

* 90% significance parameter.

** 95% significance parameter.

Number of observations: 270

3. Empirical evidence: Incorporating of technological catch-up.

The following are two alternative specifications for the convergence equation, which highlight the implications of the technological gap between European countries. Given current technology, less advanced countries may register greater growth by imitating and adapting to techniques that have been previously developed by leading countries (c*atch-up* hypothesis), the distance or technological gap separating an economy from a leading economy, thereby positively affecting its economic growth and also the convergence process. It could also be considered that the existing human capital within an economy will condition its ability to imitate and adopt techniques developed by leaders, thus opening up an alternative in which educational policy and investment in human capital could influence the European convergence model.

Firstly, the convergence model specification was modified (2.7.) by incorporating an additional term representing technological gap (*b*) for the purpose of adding a *catch-up* element as a convergence mechanism (2.8.a). It is therefore considered that the greater the technological gap between the leading country (Germany in our analysis[13]) and other European countries, the higher their economic growth rate, as it is easier to adopt existing technology than to innovate. The including of this type of variable has been proposed in different analyses in an endeavour to control the effect of technological diffusion on less advanced countries or regions. (Benhabib and Spiegel, 1994). The most common way of incorporating the *catch-up* effect consists in using the logarithm of the ratio between a leading country's VAB per effective unit of work and that of other member states, this also being the option chosen in our analysis.

A second possibility consists of including human capital in the model as a determining factor of technological gap. The convergence model therefore includes a term representing interaction between technological gap and the level of human capital, thus enabling us to contrast whether or not more human capital facilitates absorption of technology developed by leading countries[14].

[13] Use of Germany as leading country is justified due to its role as central European economy and having the highest real per capita product throughout the nineties (Esteve and Pallardó, 1997).
[14] The issue of other channels identified in the literature for human capital is an avenue for future research.

$$\frac{\ln y_t - \ln y_{t-T}}{T} = \beta_0 a - \beta_1 \ln y_{t-T} + \beta_2 \ln(S_k) + \beta_3 \ln(S_g) + \beta_4 \ln(S_h) - \\ - \beta_5 \ln(n + g + \delta) + \beta_6 \ln(\tau) + \beta_7 \ln(1-\tau) + \beta_8 b + u_t \quad (2.8.a)$$

$$\frac{\ln y_t - \ln y_{t-T}}{T} = \beta_0 a - \beta_1 \ln y_{t-T} + \beta_2 \ln(S_k) + \beta_3 \ln(S_g) + \beta_4 \ln(S_h) - \\ - \beta_5 \ln(n + g + \delta) + \beta_6 \ln(\tau) + \beta_7 \ln(1-\tau) + \beta_8 \ln(S_h) * b + u_t \quad (2.8.b)$$

Table 3 shows the results of the 2.8.a (Model VI) and 2.8.b (Model VII) equation estimations. Contrasts carried out support the estimation method and the specification chosen in the previous section. Firstly, regarding convergence rate, the two proposed models provide evidence to support the existence of conditional convergence between Member States. This is also maintained in the same range as the specifications presented above, and confirms that the process occurs slowly. It proves that the estimation of this parameter is highly resistant to the variables analysed. The same can be said about the results of public investment, which remains negative and non-significant, and the variables related to private sector investment capacity [S_k and $(1-\tau)$], the interpretation of which was discussed in the previous section.

With respect to the results derived from incorporating *catch-up* technology in this convergence analysis, we are able to initially highlight that in Model VI the technological gap is positive and significant, thus indicating that as European countries come closer to the selected leader, therefore reducing the technological gap, technical progress rates are reduced and economic convergence processes improve. At the same time, the human capital variable is still favourable, thus supporting its important role as a growth-determining factor. In addition, Model VII results suggest that the human capital effect is mainly channelled through its contribution to the spreading and absorption of technology, represented by the term $\ln(S_{hit}) * b$, thereby reinforcing the importance of this variable as a convergence mechanism. Despite the positive results mentioned, a not so encouraging conclusion is also reached: transfer of technology between European states is not happening as easily and quickly as would be expected. Its influence on the convergence rate, although positive, is nevertheless limited, as proven by the fact that the convergence rate does not considerably increase when taking this mechanism into account.

TABLE 3. Convergence Regression, taking Technological gaps ("catch-up") into account. Dependent Variable: $\ln(y_{it} / y_{i,t-1})$. UE-15 (1980-1997).

FIXED EFFECT PANEL DATA MODEL		
	Model VI	**Model VII**
$\ln(y_{i,t-1})$	-0.0105(-1.47)*	-0.017(-2.64)**
$\ln(S_{kit})$	-0.0077(-0.88)	-0.018(-1.78)**
$\ln(S_{git})$	-0.0034(-0.73)	-0.0049(-1.058)
$\ln(S_{hit})$	0.0039(1.45)*	
$\ln(S_{hit})* b$		0.0025(4.29)**
$\ln(n_{it} + g + \delta)$	-0.053(-0.78)	-0.064(-0.95)
$\ln(1-\tau_{it})$	0.018(2.14)**	0.032(3.31)**
B	0.0031(2.87)**	
Test F ind. effects	F(14,233)=7.29	F(14,234)=4.39
Hausman test	$\chi^2(7) = 44.48$	$\chi^2(6) = 15.67$
Wald Sig. Test	331.25 (G.L.=7)	329.101(G.L.=6)
Self-corr. 1st level	0.480	1.211
Self-corr. 2nd level	1.152	1.859

G.L. = degree of freedom. T-statistic in parentheses.
* 90% significance parameter.
** 95% significance parameter.
Number of observations: 270

IV. Summary and conclusions.

The objective of this study is to provide empirical evidence on an issue that has been recently subject to considerable debate: the European convergence process and the effects on such of public policy implemented by Member States since the nineteen eighties. In order to do so, this paper extends the standard outline developed by Mankiw, Romer and Weil (1992), including the role of Government, as proposed by Bajo (2000). This has enabled empirical contrast of the process and the influence of different variables relating to public sector intervention on European economies. The evidence presented should be evaluated in light of the complexity of the issue and the safeguards raised by the neoclassical model[15].

The unit of reference was taken as the 15 members of the European Union, information being available from a consistent database covering the entire period analysed: 1980-1997. In addition, work based on European regions as a unit of reference highlights the so called "*national effect*", which suggests that country regions behave in a very similar way to the nation as a whole (Cuadrado, 2001). The analysis carried out enabled confirmation of certain results that were recently obtained from alternative approaches demonstrating that European Member State convergence is taking place in a slow and discontinuous way. This conclusion contrasts with those reached by well-known cross-national studies (Islam, 1995, Caselli *et al*., 1996, amongst others) that show evidence of rapid convergence across countries and demonstrate the existence of special features in Europe. Our conclusion becomes more apparent given the fact that the technology spreading process is not occurring as quickly and easily as suggested by convergence models.

This study has also enabled us to deal with certain aspects relating to the influence of public policy on economic convergence, our attention being focussed on public investment, education costs and taxation system impact. The controversy on the future of investment programs undertaken by Member States makes evaluation of the results necessary, mainly since the eighties, as it is during this period that they were more important and given greater budget priority.

The reduced convergence rate shown by the estimations carried out suggests that Member States are far from stationary, meaning that public policy in European countries can therefore substantially affect biased situations. In fact, the reduced rate of convergence obtained shows signs of a substantial recovery at the end of the period. These encouraging results support the effectiveness of policies implemented by Member States designed to reduce existing inequality. With respect to how public policy has influenced convergence of European States, the analysis shows that education policy undertaken by Member States has worked best, thus suggesting that active policies focussed on increasing investment in human capital could play an important role in promoting income convergence in Europe.

[15] See Klenow and Rodríguez-Clare (1997).

This paper also analyses the influence of public investment and taxation policy decisions, implemented through tax rates τ. In the case of public investment, the only evidence of a positive effect on growth rates in European countries was observed from 1980-1985. It is possible that the effort required from countries with greater infrastructure deficiencies did involve substantial costs in terms of aggregate growth. Finally, the results obtained demonstrate the importance of an adequately sized public sector that encourages accumulation of private capital, in order to achieve convergence in the European Union.

Referencias bibliográficas:

Álvarez I. and Delgado M.J. (2004) Sector Público y Convergencia Económica en la UE, Proyecto de Investigación del Instituto de Estudios Fiscales, Madrid.

Arellano M. and S. Bond (1998): "Dynamic Panel Data Estimation Using DPD98 for Gauss: A Guide for Users". www.cemfi.es

Arellano M. (2002): Modelling Optimal Instrumental Variables for Dynamic Panel Data Models. Econometric invited lecture, European meeting of the Econometric Society, Venice, August 2002. CEMFI Working Paper N° 0310.

Armstrong H.W. (2002): "European Union Regional Policy: Reconciling the Convergence and Evalutation Evidence", in Cuadrado J.R. and Parellada M. (Eds.): *Regional Convergence in the European Union, Facts, Prospects and Policies*, Springer-Verlag, Berlín.

Bajo O., C. Díaz and D. Montálvez (1999): "Política Fiscal y Crecimiento en las Comunidades Autónomas", *Papeles de Economía Española*, 80, 203-218.

Bajo O. (2000): "A Further Generalization of the Solow Model: The Role of the Public Sector". *Economics Letters*, 68, 79-84.

Barro R. (1990): "Government Spending in a Simple Model of Endogenous Growth". *Journal of Political Economy*, 98(5), S103-S125.

Barro R. and X. Sala-i-Martin (1991): "Convergence across States and Regions". Brookings Papers on Economic Activity, 2, 107-58.

Barro R. (1997): "Determinants of Economic Growth: A cross-country Empirical Study". The MIT Press, Cambridge, MA.

Benhabib J. and Spiegel M.M. (1994): "The role of human capital in economic development: Evidence from agrégate cross-country data", *Journal of Monetary Economics*, 34, 143-173.

Caselli, F. Esquivel G. and Lefort (1996): "Reopening the Convergence Debate: A New Look at Cross-Country Growth", *Journal of Economic Growth*, september.

Cuadrado-Roura J.R. (2001): "Regional Convergence in the European Union: From hipótesis to the actual trends", *The Annals of Regional Science*, 35, 333-356.

De la Fuente A. and Da Rocha J.M. (1996): "Capital humano y Crecimiento: un Panorama de la Evidencia Empírica y algunos resultados para la OCDE", *Moneda y Crédito*, 203, 43-83.

De la Fuente A. (1997): "Fiscal Policy and Growth in the OECD", Documento de Trabajo D-97007, Dirección General de Análisis y Programación Presupuestaria, Ministerio de Economía y Hacienda, Madrid.

De la Fuente A.(2000): "Convergence Across Countries and Regions: Theory and Empirics". CEPR Discussion Paper Series, N° 2465.

De la Fuente A. y Doménech R. (2002): "Human Capital in Growth Regressions: How much Difference does data quality make? An update and Further Results", CEPR Discussion Paper 3587.

Easterly W. and Rebelo S. (1993): "Fiscal Policy and Economic Growth: An empirical investigation", *Journal of Monetary Economics*, 32, 417-458.

Esteve V. and V. Pallardó (1997): "Convergencia Real en la Unión Europea", *Revista de Economía Aplicada*, 5 (14), 25-49.

González Martínez M.I. (2003): "¿Hay convergencia entre los países de la UE?", Papel presentado en las VIII Jornadas de Economía Internacional, Ciudad Real.

González-Páramo J.M. y Martinez D. (2003): "Convergence across Spanish Regions: New Evidence on the Effects of Public Investment", *TheReview of Regional Studies*, 33 (2), 184-205.

Gorostiaga A. (1999): "¿Cómo Afectan el Capital Público y el Capital Humano al Crecimiento?: Un Análisis para las Regiones Españolas en el Marco Neoclásico", *Investigaciones Económicas*, Vol. XXIII (1), 95-114.

Hausman J. (1978): "Specification tests in Econometrics". *Econometrica*, 46, 1251-1271.

Klenow P.J., and Rodríguez-Clare, A. (1997): "The neoclassical revival in growth economics: Has it gone too far?" in Ben Bernanke and Julio Rotenberg, eds., NBER Macroeconomics Annual. Cambridge, MA, pp. 73-102.

Islam N.(1995): "Growth Empirics: A Panel Data Approach". *Quarterly Journal of Economics*, 110, 1127-1170.

Mankiw N.G., D. Romer and D.N.Weil (1992): "A Contribution to the Empirics of Economic Growth". *Quarterly Journal of Economics*, 107, 407-437.

OCDE (1981): *Educational Statistics in OCDE Countries*, París.

OCDE (1992): *Public Educational Expenditure, Costs and Financing: An Analysis of Trends* (1970-1988), París.

OCDE (Several Years): *Education at a glance*, París.

Quah D.T. (1995): "Empirics for Economic Growth and Convergence", *European Economic Review*, 40, 1353-1375.

Quah D.T. (1996): "Twin-Peaks: Growth and Convergence in Models of Distribution Dynamics", *Economic Journal*, 106, july, 1045-1065.

Sapir, A. (2003): “An Agenda for a Growing Europe: Making the EU Economic System Deliver”, Report of an Indpendent High-Level Study Group estabblished on the initiative of the President of the European Commission, chaired by André Sapir.

Sosvilla-Rivero S. and J. Alonso Meseguer (2003): “El efecto del capital humano sobre el crecimiento: ¿Importa el periodo muestral?”, Documento de trabajo 2003-22, FEDEA.

Sturm, J. and J. de Haan (1995): “Is Public Expenditure Really Productive? New Evidence for USA and The Netherlands”, *Economic Modelling*, 12, 60-72.

White H. (1980): “A Heteroskedastic-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedastic”. *Econometrica*, 48, 817-838.