SPEED OF CONVERGENCE AND ECONOMIC POLICY INSTRUMENTS

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ABSTRACT

This article presents an innovative methodology to empirically evaluate the response of the rate of convergence in the neoclassical growth model to changes in the conditional factors. We apply this method to test the sensitivity of the speed of convergence in the EU-15 during the period 1980-2002 to increases in human and public capital.

INTRODUCTION

The relation between private productivity and policy instruments has been a topic of considerable interest in the literature on economic development. A key aspect in the literature on convergence has been the determination of the speed of convergence towards the stationary state. This is determined by its own structural characteristics, among which technology, public policies and the population growth rate are included. Recently, in the debate on convergence, the role played by these conditioning factors has gained prominence – primarily public policy instruments – with the objective of establishing whether part of the observed convergence (if any) can be attributed to these instruments.

In the context of the EU, development and cohesion policies have primarily supported public investment in infrastructures and in education, in addition to support policies for the private sector during the last 20 years. The analyses carried out suggest that these efforts have contributed positively to the process of convergence in productivity in the EU (Salinas *et al.*, 2006). However, recent difficulties encountered in relation to the reduction of disparities in the EU have led to questioning to what extent the speed of convergence could be altered by means of public policies in the European Union. In spite of a clear interest in this matter, few papers have analyzed the sensitivity of the speed of convergence and the majority are theoretical research papers (Turnovsky, 2002, Gokan, 2003, Klump *et al.*, 2008). Unlike these works, in this article a methodological proposal is put forth to estimate the response of the speed of convergence in the EU to changes in economic policy instruments. The analysis proposes two scenarios of convergence: the first one will make it possible to estimate the effect on the speed of convergence arising from changes in the instruments in the EU as a whole; and a second scenario where the effect on the speed of convergence resulting from changes in each one of the countries is considered separately. In this way an attempt will be made to identify not only the potential of various public policies to influence European convergence, but also the role they may play in each country toward achieving convergence in the EU. The proposal develops various scenarios with Matlab that will make it possible to evaluate the sensitivity of the parameter of convergence in the face of variations in the analyzed determining factors, while the other factors remain *ceteris paribus*.

The article is structured as follows: in the next section, the proposal for empirically evaluating the sensibility of the speed of convergence in the face of changes in the conditioning factors is presented. Section 3 describes the data and presents the findings. Finally, in Section 4, the primary conclusions are presented.

CONDITIONAL CONVERGENCE AND SENSITIVITY ANALYSIS

As of the research carried out by Mankiw *et al.* (1992) and Barro y Sala-i-Martin (1995), the neoclassical growth model is commonly used in order to contrast

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conditional convergence. The metodology proposed to examine the response of the rate of convergence consists of the estimation of the convergence equation, recovery of the structural parameters and evaluate the sensibility of the parameter of convergence under specific assumptions about changes in the model. In addition, we simulate those changes - In the estimation of the model we used the routine programming in Matlab available in http://www.spatial-econometrics.com/. The simulations programming in Matlab for this work are available on request- by introducing an extension in the neoclassical growth model. To do so, the fixed effects model provides the basis -. The estimation method is determined by the Matlab programming used to perform the sensitivity analysis. Since GMM approach is suitable to deal with growth models in empirical work, we have also estimated the model with this method and we have reached similar results -, where it is assumed that each explanatory variable has a single coefficient; that is, it has the same effect on the dependent variable, while each individual variable has a different constant which represents the individual effect. Formally, the model to be estimated is the following:

$$\ln\left(\frac{y_{i,t}}{y_{i,t-1}}\right) = \mu + \beta \ln(y_{i,t-1}) + \alpha \ln(x_{i,t}) + \delta\eta_i + u_{i,t} \;;(1)$$

where y_{it} is the annual GDP per employee of $i = 1,\ldots,N$ countries (*N=15*) and for an annual period of $t = 1,\ldots,T$ (*T=22* from 1980 until 2002); $x_{i,t}$ is a vector of $k \times 1$ explanatory variables; η_i is the individual effect; and $u_{i,t}$ is a disturbance term. In this case, the concept of conditioned convergence is analyzed by introducing heterogeneity in the model by means of the introduction of fixed effects and/or the effect of other variables, $x_{i,t}$, assuming that the fixed effects η_i are correlated with them.

The estimation of the model (1) is carried out in deviations with respect to the mean using Ordinary Least Squares (OLS), making it possible to consistently estimate the parameters of the model associated with convergence-β and with the explanatory variables since its consistency will not depend on the specification of fixed effects η_i which have been eliminated with the transformation. This estimation is also equivalent to estimating with the OLS model (1) or the model with the variables transformed by orthogonal deviations, a transformation proposed by Arellano (1988) - Given the model $y_{i,t} = \alpha x_{i,t} + \eta_i + u_{i,t}$ he defines the transformation in orthogonal deviations as: $\tilde{y}_{i,t} = \frac{(T-t-1)}{T-t}\left[y_{i,t} - \frac{1}{(T-t-1)}(y_{i,(t+1)} + \ldots + y_{i,T})\right]$ -.

The extension of the estimated model (1) takes place through the introduction of changes (simulated increases) in exogenous variables of interest. The simulated increases are based on the minimum of the selected variable and they continue increasing with a fixed value, *inc* , until reaching a maximum value that, in this case, has been fixed at 100%, since the variables are taken as the percentage of GVA; but both the minimum value as well as the maximum value could be modified with absolute flexibility. The variations generated with Matlab are then placed in rows, until they complete a column, and they continue being placed in the first row of the next column until it has been completed - as has been mentioned above - and the same process continues likewise until a maximum value of 100% is reached. Therefore, the number of columns will depend on the increase *inc* selected, which in our paper is 5%. Furthermore, the analysis of the variations has been approached in two ways:

a. Evaluating variations of all of the countries at the same time:

$$\Delta(X_t)_{T\times S} = \begin{bmatrix} \Delta_{1,1} = -\min(X_t) & \Delta_{2,1} = \Delta_{1,T} + inc & \ldots & \Delta_{S,1} = \Delta_{S-1,T} + inc \\ \Delta_{1,2} = \Delta_{1,1} + inc & \Delta_{2,2} = \Delta_{2,1} + inc & \vdots & \Delta_{S,2} = \Delta_{S,1} + inc \\ \vdots & \vdots & \ddots & \vdots \\ \Delta_{1T} = \Delta_{1,T-1} + inc & \Delta_{2,T} = \Delta_{2,T-1} + inc & \cdots & \Delta_{S,T} \approx 100\% \end{bmatrix} ;(2)$$

or vectorially:

$$\Delta_j(X_t) = [\Delta_{1,t}(X_t), \Delta_{2,t}(X_t), \ldots, \Delta_{S,t}(X_t)] \;;(3)$$

b. Evaluating variations of a specific country:

$$\Delta^i(x_{i,t})_{T\times S} = \begin{bmatrix} \Delta^i_{1,1} = -\min(x_{i,t}) & \Delta^i_{2,1} = \Delta^i_{1,T} + inc & \ldots & \Delta^i_{S,1} = \Delta^i_{S-1,T} + inc \\ \Delta^i_{1,2} = \Delta^i_{1,1} + inc & \Delta^i_{2,2} = \Delta^i_{1,1} + inc & \vdots & \Delta^i_{S,2} = \Delta^i_{S,1} + inc \\ \vdots & \vdots & \ddots & \vdots \\ \Delta^i_{1,T} = \Delta_{1,T-1} + inc & \Delta^i_{2,T} = \Delta^i_{2,T-1} + inc & \cdots & \Delta^i_{S,T} \approx 100\% \end{bmatrix} ;(4)$$

or vectorially as:

$$\Delta^i_j(x_{i,t}) = [\Delta^i_{1,t}(x_{i,t}), \Delta^i_{2,t}(x_{i,t}), \ldots, \Delta^i_{S,t}(x_{i,t})] \;;(5)$$

Estimations of the model (1) and the vectors of (3) and (5) with the simulated variables will be used in order to carry out the estimations of the effects of specific explanatory variables that could be used as an instrument of economic policy, while the other variables remain *ceteris paribus*, in order to evaluate the effects on convergence gathered in parameter β .

Generically, the effect of introducing the increase of the exogenous variable for all of the countries can be evaluated with the following model:

$$\ln\left(\frac{y_{i,t}}{y_{i,t-1}}\right)-\hat{\alpha}\ln(x_{i,t}^{l\neq m})=\mu+\beta\ln(y_{i,t-1})+\gamma\ln(x_{i,t}^{m}+\Delta_j)+\delta\eta_i+u_{i,t}\ ;(6)$$

where $\Delta_{j,t}$ is a column vector, corresponding to column j which incorporates the gradual increases for $t=1,\ldots,T$ for the explanatory variable $x_{i,t}^{m}$ of each country, to be evaluated of the k exogenous variables ,being $l=1,\ldots,k$. In this way, $j=1,\ldots,S$ estimations of the model (6) are carried out, resulting in different values of the parameter of convergence β.

In particular, the effect of variations on the variable of a specific country can be evaluated, estimating the model:

$$\ln\left(\frac{y_{i,t}}{y_{i,t-1}}\right)-\hat{\alpha}\ln(x_{i,t}^{l\neq m})=\mu+\beta\ln(y_{i,t-1})+\gamma\ln(x_{i,t}^{m}+\Delta_j^{i})+\delta\eta_i+u_{i,t}\ ;(7)$$

where $\Delta_{j,t}^{i}$ is a column vector, corresponding to column j which incorporates the gradual increases for $t=1,\ldots,T$ for the explanatory variable $x_{i,t}^{m}$ of country i, to be evaluated of the k exogenous variables ,being $l=1,\ldots,k$. In this way, $j=1,\ldots,S$ estimations of model (7) will be carried out for the $i=1,\ldots,N$ countries, resulting in different values of the convergence parameter β for each country.

DATA AND RESULTS

The study refers to the EU-15 countries and covers the period 1980-2002. The data used come from World Development Indicators (2005). This database contains information for employment, population, gross value added (GVA) and gross investment expressed in constant terms that are homogenized with purchasing power parity (PPP constant international US$ in the year 2000). Data on public education expenditure is taken from OECD Education at a Glance and expressed in the same terms than the rest of variables.

Table 1: Variables employed

y_{it}	GVA per worker (PPP international dollars in the year 2000)
S_{kit}	Private investment as a percentage of GVA
S_{git}	Public investment as a percentage of GVA
S_{hit}	Public investment in education as a percentage of GVA
g	Rate of exogenous technical change constant and equal to 0.02
n_{it}	Rate of population growth by worker's age
δ	Rate of capital depreciation constant and equal to 0.03

Below the scheme developed in the previous section has been applied to the data on the EU. To do so and in the first place, the equation (1) is estimated by applying the model of fixed effects proposed above - The obtaining of the convergence equation can be consulted in Delgado and Alvarez, (2001) -. The Wald test statistics show that the explanatory variables introduced in the analysis are conjointly significant.

Table 2: Estimation of Convergence Equation with time variable $\ln(y_{it-it}/\ y_{it-it-1})$

Independent variables	**Data panel model with fixed effects**
$\ln(y_{it-1})$ $\ln S_k-\ln(n+g+\delta)$ $\ln S_g-\ln(n+g+\delta)$ $\ln S_h-\ln(n+g+\delta)$	-0.063 (-3.12)** 0.024 (1.67) 0.01 (1.89)* -0.015 (-1.36)
Speed of convergence λ	**0.06**
Test F Individual effects Hausman Test Wald F Test	F(14,309)=4.49 $\chi^2(6)$=7.27 F(6,309)=4.9

*The t-ratios shown in parentheses (). * Significant parameter at 90%, ** at 95%.*

The results of the estimation show a significant, positive speed of convergence that is in line with the most recent papers where it is proven that in recent decades the convergence process in the EU has intensified. The estimations carried out also make it possible to obtain some results as to the influence of the different variables related to public policies developed in European economies: public provision for infrastructures and education. In the first place, a positive and significant influence of public investment on the growth rate of European countries is derived from the analysis carried out. Significant results are not obtained for human capital, although this is a common finding in the literature, given the difficulties that arise when approaching this productive factor.

In order to detect the effect of changes in the economic policy instruments on the sensitivity of the speed of convergence equations, (6) and (7) were estimated. These equations were estimated with Matlab and, in all of the simulations, the values of the previously

obtained parameters in the convergence analysis were used. In this study, the analysis focused precisely on the two primary policies developed within the European Union in recent decades: public investment and education expenditure - The programming used will make it possible to carry out this analysis for any of the conditioning convergence factors proposed in the model -.

- Figure 1 presents the sensitivity function of the speed of convergence with respect to changes in the rate of public investment. The origin represents the result of the estimation of the speed of convergence with data on the EU-15. The graph shows that for the increase interval of the public investment rate, which is approximately between 0 and 30%, a positive response is obtained for the rate of speed, favoring convergence among member states. Another result of interest is that there is a limit to the capacity of public investment to encourage convergence, changing the track record of the beta convergence if public investment continue to growth. These are important findings since it endorses public policies devoted to increasing public infrastructures in European states but also show that we must take into account other factors that can conditioned their capacity to influence in growth (this is the case of private capital) and therefore high increases in public investment could not achieve the expected results.

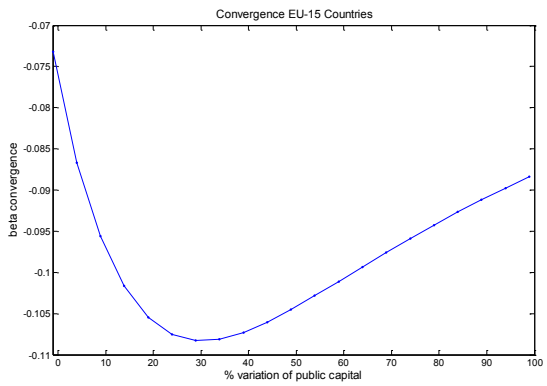

Figure 1: Response of β to changes in the rate of public investment

- Figure 2 represents the same analysis, but focusing in the sensitivity of the speed of convergence with respect to the changes in the public investment rate of each European economy separately. The graphs represent the effect on beta of changes in the rate of public investment in each one of the countries under study. In this case, we observed a negative response for the rate of speed for the increase interval in the rate of public investment between 0 and 5% in each country. From this interval, the increases in the rate of investment will not have response in the rate of convergence. The only exception is Greece, which increases the rate of investment greater than 5% achieve a positive effect on the speed of convergence.

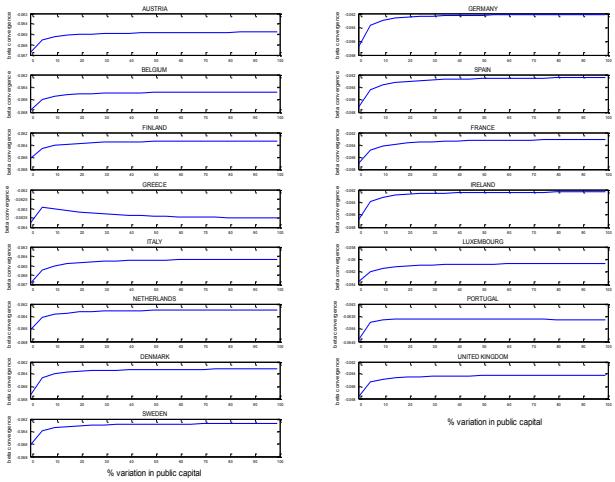

Figure 2: Response of β to changes in the rate of public investment by country

- Figure 3 presents the sensitivity function of the speed of convergence with respect to the changes in the rate of public expenditure on education in the European Union. The graph shows that the increase interval of the rate of expenditure on education that influences the speed of convergence is greater than for the public investment (between 0 and 40%). In this case, we also find a limit to the capacity of public expenditure on education to encourage convergence.

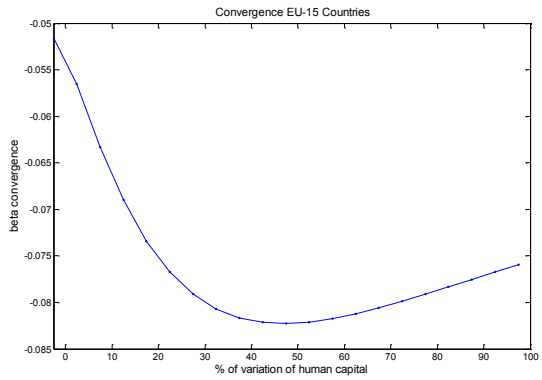

Figure 3: Response of β to changes in the rate of expenditure on education

- Figure 4 presents the analysis of sensitivity by country. The results show that the increase in the rate of expenditure on education in each one of the countries studied separately favors the speed of convergence in all cases, with the only exception of Netherland and Luxembourg. Another aspect to

highlight is that the ability to influence is limited to the range of 0 to 20%, being much lower in the cases of Germany, Spain and France.

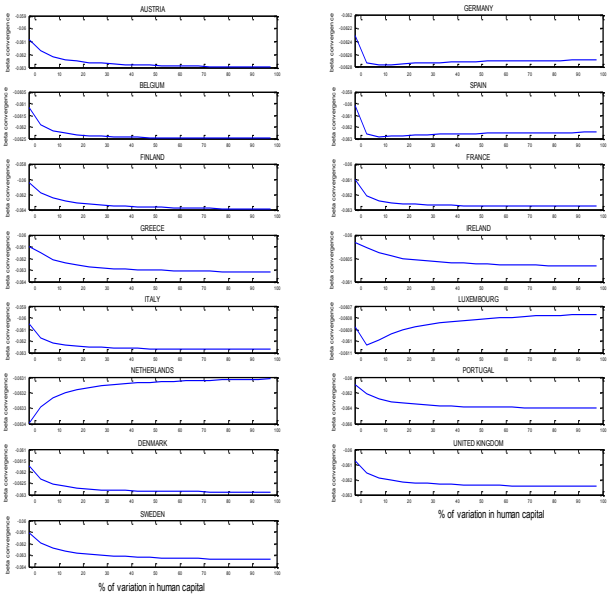

Figure 4: Response of β to changes in the rate of expenditure on education by country

CONCLUSIONS

The methodology proposed in this paper has made it possible to analyze the sensitivity of the speed of convergence with respect to simulated changes in the economic policy instruments, specifically public and human capital. Our result on the speed of convergence of the EU-15 showed that it depends on the increases of public and human capital accumulation, but that, not surprisingly, there is a limit to their ability to favour convergence.

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