The Impact of Structural Funds Policy on European Regions Growth. A Theoretical and Empirical Approach

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Abstract

In this paper we try to estimate the impact of Structural Funds on the growth rates of Objective 1 European regions during the two …rst Programming periods (1989-2000). For that purpose, we develop a "hybrid" model of economic growth that partially endogenizes the rate of technical progress and we test its main implications following a panel data approach. Our results suggest that Structural Funds have positively in‡uenced the growth process of Objective 1 regions although their impact has been much stronger during the …rst Programming period than during the second. The same quantitative di¤erence between the two Programming periods appears on the estimated rates of ¯ convergence and the catching-up e¤ect.

Key words: growth, convergence, catch-up, structural funds
JEL: C23, E62, H50, O47

1 Introduction

The main purpose of European Cohesion policy is to decrease regional disparities within the European Union. In accordance with the Treaty, the Union

works to "promote harmonious development" and aims particularly to "narrow the gap between the development levels of the various regions". This principle implies that Objective 1 is the main priority and more than 2/3 of the budget of the Structural Funds is allocated to helping areas lagging behind in their development. These regions have a GDP per capita below 75% of the Community average and share some identical economic indicators: low level of investment, a higher than average unemployment rate, lack of services for businesses and individuals and poor basic infrastructure, among others.

The Structural Funds do not constitute a single source of …nance within the European Union budget. They have their own speci…c thematic area. The European Regional Development Fund (ERDF) …nances infrastructure, job-creating investments, local development projects and aid for small …rms. The European Social Fund (ESF) aims to prevent and combat unemployment as well as developing human resources and promoting integration into the labour market. The European Agricultural Guidance and Guarantee Fund (EAGGF) supports rural development and improvement of agricultural structures. Although all of them work hand in hand to help the take o¤ of economic activities in these regions by providing them with the basic infrastructure they lack, adapting and raising the level of human resources and encouraging investments in businesses.

Thus far, Structural policies seem to have been designed on the basis of three main assumptions: (i) there exits gaps among EU regions, (ii) Structural policies are able to reduce those gaps, and (iii) regional growth and convergence leads to cohesion. So, it is crucial to evaluate the impact of Structural Funds in order to help the European Commission in the pursuit and planning of future policy to maximize its impact on economic development. In view of the scarcity of studies on this topic, we propose a theoretical model of economic growth as a framework to evaluate empirically the impact of the Structural Funds programs on the Objective 1 European regions growth and convergence processes.

The "growth" approach is particularly appropriate to study the impact of Structural Funds because the Funds Programs are designed to enhance the accumulation of production factors that a¤ect the growth rate of the recipient

economies. From a theoretical perspective, growth models provide di¤erent insights into the e¤ects of public assistance and infrastructures. In the context of a neoclassical Solow growth model, regional funds would …nance a greater level of physical capital, which would correspond to a higher steady state income. However, due to the decreasing marginal product of capital, the investment rate declines towards the steady state income where the stock of capital per person is constant. In this way, a higher investment rate in poorer regions may increase the convergence speed to rich regions, but only transitionally since it not raises the growth rate in the long run (see for example Boscá, Doménech and Taguas (1999)). On the opposite, endogenous growth theories grant public policies an important role in the determination of growth rates in the long run. For instance, Aschauer (1989) and Barro (1990) predict that if public expenditures are considered an input in the production function, then policies …nancing new public infrastructures should increase the marginal product of private capital, hence fostering the capital accumulation and growth. An application of this approach to evaluate the impact of Structural Funds in some European Union countries is contemplated in Pereira (1999). However, there is enough evidence that an important fraction of observed productivity disparities across regions, cannot be traced back to di¤erences in factor stocks, but in total factor productivity (TFP) di¤erentials. Henceforth, they play an important role to complete the account of growth and explain the evolution of disparities across regions (or countries). So, the dynamics of technical e¢ciency is a crucial issue that should be explored within a suitable framework.

In this paper, we develop a "structural hybrid" model of growth which extends the one commonly used in the literature by partially endogenizing the rate of technical progress. Indeed, similar "hybrid" models were used previously in the literature (see Benhabib and Spiegel (1994), de la Fuente (1995), de la Fuente (2002) among others). In our model, we assume that technological progress in an economy evolves as a consequence of two complementary forces:(i) the exogenous mechanism of technological di¤usion across countries or regions, the so-called catch-up e¤ect, and (ii) an endogenous component coming

from public policy. We consider that public expenses in activities that enhance productivity are crucial determinants of the evolution of regional (or countries) TFP levels. In particular, Structural Funds can enhance the TFP in several fronts. The ERDF resources are mainly used to co…nance infrastructure and productive investments leading to the creation or maintenance of jobs. In practise, all development areas are covered: transport, communication technologies, energy, research and innovation, social infrastructure, training, etc. The ESF promotes the return of the unemployed and the incorporation of disadvantaged groups to the labour force, mainly by promoting equal opportunities in accessing the labour market, improving education and training systems, promoting a skilled workforce, boosting human potential in the …eld of research and development, etc. The EAGGF …nances rural development measures such as investments in agricultural holdings (modernization, reduction in production costs, product quality, etc.), aids for the setting up of young farmers and vocational training, processing and marketing of agricultural products, and development of rural areas through the provision of services, encouragement for tourism, etc. All these programs work together trying to provide a fertile ground for technological progress and, consequently for growth and development in European regions.

To check the Cohesion Policy e¤ects, we test the equation derived from the model that relates the rate of growth of income per capita with the initial level of income per capita, the Structural Funds, the catching-up variable and the initial level of TFP. The sample is composed by forty-one Objective 1 European regions during the two …rst Programming periods of Structural Funds which comprehends from 1989 to 2000. We estimate by OLS using a panel data approach, where the use of …xed e¤ects emerges endogenously from the structural speci…cation of the model.

Proceeding in this way, the results of our estimation show a very weak e¤ect of Structural Funds on the Objective 1 regions rates of income growth along the period considered. However, the results are appreciably di¤erent when we divide the sample in the two Programing periods. Our estimation results show

that during the …rst Programming period, Structural Funds have had a clear positive e¤ect in regions growth while their impact has been quite null during the second Programming period. The same di¤erence between periods emerges when we try to measure the presence of a catching-up e¤ect and the speed of convergence among regions. Both phenomena are very signi…cant in the …rst period but not in the second.

The rest of the paper will be organized as follows. Section 2 develops the "hybrid" growth model that partially endogenizes the rate of technical progress. Section 3 brie‡y describes the data set and introduces some descriptive information. Section 4 o¤ers our main empirical results, and …nally Section 5 is devoted to conclusions.

2 The model

In this section we develop a "hybrid" model of economic growth. The term hybrid is used in the sense that technological growth is happening as a consequence of both, exogenous and endogenous forces. The endogenous component comes from public expenses in activities that enhance productivity. In particular we are going to focus on the Structural Funds that the European Union allocates to the less developed European Regions since the aim of Structural Funds is to ameliorate their productive capacity. The exogenous component is the catch-up e¤ect which implies that less developed economies can increase their technology level faster than the more advanced, since it is easier to copy existent technologies than to invent new ones.

Then, the model we will develop extend the one commonly used in the literature in the following way.

Technology is given by a Cobb-Douglas aggregate production function with constant returns to scale.

$$Y_t = K_t^{®}(A_t L_t)^{1 \, i \, ®} = A_t L_t k_t^{®}; \qquad (1)$$

where $k_t = \frac{K_t}{A_t L_t}$ is the capital /labour ratio in e¢ciency units of labour, L_t is the labour force that grows at an exogenous and constant rate n; and A_t is a technological index which evolves over time following the next equation,

$$\dot{A}_t = S_t^{\circ}(A_t f_0)^{1-\circ}; \tag{2}$$

where S represents Structural Funds which are a …xed fraction μ of GDP per capita

$$S_t = \mu \frac{Y_t}{L_t} = \mu A_t k_t^{\circledR}; \tag{3}$$

and $f_0 = \frac{A_{0l}}{A_{0i}}$ is the catch-up factor, which measures the initial technological distance between one region i and the leader l.

Substituting (3) into (2) we get the rate of technological progress as a function of μ, f_0 and k

$$g_t = \frac{\dot{A}_t}{A_t} = \mu^{\circ} k_t^{\circledR \circ} f_0^{1-\circ}: \tag{4}$$

The household sector is the usual one in these models. The representative individual solves the following problem,

$$\max \int_0^{\infty} \frac{C^{1-¾}}{1-¾} L_t e^{-½t} dt$$
$$s.t.: \dot{K} = Y - LC - ±K$$

where C is consumption per capita and the reminder parameters are the standard in the literature.

Solving this problem we obtain the dynamic system of the model which can be written in terms of intensive variables $\left(c = \frac{C}{A};\ k = \frac{K}{AL}\right)$ as

$$\frac{\dot{c}}{c} = \frac{1}{¾}\left(\circledR k_t^{\circledR - 1} - ½ - ± - \frac{\dot{¢}}{¢} - g\right); \tag{5}$$

$$\frac{\dot{k}}{k} = k_t^{\circledR - 1} - \frac{c_t}{k_t} - ± - (n+g): \tag{6}$$

There, we can obtain the steady state values of capital and the rate of growth (denoted with an upper star),

$$k^{\alpha} = \left(\frac{\beta}{\nu + \delta + g}\right)^{\frac{1}{1-\beta}};$$

$$g^{\alpha} = \mu^{\alpha}\left(1-\alpha\right)\left(\frac{\beta}{\nu + \delta + g}\right)^{\frac{\beta\alpha}{1-\beta}}.$$

To explore the transitional dynamics we will use the saddle path solution of the log-linearized system.

$$\hat{k}_t - \hat{k}_0 = (1 - e^{-\lambda t})(\hat{k}^{\alpha} - \hat{k}_0); \tag{7}$$

or

$$\hat{y}_t - \hat{y}_0 = (1 - e^{-\lambda t})(\hat{y}^{\alpha} - \hat{y}_0); \tag{8}$$

where $\hat{k} = \ln k$ and $\hat{y} = \ln y = \beta\hat{k}$.

From the last equation we can derive an expression for the rate of growth of income per capita,

$$\frac{1}{t}\ln\frac{Y_t/L_t}{Y_0/L_0} = g + \frac{1-e^{-\lambda t}}{t}(\hat{y}^{\alpha} - \hat{y}_0). \tag{9}$$

Replacing $\hat{y}_0 = \ln\frac{Y_0}{L_0} - \ln A_0$ and inserting country sub-indexes, this expression becomes

$$\frac{1}{t}\ln\frac{\frac{Y_{it}}{L_{it}}}{\frac{Y_{i0}}{L_{i0}}} = g_i + \frac{1-e^{-\lambda_i t}}{t}\hat{y}_i^{\alpha} + \frac{1-e^{-\lambda_i t}}{t}\ln A_{i0} - \frac{1-e^{-\lambda_i t}}{t}\ln\frac{Y_{i0}}{L_{i0}}. \tag{10}$$

To make use of a panel data approach in our estimation, equation (10) must be rewritten in this way

$$\frac{1}{s}\ln\frac{\frac{Y_{it+s}}{L_{it+s}}}{\frac{Y_{it}}{L_{it}}} = g_i + \frac{1-e^{-\lambda_i s}}{s}\hat{y}_i^{\alpha} + \frac{1-e^{-\lambda_i s}}{s}\ln A_{it} - \frac{1-e^{-\lambda_i s}}{s}\ln\frac{Y_{it}}{L_{it}}; \tag{11}$$

where $\ln A_{it} = \ln A_{i0} + g_i t$ and s is a …xed number of years.

Using the Taylor's Theorem and making some algebra, $\hat{y}_i^*$ and g_i may be expressed in the following way:

$$\hat{y}_i^* = \alpha \hat{k}_i^* + \hat{y}_I - \alpha B_\mu \left(\frac{\mu_i}{\mu_I} - 1 \right) - \alpha B_f (f_i - 1); \tag{12}$$

and

$$g_i = g_I + g_\mu(\mu_I; \gamma_I; f_I)(\mu_i - \mu_I) + g_f(\mu_I; \gamma_I; f_I)(f_i - 1); \tag{13}$$

where B_μ; B_f; g_μ and $g_f > 0$.[1]

Finally, The equation we will estimate is obtained replacing into (11) the expressions (12) and (13) and assuming the same β for all regions

$$\frac{1}{s} \ln \frac{\frac{Y_{is+t}}{L_{is+t}}}{\frac{Y_{it}}{L_{it}}} = c + \phi_1 \left(\frac{\mu_i}{\mu_I} - 1 \right) + \phi_2 (f_i - 1) + \phi_3 t + \phi_4 \left(\frac{\mu_i}{\mu_I} - 1 \right) t + \phi_5 (f_i - 1) t + \phi_6 \ln A_{i0} - \phi_6 \ln \frac{Y_{it}}{L_{it}} + u_{it}; \tag{14}$$

where

$c = g_I + \frac{1 - e^{-\beta s}}{s} q_I$;

$\phi_1 = -g_I(1 - \alpha B_\mu) - \frac{1 - e^{-\beta s}}{s} \alpha B_\mu$;

$\phi_2 = g_I(1 - \gamma - \gamma \alpha B_f) - \frac{1 - e^{-\beta s}}{s} \alpha B_f$;

$\phi_3 = \frac{1 - e^{-\beta s}}{s} g_I$;

$\phi_4 = \frac{1 - e^{-\beta s}}{s} \gamma g_I(1 - \alpha B_\mu)$;

$\phi_5 = \frac{1 - e^{-\beta s}}{s} g_I(1 - \gamma - \gamma \alpha B_f)$;

$\phi_6 = \frac{1 - e^{-\beta s}}{s}$; and

u_{it} is an error term.

This equation is an expression that relates the rate of per capita income growth of each region with the received Structural Funds and the catch-up variable, as well as the initial value of income per capita. It also appears in the

[1] See in the Appendix the corresponding expressions.

equation the initial value of the TFP, A_{i0}; that is unobservable but it is constant and speci…c for each regions. Then, in the estimation it will be captured by a …xed e¤ect.

In the following sections we describe the data and the estimation results.

3 Data description

Our sample is composed by regional data in EU15 including those regions elected as Objective 1 during the two …rst Programming periods of European Structural Funds (1989-93 and 1994-99). We consider a total of forty-one European Regions.[2]

We take the data of GDP per inhabitant in PPP units from the Eurostat New Cronos Regio database. The amount of Structural Funds is taken from the European Commission (1999) Six Periodic Report on the Social and Economic situation of the regions of the Community. We use annual rates of growth of GDP per capita from 1989 to 2000 and we build the catch-up variable as the ratio between the GDP per capita of the European Union and each region at the beginning of each sub-period. To measure the role of Structural Funds on economic growth we consider three di¤erent variables:

(i) the total annual amount of Structural Funds divided by GDP,

(ii) the percentage of Funds each region receives respect to the received Funds by all Objective 1 regions, and

(iii) the total annual amount of Funds.

[2] The sample is composed by the following NUTS 2 regions. For Belgium: Hainaut. For Germany: Bradenburg, Mecklenburg-Vorpommern, Sachsen, Sachsen-Anhaltz. Spain: Galicia, Asturias, Cantabria, Castilla León, Castilla La Mancha, Extremadura, Comunidad Valenciana, Andalucía, Murcia, Ceuta y Melilla, Canarias. For France: Corse, Goudaloupe, Martinique, Frech Guiana, Reunion. For Italy: Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia, Sardegna. For Netherland: Flevoland. For Portugal: Norte, Centro, Lisboa e Vale do Tejo, Alentejo, Algarve, Açores, Madeira. For United Kingdon: Northern Ireland. Greece and Ireland are considered the entire county as regions because their Structural Funds are not dissagregated by NUTS2 level.

All the variables are measured at the beginning of each sub-period. For these three measures we also take the Funds disaggregated in ESF, ERDF, and EAGGF.

The main reason to test the model with three di¤erent measures of Structural Funds is to improve the robustness of the results. We use two "relative" measures: the ratio Funds/GDP, that is the most standard in the literature and measures the weight of Funds with respect to the regions economic size, and the proportion of the total Objective 1 Funds received by each region, which measures the weight of the region in the Structural Funds budget. We also use the "absolute" value of Funds since it could capture an scale e¤ect of the Funds. The size of funds could be relevant itself since we think that the investments with a stronger impact on growth will be probably largely costly, with independence on the size of the region.[3]

We o¤er the variables notation we use in the square room below.

[3] We have also considered the ratio Funds/GDP per capita, since this variable could be closer to the aim of the Structural Funds allocation in favour of backward regions according to their GDP per capita levels. The empirical results are very similar to that obtained using the variable Funds/GDP, so we do not report them to save space.

Growth	annual growth rate (%) of GDP per capita in PPP units
y_0	logarithm of the initial value of GDP per capita in PPP units
catch	catch-up variable
ESFGDP	% of annualized ESF/GDP
ERDFGDP	% of annualized ERDF/GDP
EAGFFGDP	% of annualized EAGGF/GDP
FUDSGDP	% of the sum of the three Funds/GDP
ESFEU	% of the annualized ESF over the ESF received by all regions Objective 1
ERDFEU	% of the annualized ERDF over the ERDF received by all regions Objective 1
EAGGFEU	% of the annualized EAGGF over the EAGGF received by all regions Objective 1
FUNDSEU	% of the sum of Funds over the sum of Funds received by all regions Objective 1
totalESF	total annualized amount of ESF
totalERDF	total annualized amount of ERDF
totalEAGGF	total annualized amount of EAGGF
totalFUNDS	the sum of the tree previous Funds
X:t	variable X multiplied by the tendency

We make the exercise considering three di¤erent sub-samples corresponding to three di¤erent periods. The …rst one takes the period 1989-2000. The second and third are divisions of the whole sample period between the two Programming periods. We do this distinction by two main reasons: (i) obviously, if the Programs are di¤erent in the total amount of resources, their allocation among regions, and in the period of time they are executed then, their e¤ects could also be di¤erent, and (ii) there is the extended rumour among economists that the European regions have su¤ered a slow down in their growth processes in the second period, and the e¤ects of Funds could have been less fruitful. So, we will check whether this expected di¤erence appears on data.

A preliminary view of the data shows that the location of Structural Funds among European regions is inversely correlated with their starting GDP per capita levels as we can see in Figures 1 and 2. Following the Cohesion Policy aim of helping the more backward regions this is what we must expected. However,

there is far from an evidence of a nearly proportionate relationship. Some backward regions received amounts of structural funds per GDP similar to less depressed regions.

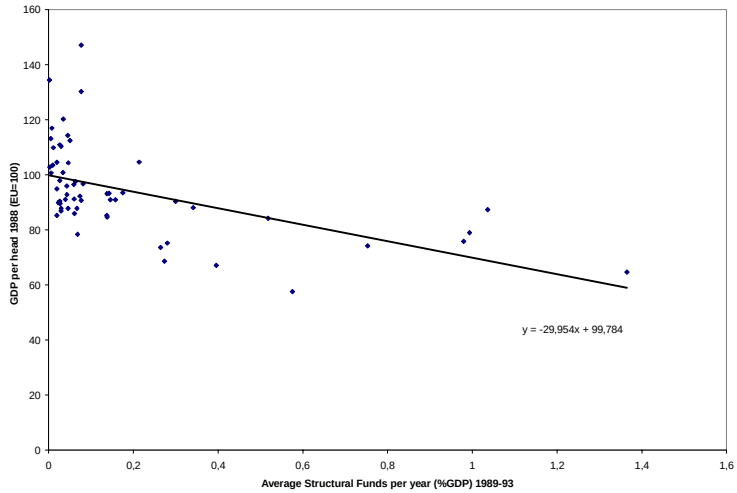

Figure 1: Relationship between the regional GDP per capita in 1988 and the Structural Funds recieved in the First programming period.

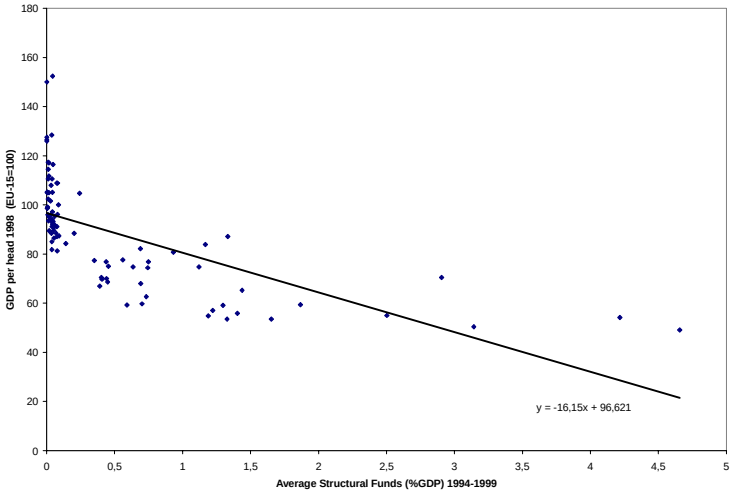

Figure 2: Relationship between the regional GDP per capita in 1993 and the Structural Funds recieved in the Second Programming period.

The regression line slopes make evident that in the …rst Program of Struc-

tural Funds the redistribution is smaller than in the second. Although the …nancial redistribution through the Structural Funds has increased, it still remains very imperfect. Obviously, other criteria di¤erent than per capita GDP are included for determining this allocation, and institutions bargaining implying the national, regional and community authorities surely play a decisive role.

Furthermore, Figure 3 shows that the regional dispersion of regional GDP per capita respect to the EU15 has not decreased progressively during the whole period. We observe that during the …rst Programming period, the standard deviation of the distribution goes down from 1990, but during the second programming period begins going up and recovers part of the initial gains. During the last period of the sample, the tendency seems going to enlarge the disparity of the deviations of regional GDP per capita respect to the EU15. This fact could be in agreement with the extended idea of the downturn of European regions and the smaller impact of Structural Funds in the last years.

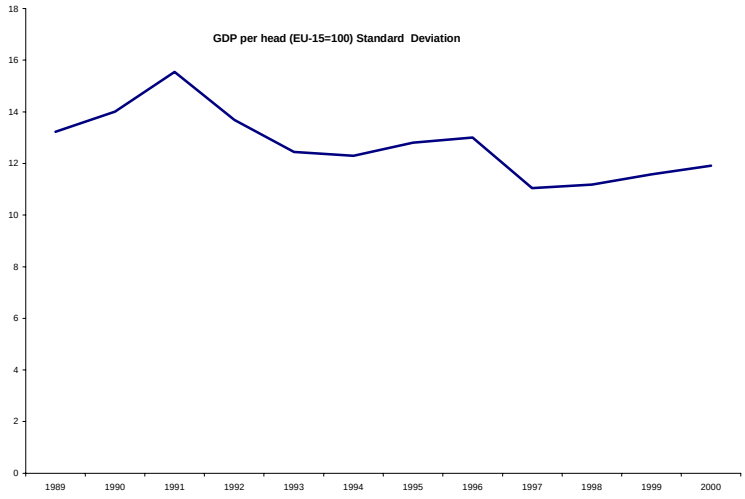

Figure 3: Standard deviation of the regional GDP per capita di¤erences respect to the EU15

Next, we proceed to estimate of the equation (14) of our model and we describe in the following section the empirical results we have obtained.

4 Estimation Results

To analyze the e¤ect of the Structural Funds of European Union on the rates of growth in Objective 1 regions, we estimate equation (14) by OLS following a panel data approach with …xed e¤ects, where the regional dummies capture the value of A_{i0}, which is not observable but is …xed along the period and particular for each region.

We should expect a positive impact of Structural Funds on the growth rates since they are the basis of the EU Cohesion policy. In our equation , the coe¢cient that tell us whether the impact on growth of Structural Funds is positive or negative is $'_4$ since the theoretical model predicts its sign. It includes the funds variable multiplied by the tendency. Tables 1, 2 and 3 show the results of the regressions for the total sample period that comprehends from 1989 to 2000. In Table 1 we observe that the variables of Funds/GDP are not signi…cant, except the ERDF which is positive and signi…cant at 10% of probability. In Table 2, we see that the variables of percentages respect to the total Objective 1 Funds are positive but not signi…cant. However in Table 3, the coe¢cients of Total Funds and their amounts split into ESF, ERDF, EAGGF are positive and signi…cant. [4] This di¤erence on signi…cativity among the three variables could be caused by the high correlation between the initial income variable and the "relative" measures of funds which biases their estimates.[5] However the total amount of funds is much less correlated and their coe¢cients are more e¢ciently estimated.

Nevertheless, our theoretical model does not predict the sign of coe¢cient $'_1$; which includes the variable Funds without multiply by the tendency, since is the sum of two opposite sign components. The positive contribution comes from the expression of g_i^{α} and the negative from $\hat{y}_i^{\alpha}$: In our estimations these signs are negative for all Funds, which in terms of the model implies that the

[4] We include each fund separately in di¤erent regressions because they are very correlated and introducing all together in the same regression causes a multicolinearity problem.

[5] Note that as we saw above, the allocation of Funds (%GDP) among regions is inversely related to the initial value of their GDP per capita.

impact of Funds is larger in the long run level of income, $\hat{y}_i^*$ than in the long run rate of growth, g_i^*:

On the other hand, to test if there is a catch-up phenomenon among Objective 1 regions, we have to look at coe¢cient $'_5$, catch-up multiplied by the tendency, because it measures the catching up e¤ect during the transition to the steady state, when the catching up process is more relevant. We see that it is positive and signi…cant in all regressions of Tables 1, 2 and 3. So, there is a catching up process during this period. This implies that there is an active mechanism of exogenous growth di¤erent from the neoclassical concept of ¯ ¡ convergence, due to the existence of decreasing marginal returns on factors.[6]

Moreover, the initial income variable appears negative and signi…cant in all regressions. This result implies that there also exits ¯ ¡ convergence during the analyzed period.[7] Tables 1, 2 and 3 report the estimations of the speed of convergence, $\hat{\lambda}$: They range from 28.11% to 31.39%, which implies that there is a large tendency among European regions Objective 1 to converge to their respective steady states (the so-called conditional convergence in the literature). Furthermore, it is interesting to test whether all regions tend to a common steady state (what is called absolute convergence).[8] In Table 4 we present the results of a simple exercise to estimate the speed of convergence. In the above section of Table 4 we introduce a constant term as a common element and no other variable that permits to distinguish among di¤erent steady states,

[6] The concep of ¯ ¡ convergence is linked to the neoclassical growth model which predicts that the growth rate of a region is positively related to the distance that separates it from its steady state.

[7] The variables of initial income and catch-up are very correlated by construction. Then, it has not sense to introduce both in the same regression, since the estimation of their coe¢cients would be biased as we will see in Table 4.

[8] The concep of conditional ¯ ¡ convergence provide a measure of the speed at which each region approaches its position in a stationary distribution characterized by regional inequality. Note that if economies have very di¤erent steady states, this concept is compatible with a persistent high degree of inequality among economies. However, absolute ¯ ¡ convergence can be interpreted as a summary indicator of the strength of the tendency towards the reduction of inequalities.

so the estimation of β can be interpreted as an approximation to the speed of absolute convergence. However, in the section below we introduce …xed e¤ects by region. In this case, the estimated value for β could be interpreted as an approximation of the speed of conditional convergence since …xed e¤ects could be capturing di¤erences in the regions steady states. Our results indicate that absolute convergence exits along the period and it is around 9%, much smaller that conditional convergence as we should expect. In the estimation results with …xed e¤ects, when we introduce the variable catch:t the speed of convergence (28.5%) is more than the double than without this variable (12.23%).[9] Moreover, the variable catch:t is not signi…cant in the estimation without …xed e¤ects. This result comes from the fact that the catch-up variable, by de…nition is related to the state of each region, A_{i0},.So, the absence of …xed e¤ects in our estimations leads to a problem of omission of relevant variables which biases the estimation of the initial income coe¢cient. This fact also explains the di¤erences observed among the estimated values of β and the lack of signi…cancy of the catch:t variable in the regression with the constant term.

Regarding to the e¤ects of Structural Funds on the speed of convergence we observe that the estimated values of β reported in Tables 1, 2 and 3 do not di¤er substantially from the 28.5 % obtained in the estimation with …xed e¤ects. They are slightly higher. So, we infer that the convergence process of Objective 1 regions does not seem to be greatly a¤ected by the impact of Structural Funds.[10]

In a previous work by García-Solanes and María-Dolores (2002) they estimate the absolute and conditional β ¡ convergence rate for the EU12 countries over the period 1989-99 and the EU 12 regions over the period 1989-96, using also a panel data approach with annual growth rates. They obtain that absolute β ¡ convergence is 8.6% among countries and 2.5% among regions.[11] However,

[9] The previous convergence literature always predicts that the speed of convergence estimated with …xed e¤ects is larger than without them.

[10] This weak impact of structural Funds on the converge rate of European regions is also obtained by Dall´erba and Le Gallo (2003) using a spatial econometric analysis.

[11] Dall´rba and Le Gallo (2003) obtain a rate of absolute β ¡ convergence of 1.98% for a

conditional convergence rates enlarge to 16.91% for countries and 17.9% for regions. Our results for Objective 1 regions are in the middle. Objective 1 regions converge to the same steady state at an equal rate than countries, but converge to their respective steady states slower than countries. To compare the behavior of Objective 1 regions respect to the overall set of EU12 regions, we remake our exercise for the period 1989-96 and we obtain that the absolute and conditional convergence rates are 13.3% and 22.95% respectively. So, during this period. Objective 1 regions converge among them much faster than the overall set of EU12 regions do.

The results we have shown prove that the exogenous component of growth that the model proposes is active in regions Objective 1 along the period 1989-2000. However, the e¤ect of Structural Funds as an engine of growth has been very weak in the light of our results. Due to the importance of Structural Funds it is necessary to try to accurate more this result and to discern whether the poor e¤ect of Structural Funds on growth is di¤erent between the two Programming periods. Thus, we divide the whole sample period into the two sub-samples corresponding to both Programing periods.

In Tables 5 and 6, we present the results of the estimation of equation (14) for the sample data corresponding to the …rst Structural Funds Program.[12] The …rst di¤erence we observe respect to the previous results is that the adjusted R-squared is larger, reaching values between 0.7 and 0.9 versus to the previous range from 0.5 to 0.7. But a more important result is that all our measures of Structural Funds are positive and signi…cant and the size of their coe¢cients is larger than in the previous estimations. This means that e¤ectively, the …rst Structural Funds Program (1989-1993) had a positive impact on the growth rates of Regions Objective 1. It is also important to emphasize that during this period, the rate of conditional ¯ convergence has been much larger (see the

sample of 145 European regions during the period 1989-99 using a cross-section approach.

[12] The estimation results for the respective variables of Total Funds and the %Funds/UE are the same because the %Funds/UE are a linear transformation of the Total Funds variables. We only report the results corresponding to the %Funds/UE variables.

reported values in Tables 5 and 6).

In Table 7, we remake the exercise of convergence for the …rst Programming period. The results of the estimations with and without …xed e¤ects are qualitatively equivalent to that obtained with the whole sample period. The di¤erence is that the size of the estimated values of β for the First Programing period is much larger: The absolute β convergence rate is around 15%, and the conditional β convergence rate increases to 28.42%, and 46.13% when the variable catch:t is introduced into the regression.

Therefore, we observe that the most important results are quantitatively di¤erent during the …rst Programming period of Structural Funds. Next, we proceed to estimate equation (14) for the sub-sample corresponding to the second Programing period. Tables 8 and 9 show the results. As we expected, they are worse than the former. The adjusted R-squared are very low, between 0.03 and 0.05. This means that the independent variables have a very small explanatory power of the growth rate of regions Objective 1 during this second period. On the one hand, the Structural Funds variables are positive but not signi…cant at all or even negative. On the other hand, the exogenous forces of growth are much less active: the catch:t variable is positive and the coe¢cient of y_0 is negative but not always signi…cant.[13] We present the results of this convergence exercise in Table 10. Notice that in this second period absolute β convergence does not exist. Moreover, the variable y_0 is marginally signi…cant on the estimation with …xed e¤ects and the estimated speed of convergence is much smaller, 3.75%. Only when the variable catch:t is introduced into the regression, the variable y_0 becomes signi…cant and the estimated β enlarges to 9.48%.

As we just saw, our results in terms of the impact on growth of Structural Funds and the convergence rate are very di¤erent on the two sub-sample periods. The …rst Structural Funds Program had a clear positive impact on the growth

[13] The variable catch::t is positive and signi…cant and the initial income variable is negative and also signi…cant in all the estimations with the Funds/GDP per capita variables. The estimated value of β is around the 15%. They are not o¤ered to sace espace.

rates of European regions Objective 1, but the second Program did not have the same impact. There, we can say that the weak e¤ect of Structural Funds observed on the estimations over the whole sample period is explained by the null or even negative e¤ect they have had on the growth rates of Objective 1 regions during the second Programming period. It is also important to note that our bad results for the second sub-sample might be leaded in part by worse data quality, since the last two observations contains projections of the regions GDP per capita instead of the authentic values. Then, there may be a measure errors problem biasing the coe¢cients estimates.

5 Conclusions

The European Union´s Structural Funds are intended to help increase economic and social cohesion between Member States, and constitute an important instrument for reducing regional imbalances and di¤erences in economic development. The Funds´s contributions have grown from 8 billion euros per year in 1989 to 32 billions euros per year in 1999. The EU continues to give a high priority to regional and structural policies for the period 2000-2006 and has allocated a total of 195 billions euros to be placed at the disposal of Structural Funds, a …gure that accounts for approximately one third of total EU budget. Some …fty regions Objective 1, home to 27% of the European population, will receive 135,90 billions euros, more than two thirds of the appropriations of the Structural Funds with the aim that the Structural Funds will support the take o¤ of economic activities in these regions by providing them with the basic infrastructure they lack, whilst adapting and raising the level of trained human resources and encouraging investments in businesses.

However, in the light of our results it is far from clear that the Structural Funds will manage this objective. We just saw that the Structural Funds had a signi…cant impact on the rates of growth of the regions Objective 1 during the …rst Programming period, but we can not say the same for the second Program. Although data are worse for the last period, the results are bad enough to

believe that the growth and convergence processes in regions Objective 1 are downwards and the positive e¤ects of Structural Funds could have disappeared.

Since the resources devoted to the Structural Funds constitute a very important part of the EU budget, and Objective 1 is the main priority of the European Unions´s Cohesion policy, it is necessary to closely follow the impact of Structural Funds on the trajectory of growth and convergence processes in Regions Objective 1, with more and better data. It is equally important to analyze these e¤ects under the adequate theoretical framework. Far from been the only one, in this paper we have proposed a reasonable "hybrid" model of economic growth, which permits to interpret the estimated coe¢cients and then to analyze the e¤ects on growth of the Structural Funds, as well as to distinguish between the trend to convergence (what is called ¯ ¡ convergence) and catching-up e¤ect that are also in‡uencing the growth rates of the regions.

Thus, our empirical evidence on the positive impact of the Structural Funds Programs (during 1989-93 and 1994-99 periods) on the Objective 1 regions rates of growth and speed of convergence is quite mixed, in spite of policymakers generally show excessive optimism in their evaluations. We believe, however, that our empirical results invite to re‡ect about issues as the design of Structural Funds, their allocation, and their ability to reduce gaps among regions within the European Union.

The EU enlargement process to Eastern countries will channel a big share of the Structural Funds budget to these countries with the aim that they contribute to higher economic growth and development. Whatever way, the experience from the two previous Programs of Structural Funds within the current European regions suggest that placing too high expectations on the ability of structural funds to reduce regional disparities could be misplaced.

TABLE 1

Estimation by OLS with …xed e¤ects by region				
y_0	¡ 0:26459 ¡ 12:1	¡ 0:25828 ¡ 12:07	¡ 0:26945 ¡ 12:54	¡ 0:27068 ¡ 11:68
FUNDSGDP	¡ 0:02466 ¡ 3:14			
ESFGDP		¡ 0:12244 ¡ 4:6		
ERDFGDP			¡ 0:04688 ¡ 3:02	
EAGGFGDP				¡ 0:09578 ¡ 2:51
FUNDSGDP:t	0:0007 0:78			
ESFGDP:t		¡ 0:0008 ¡ 0:23		
ERDFGDP:t			0:00289 1:61	
EAGGFGDP:t				0:00599 1:45
catch:t	0:00808 10:1	0:00821 11:68	0:00792 9:81	0:00774 9:6
$\bar{A}$	30.73%	29.88%	31.39%	31.56%
$\bar{R}^2$	0.68077	0.76766	0.68406	0.67177
Temporal dummies are included in all regressions.				
t- statistics are White Heteroskedasticity-consistent.				
Sample period: 1989-2000. Dependent variable: Growth				

TABLE 2

Estimation by OLS with …xed e¤ects by region				
y_0	¡ 0:25614 ¡ 9:16	¡ 0:25195 ¡ 8:35	¡ 0:25816 ¡ 9:46	¡ 0:25965 ¡ 8:47
FUNDSEU	¡ 0:00734 ¡ 3:49			
ESFEU		¡ 0:0087 ¡ 4:11		
ERDFEU			¡ 0:00746 ¡ 3:3923	
EAGGFEU				¡ 0:00326 ¡ 2:91
FUNDSEU:t	5:62E ¡ 05 0:33			
ESFEU:t		1:95E ¡ 05 0:09		
ERDFEU:t			9:95E ¡ 05 0:76	
EAGGFEU:t				0:00021 0:84
catch:t	0:00749 7:62	0:00737 7:52	0:00749 7:55	0:0073 7:26
$\hat{A}$	29.6%	29.03%	29.86%	30.06%
$\bar{R}^2$	0.47399	0.48142	0.47243	0.46495
Temporal dummies are included in all regressions.				
t- statistics are White Heteroskedasticity-consistent.				
Sample period: 1989-2000. Dependent variable: Growth				

TABLE 3

Estimation by OLS with …xed e¤ects by region				
y_0	¡ 0:24822 ¡ 8:85	¡ 0:23559 ¡ 7:72	¡ 0:25252 ¡ 9:12	¡ 0:24508 ¡ 7:62
totalFUNDS	¡ 0:00017 ¡ 4:01			
totalESF		¡ 0:00094 ¡ 6:14		
totalERDF			¡ 0:00022 ¡ 2:7	
totalEAGGF				¡ 0:00063 ¡ 3:68
totalFUNDS:t	8:3E ¡ 06 3:72			
totalESF:t		3:04E ¡ 05 4:03		
totalERDF:t			1:35E ¡ 05 2:74	
totalEAGGF:t				2:33E ¡ 05 1:93
catch:t	0:0081 8:23	0:008 8:49	0:0078 7:76:36	0:008 8:12
$\bar{R}^2$	28.53%	26.86%	29.1%	28.11%
R^2	0.48397	0.50249	0.47207	0.47703
Temporal dummies are included in all regressions.				
t- statistics are White Heteroskedasticity-consistent.				
Sample period: 1989-2000. Dependent variable: Growth				

TABLE 4

Estimation by OLS				
c	0:82134 4:4	¡ 0:05919 ¡ 2:41	0:12149 0:58	0:8735 4:3
y_0	¡ 0:08215 ¡ 4:15		¡ 0:01739 ¡ 0:88	¡ 0:08852 ¡ 4:05
catch		0:074 4:36	0:062 2:75	
catch:t				0:00078 1:22
$\hat{A}$	8.5713.3%			9.27%
$\bar{R}^2$	0.18629	0.22981	0.22896	0.18778
Estimation by OLS with …xed e¤ects by region				
y_0	¡ 0:11516 ¡ 6:03		0:00639 0:45 ¡ 0:7	¡ 0:24794 ¡ 8:86
catch		0:16877 9:52	0:17416 9:07	
catch:t				0:007 7:57
$\hat{A}$	12.23%			28.5%
$\bar{R}^2$	0.27582	0.48992	0.48769	0.43768
t- statistics are White Heteroskedasticity-consistent.				
Sample period: 1989-2000. Dependent variable: Growth				

TABLE 5

Estimation by OLS with …xed e¤ects by region				
y_0	¡ 0:28627 ¡ 8:78	¡ 0:27804 ¡ 10:73	¡ 0:28832 ¡ 8:04	¡ 0:3085 ¡ 16:44
FUNDSGDP	¡ 0:0019 ¡ 0:04			
ESFSEGDP		0:0876 0:61		
ERDFGDP			¡ 0:0165 ¡ 0:15	
EAGGFGDP				¡ 0:1751 ¡ 4:22
FUNDSGDP:t	0:0079 1:73			
ESFGDP:t		0:0354 2:31		
ERDFGDP:t			0:0146 1:51	
EAGGFGDP:t				0:0321 3:76
catch:t	0:0059 3:13	0:0059 3:41	0:0059 2:93	0:0068 5:05
$\hat{A}$	33.72%	32.58%	34.01%	36.89%
$\bar{R}^2$	0.9026	0.9029	0.9021	0.9043
Temporal dummies are included in all regressions.				
t- statistics are White Heteroskedasticity-consistent.				
First Programming period. Dependent variable: Growth				

TABLE 6

Estimation by OLS with …xed e¤ects by region				
y_0	¡ 0:3774 ¡ 7:45	¡ 0:3818 ¡ 7:43	¡ 0:3749 ¡ 7:44	¡ 0:3776 ¡ 7:42
FUNDSEU	0:12316 0			
ESFEU		¡ 0:1262 0		
ERDFEU			¡ 0:4917 0	
EAGGFEU				¡ 3:9382 0
FUNDSEU:t	0:0013 3:67			
ESFEU:t		0:0014 4:51		
ERDFEU:t			0:0013 3:39	
EAGGFEU:t				0:0011 3:49
catch:t	0:0078 3:44	0:0079 3:48	0:0078 3:42	0:008 3:5
$\hat{\alpha}$	47.4%	48.1%	47%	47.4%
$\bar{R}^2$	0.7094	0.7115	0.7073	0.7043
Temporal dummies are included in all regressions.				
t- statistics are White Heteroskedasticity-consistent.				
First Programming period. Dependent variable: Growth				

TABLE 7

Estimation by OLS				
c	1:3625 4:39	¡ 0:0793 ¡ 2:69	¡ 0:2784 ¡ 0:33	1:3415 4:29
y_0	¡ 0:1416 ¡ 4:23		0:0197 0:23	¡ 0:14 ¡ 4:17
catch		0:0896 4:49	0:1009 1:84	
catch:t				0:0013 0:61
$\hat{A}$	15.27%			15.08%
$\bar{R}^2$	0.2653	0.2965	0.2908	0.2619
Estimation by OLS with …xed e¤ects by region				
y_0	¡ 0:2474 ¡ 6:6		¡ 0:1184 ¡ 2:74	¡ 0:3695 ¡ 7:21
catch		0:1943 6:36	0:1186 3:29	
catch:t				0:0074 3:86
$\hat{A}$	28.42%			46.13%
$\bar{R}^2$	0.632	0.6454	0.6599	0.63923
t- statistics are White Heteroskedasticity-consistent.				
First Programming period. Dependent variable: Growth				

TABLE 8

Estimation by OLS with …xed e¤ects by region				
y_0	¡ 0:0422 ¡ 1:31	¡ 0:0491 ¡ 1:54	¡ 0:0433 ¡ 1:33	¡ 0:0485 ¡ 1:52
FUNDSGDP	0:02 2:53			
ESFSEGDP		1:09		
ERDFGDP			0:0376 2:69	
EAGGFGDP				0:067 1:49
FUNDSGDP:t	¡ 0:0029 ¡ 3:19			
ESFGDP:t		¡ 0:0102 ¡ 2:88		
ERDFGDP:t			¡ 0:0049 ¡ 2:98	
EAGGFGDP:t				¡ 0:0118 ¡ 2:78
catch:t	0:0015 0:98	0:0009 0:67	0:002 1:33	0:0013 0:91
$\bar{A}$	4.31%	5.03%	4.42%	4.97%
$\bar{R}^2$	0.0621	0.034	0.0588	0.0352
Temporal dummies are included in all regressions.				
t- statistics are White Heteroskedasticity-consistent.				
Second Programming period. Dependent variable: Growth				

TABLE 9

Estimation by OLS with …xed e¤ects by region				
y_0	¡ 0:0829 ¡ 1:86	¡ 0:0875 ¡ 1:88	¡ 0:0813 ¡ 1:87	¡ 0:0909 ¡ 1:85
FUNDSEU	¡ 0:0007 0			
ESFEU		¡ 0:1787 0		
ERDFEU			¡ 0:0054 0	
EAGGFEU				0:0024 0
FUNDSEU:t	5:68E ¡ 06 0:02			
ESFEU:t		0:00016 0:43		
ERDFEU:t			¡ 7:44E ¡ 05 ¡ 0:35	
EAGGFEU:t				0:00031 0:63
catch:t	0:0034 1:99	0:0033 1:94	0:0035 2:05	0:0032 1:85
$\hat{\sigma}$	8.65%	9.15%	8.47%	9.53%
$\bar{R}^2$	0.0514	0.0531	0.0519	0.0551
Temporal dummies are included in all regressions.				
t- statistics are White Heteroskedasticity-consistent.				
Second Programming period. Dependent variable: Growth				

TABLE 10

Estimation by OLS				
c	0:1954 0:83	0:0238 ¡ 0:82	0:0199 0:08	0:0197 0:82
y_0	¡ 0:0158 ¡ 0:64		0:0004 0:015	¡ 0:016 ¡ 0:64
catch		0:0145 0:7	0:0147 0:63	
catch:t				¡ 3:66E ¡ 05 ¡ 0:05
$\hat{A}$	1.6%			1.6%
$\bar{R}^2$	0.0027	0.0057	-0.0025	-0.0056
Estimation by OLS with …xed e¤ects by region				
y_0	¡ 0:0368 ¡ 1:52		0:0159 0:71	¡ 0:0904 ¡ 2:31
catch		0:112 2:85	0:1287 2:41	
catch:t				0:0031 2:13
$\hat{A}$	3.75%			9.48%
$\bar{R}^2$	0.0611	0.135	0.1272	0.0857
t- statistics are White Heteroskedasticity-consistent.				
Second Programming period. Dependent variable: Growth				

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APPENDIX.

We present below the algebraic derivation of the model.

The household sector solves the following problem:

$$\max \int_0^{\infty} \frac{C^{1-\theta}}{1-\theta} L_t e^{-\rho t} dt$$

$$\text{s.t.: } \dot{K} = Y - LC - \delta K$$

The present value Hamiltonian for this problem is then,

$$H = \frac{C^{1-\theta}}{1-\theta} L_t e^{-\rho t} + \lambda \left[K^{\alpha} (AL)^{1-\alpha} - LC - \delta K \right].$$

Solving the corresponding FOC, we obtain the standard equation for the evolution of consumption over time.

$$\frac{\dot{C}}{C} = \frac{1}{\theta} \left[\alpha k_t^{\alpha-1} - \rho - \delta \right].$$

To explore the system's transitional dynamics, we begin by log-linearizing it. Defining $\hat{c} = \ln c$, and $\hat{k} = \ln k$, the system can be rewritten as

$$\dot{\hat{c}} = \frac{1}{\theta} \left[\alpha e^{\hat{k}(\alpha-1)} - \rho - \delta \right] - \mu \left[f_0^{1-\gamma} e^{\hat{k}\alpha(1-\gamma)} \right] \equiv F(\hat{c}, \hat{k}, \mu, f_0), \qquad (1)$$

$$\dot{\hat{k}} = e^{\hat{k}(\alpha-1)} - e^{\hat{c}-\hat{k}} - (\delta + n) - \mu \left[f_0^{1-\gamma} e^{\hat{k}\alpha(1-\gamma)} \right] \equiv G(\hat{c}, \hat{k}, \mu, f_0). \qquad (2)$$

Equalling both equations to zero and solving the system, we observe that the steady state is a saddle point and the stable root corresponds to the negative eigenvalue. Since the equilibrium trajectory of the model corresponds to the saddle path of the system, the speed of convergence toward the steady state will be determined by this negative eigenvalue. Let us denote by β the convergence coefficient. We will use the saddle path solution of the log-linearized system as an approximation to the equilibrium trajectory of the original system. Thus, the equilibrium path of $\hat{k}$ is given by

$$\hat{k}_t - \hat{k}_0 = (1 - e^{-\beta t})(\hat{k}^* - \hat{k}_0): \qquad (3)$$

Defining $\hat{y} = \ln y$, we have that $\hat{y} = \alpha\hat{k}$ and (3) becomes

$$\hat{y}_t - \hat{y}_0 = (1 - e^{-\beta t})(\hat{y}^* - \hat{y}_0):$$

In terms of income per capita and dividing by t we have

$$\frac{1}{t}\ln\frac{Y_t/L_t}{Y_0/L_0} = g + \frac{1 - e^{-\beta t}}{t}(\hat{y}^* - \hat{y}_0): \qquad (4)$$

Replacing $\hat{y}_0$ by $\ln\frac{Y_0}{L_0} - \ln A_0$; and inserting regions sub-indexes, equation (4) transforms into an equation that can be estimated,

$$\frac{1}{t}\ln\frac{\frac{Y_{it}}{L_{it}}}{\frac{Y_{i0}}{L_{i0}}} = g_i + \frac{1 - e^{-\beta_i t}}{t}\hat{y}_i^* + \frac{1 - e^{-\beta_i t}}{t}\ln A_{i0} - \frac{1 - e^{-\beta_i t}}{t}\ln\frac{Y_{i0}}{L_{i0}}: \qquad (5)$$

Notice that in principle initial technology levels, technical progress rates, convergence coefficients and steady state $\hat{y}$ levels ccould differ across countries. To specify these differences across countries let´s go back to the model.

We start writing equations (1) and (2) in a more compact way,

$$\underline{w} = \acute{A}(w;\varphi); \text{ where } w = (\hat{c};\hat{k}) \text{ and } \varphi = (\mu; f_0):$$

By using the Taylor's Theorem, we approximate $\acute{A}(w;\varphi)$ around the point $(w_l;\varphi_l)$, where φ_l corresponds to the parameter vector of a leader region and w_l is its steady state value of $(\hat{c};\hat{k})$,

$$\underline{w} = \acute{A}(w;\varphi) \;'\; \underline{w} = \acute{A}(w_l;\varphi_l) + \acute{A}_w(w_l;\varphi_l)(w - w_l) + \acute{A}_\varphi(w_l;\varphi_l); \qquad (6)$$

where $\acute{A}(w_l;\raisebox{0.5ex}{»}_l) = 0$; $\acute{A}_w(w_l;\raisebox{0.5ex}{»}_l)$ is the Jacobian matrix and $\acute{A}_{\raisebox{0.5ex}{»}}(w_l;\raisebox{0.5ex}{»}_l)$ is the matrix of partial derivatives with respect to the policy parameters, both evaluated at the leader region.

Setting $\acute{A}(w;\raisebox{0.5ex}{»}) = 0$ in (6), we can obtain an approximation of the steady state value for a given $\raisebox{0.5ex}{»}$, $w^{¤}(\raisebox{0.5ex}{»})$: Then,

$$\underline{w} = 0 \) \acute{A}_w(w_l;\raisebox{0.5ex}{»}_l)(w^{¤} ¡ w_l) + \acute{A}_{\raisebox{0.5ex}{»}}(w_l;\raisebox{0.5ex}{»}_l)(\raisebox{0.5ex}{»} ¡ \raisebox{0.5ex}{»}_l) = 0; \text{ that is}$$

$$w^{¤} ' w_l ¡ [\acute{A}_w(w_l;\raisebox{0.5ex}{»}_l)]^{¡1} \acute{A}_{\raisebox{0.5ex}{»}}(w_l;\raisebox{0.5ex}{»}_l)(\raisebox{0.5ex}{»} ¡ \raisebox{0.5ex}{»}_l);$$

where

$$[\acute{A}_w(w_l;\raisebox{0.5ex}{»}_l)]^{¡1} \acute{A}_{\raisebox{0.5ex}{»}}(w_l;\raisebox{0.5ex}{»}_l) = \begin{bmatrix} F_{\hat{c}} & F_{\hat{k}} \\ G_{\hat{c}} & G_{\hat{k}} \end{bmatrix}^{¡1} \begin{bmatrix} F_{\mu} & F_f \\ G_{\mu} & G_f \end{bmatrix} =$$

$$= ¡ \begin{bmatrix} \bar{} & \bar{} \\ ¡\frac{F_{\mu}}{F_{\hat{k}}} & ¡\frac{F_f}{F_{\hat{k}}} \end{bmatrix}:$$

Hence,

$$\begin{bmatrix} \hat{c}^{¤} \\ \hat{k}^{¤} \end{bmatrix} = \begin{bmatrix} \hat{c}_l \\ \hat{k}_l \end{bmatrix} + \begin{bmatrix} \bar{} & \bar{} \\ ¡\frac{F_{\mu}}{F_{\hat{k}}} & ¡\frac{F_f}{F_{\hat{k}}} \end{bmatrix} \begin{bmatrix} \mu ¡ \mu_l \\ f ¡ f_l \end{bmatrix}:$$

Isolating $\hat{k}^{¤}$; it can be expressed as

$$\hat{k}^{¤} = \hat{k}_l ¡ B_{\mu} \left(\frac{\mu}{\mu_l} ¡ 1 \right) ¡ B_f(f ¡ 1);$$

where $f_l = 1$ and $B_{\mu}; B_f > 0$:[14] Therefore,

$$\hat{y}_i^{¤} = ®\hat{k}_i^{¤} ' q_l ¡ ®B_{\mu} \left(\frac{\mu_i}{\mu_l} ¡ 1 \right) ¡ ®B_f(f_i ¡ 1): \qquad (7)$$

Once $\hat{y}_i^{¤}$ di¤ers across regions depending on policy parameters, we turn back to (6) and rewrite it in terms of deviations of w from its own steady state,

$$(w ¡ w^{¤}) ' \acute{A}_w(w_l;\raisebox{0.5ex}{»}_l)(w ¡ w^{¤} + w^{¤} ¡ w_l) + \acute{A}_{\raisebox{0.5ex}{»}}(w_l;\raisebox{0.5ex}{»}_l)(\raisebox{0.5ex}{»} ¡ \raisebox{0.5ex}{»}_l)$$

$$' \acute{A}_w(w_l;\raisebox{0.5ex}{»}_l)(w ¡ w^{¤}) + (0):$$

[14] The expressions B_{μ}; B_f are given by,

$$¡\frac{F_{\mu}}{F_{\hat{k}}} = \frac{\frac{¡\,°g_l}{\mu_l}}{\frac{1¡®}{¾}(g_l¾ + ½ + ±) + ®g_l} = ¡\frac{B_{\mu}}{\#_l}$$

$$¡\frac{F f}{F_{\hat{k}}} = \frac{¡\,g_l(1¡°)}{\frac{1¡®}{¾}(g_l¾+½+±)+®g_l} = ¡\,B_f$$

Notice that this system has the same coe¢cient matrix $\acute{A}_w(w_l; »_l)$ for all regions and therefore the same eigenvalues. Hence, as a …rst approximation, we can take the same value of $¯$ for all countries.

Finally, we can also rewrite the long run growth rate, g; as a function of the policy parameters in deviations to the leader, taking logarithms in equation (4) of the main text and using a linear approximation around $g_l = g(\mu_l; ¿_l; f_l)$;

$$g_i = g_l + g_\mu(\mu_l; ¿_l; f_l)(\mu_i ¡ \mu_l) + g_f(\mu_l; ¿_l; f_l)(f_i ¡ 1); \qquad (8)$$

where,[15]

$g_\mu = \frac{°g_l}{\mu_l}(1 ¡ ®B_\mu)$;

$g_f = g_l(1 ¡ ° ¡ °®B_f)$:

Now, we can rewrite the growth rate of income per capita in terms of policy variables and the catch-up factor, just substituting expressions (7) and (8) in equation (5).

[15] Taking logarithms in equation (4), we have that: $\ln g^¤ = ° \ln \mu + (1 ¡ °) \ln f_0 + ®° \ln k^¤ = ° \ln \mu + (1 ¡ °) \ln f_0 + °ŷ^¤ =$

$= ° \ln \mu + (1 ¡ °) \ln f_0 + °\left[ŷ_l ¡ ®B_\mu \frac{\mu_i}{\mu_l} ¡ 1 ¡ ®B_f(f_i ¡ 1)\right]$

Taking derivatives in ths espression, we obtain the values of g_μ and g_f: