Convergence, Growth and EU Structural Funds

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The present dissertation entitled

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Declaration

I hereby declare that, except where specific reference is made to the work of others, the contents of this dissertation are original and have not been submitted in whole or in part for consideration for any other degree or qualification in this, or any other university. This dissertation is my own work and contains nothing which is the outcome of work done in collaboration with others, except as specified in the text and Acknowledgements. This dissertation contains more than 8,000 and fewer than 20,000 words excluding appendices, bibliography, tables, figures and equations. Estimations and graphs were produced with STATA/MP 13.0 for Windows (32-bit). All data and calculations results are available upon request.

(Signature)

* Text accordingly adopted from Krishna Kumar's (kks32@cam.ac.uk) LaTeX PhD thesis template for Cambridge University Engineering Department (CUED).

Dedication

This work is dedicated to my brother.

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Abstract

This dissertation examines the topic of convergence in GDP per capita within the European Union and the possibility of the policy of Structural Funds actually contributing to the reduction of economic disparities among the Member States. Starting from the Solow-Swan model of growth and based on literature discussing various growth determinants, it is tested to what extent any catch-up processes correlate to Structural Fund payments and factors such as investment in capital, openness, government effectiveness and distinctions in time periods. Using single-equation estimation techniques on country data over 2000-2013, there appears to be evidence of an overall GDP per capita convergence of at least 2% per year, with the 2008-2009 global crisis period negatively affecting growth and the quality of institutions being important, but the hypothesis of a positive, statistically significant impact of Structural Funds on growth and convergence in the whole of the European Union is rejected.

Keywords: Growth regression; absolute convergence; conditional convergence; convergence speed; beta convergence; sigma convergence; club convergence; growth factors, GDP per capita, panel data, random effects, fixed effects, GMM, Structural Funds, European Union, crisis

JEL classification: C2, F4, O4

Contents

Introduction

Motivation of research

Economic and social disparities within the European Union (EU) are persistent. Official statistics reports show extended inequalities between EU regions regarding Gross Domestic Product per capita (GDP p.c.) and link them to great differences in the standards of living of the European population, which in turn translate into obstacles to overall cohesion as well as to the effectiveness of common policies undertaken by the EU Member States. A deterioriation is expected as the current EU enlargement strategy applies to relatively poorer European nations and several Member States (MS) still deal with the aftermath of the 2009 sovereign debt crisis. With a break-out of Islamist terror attacks at the core of the EU, a continuing refugee crisis through its borders, political unrest in countries neighbouring the Eurozone and a positive Brexit referendum all happening in the last two or three years, any money used to promote integration and prosperity for the European people had better be put to good use and “more” should be done with less.

Almost from the start about 60 years ago, the EU has set aside considerable funds to help implement its so-called regional policy, ie the reduction of development and welfare gaps between the administrative regions of the Union. These are financial tools applied in the course of subsequent programming periods and have come to constitute about 1/3 of the EU Budget each time. Broadly referred to as "Structural Funds" (SF), they serve predefined objectives relevant to growth, economic convergence and social cohesion within EU territories by increasing investments in areas such as job creation, life-long learning, urban infrastructure and environmental quality. Given the afore-presented dire circumstances, it is only natural to ask whether the intended purpose of Structural Funds is fulfilled: do they contribute to growth in the EU? do they help decrease economic inequalities? do they support the European social fabric?

Following relevant literature strands and subject to data availability, what is specifically examined in this dissertation is whether Structural Funds have had a positive effect on convergence and growth for the 28 EU economies in terms of GDP p.c. during years 2000-2013. By employing panel-data econometric techniques and controlling for relevant variables including “institutional quality” and the distinctiveness of time periods, it is studied whether SF payment intensity contributes to increased GDPs p.c. for recipients and greater GDP p.c. increase rates for the “poorer” of them, either as a whole or in groups, before and after the crisis. Overall, while a convergence speed of at least 2% emerges for the total set of observations, the hypothesis of SF contributing positively to growth in the sample is rejected in chosen theory-derived specifications.

A summary on Structural Funds

Structural Funds trace their origins in the Treaty of Rome (1957), the founding act of the European Economic Community, and their evolution corresponds to the subsequent treaties and country accessions that have formed the current European Union (Tables 12 and 13, Appendix). Four Structural Funds have existed historically: the European Social Fund (ESF, 1958), aimed at improving employment opportunities and living standards, the European Agricultural Guidance and Guarantee Fund (EAGGF, 1958), aimed at supporting agriculture, the European Regional Development Fund (ERDF, 1975), in assistance to regions affected by industrial decline, and the Financial Instrument for Fisheries Guidance (FIFG, 1994, or European Fisheries Fund from 2007 onwards), to support the fisheries sector. A fifth Fund, the Cohesion Fund (CF, 1994), finances projects of energy and transport infrastructure.

Structural Funds (SF), in the sense of the four original funds and the Cohesion Fund combined, are governed by certain principles: (a) concentration of financing measures on pre-specified priority objectives, (b) multi-annual programming of funding activities, (c) partnership between the EU authorities and the national, regional or local authorities in each recipient Member State from preparing to implementing structural funding, (d) additionality, meaning that SF are meant to complement rather than substitute national investments, and (e) subsidiarity, meaning that decisions on financing individual projects are meant to be taken at the lowest appropriate administration level. Resources for SF come from customs duties on imports from outside the EU and sugar levies, as well as standard percentages of the harmonized Value-Added Tax (VAT) and the Gross National Income (GNI) of each EU country.

Most recently, SF have been allocated towards the goals of two different completed programmes: period 2000-2006 and period 2007-2013. In 2000-2006, more than 213 billion Euros were directed to the development and structural adjustment of regions lagging behind (Objective 1), the economic and social conversion of zones facing structural difficulties (Objective 2) and the development of human resources through training and employment opportunities (Objective 3) as well as separate community initiatives and innovation & technical assistance. In 2007-2013, respectively, about 345 billion Euros were invested in assisting convergence via improvements in growth and employment conditions (Objective 1), enhancing regional competitiveness & employment with an emphasis on innovation, entrepreneurship, environmental protection and preparations for economic and social changes (Objective 2) and encouraging territorial cooperation in fields including, inter alia, culture promotion and networking between Small-and-Medium Enterprises (Objective 3), as well as technical assistance.

Objectives between periods may overlap but they complement each other within each period in a general framework of Cohesion Policy for strengthening the unity of the European Union (Table 1). It can be argued, though, that not all SF-based projects contribute equally (or any at all) to the increase and equalisation of GDP per capita across regions. Evaluating the effectiveness of SF in this respect needs to take into account both the type of the fund and the objective to be served in every occasion.

'00-'06 Goals	%	Funds		'07-'13 Goals	%	Funds
Objective 1	63.8	ERDF, ESF, FIFG, EAGGF (parts)	:	Objective 1*	81.5	ERDF, ESF,
+ Cohesion	8.5	CF	:			CF
Objective 2	10.5	ERDF, ESF	:	Objective 2*	16.0	ERDF,
+ Objective 3	11.3	ESF	:			ESF
3 Community Initiatives	4.3	ERDF, ESF	:	Objective 3*	2.5	ERDF
1 Comm. Init. + Other	1.0	EAGGF (parts), FIFG		* including technical assistance etc		

Table 1: Cohesion Policy architecture, from 2000-2006 to 2007-2013: goals and funding by relative amount and type (European Commission, 2007; INFORSE, 20XX). Detailed data on payments can be found here: (a) ec.europa.eu/budget/library /biblio /documents /2014 /Internet%20tables%202000-2014.xls , (b) ec.europa.eu /regional_policy /sources/docgener /evaluation/data /financial_execution_by_period_fund_country.xls.

Online-published accounts provide a more detailed and complicated view of how the various Funds have been allocated to Objectives and periods. To facilitate comparisons from now on, Objective 1 will refer simultaneously to the Objective 1 and Cohesion goals both for 2000-2006 and 2000-2007, Objective 2 will refer to the 2000-2006 Objectives 2 & 3 and the 2007-2013 Objective 2, and Objective 3 will refer to the ERDF part of the Community initiatives in 2000-2006 (Interreg III initiative, EUR4875m; Urban II, EUR700m) and to the 2007-2013 Objective 3. Data on innovation and technical assistance financed by SF in general are reported separately from these Objectives despite what is shown in Table 1 and will not skew calculations. Any overlapping, especially where community initiatives are involved, is quite small; for example, the Urban II 2000-2006 initiative, incorporated in Objectives 1 & 2 in 2007-2013, accounts for about 10% of the ERDF funding of Objective 3 in 2000-2006 (European Commission, 2007; INFORSE, 20XX - see Appendix: Additional Readings).

Stylised Facts on EU economies

It is observed that growth in terms of GDP per capita (p.c.) has been the general tendency for EU Member States during years 2000-2013 (Figures 1 and 2). While the global financial and EU sovereign debt crises of 2008-2010 interrupted economic activity for some time, several countries have regained pace, though not necessarily returning to previous highs. Average GDP p.c. in the EU-28 rises from ~EUR18k in 2000 to ~EUR22k in 2007, falling below EUR21k in 2009 and re-increasing thereafter. The performance of Luxembourg shifts the mean upwards by ~10% to EUR20k (measuring GDP in volumes and not accounting for international purchasing power differences), and growth patterns for the rest of the countries seem to cluster in groups. The Balkans and Baltics rather lie in the lower tier of the GDP p.c. "distribution" (up to ~EUR12k), Southern states are in the middle (up to ~EUR25k) and Western and Central Europe dominate the top (up to ~EUR40k, LU excluded); variation is even more intense across individual nations (Figure 12, Appendix) and regions (Eurostat, 2015).

Naturally, GDP p.c. growth rates (as percentage changes over the previous year), the slopes of the corresponding GDP p.c. evolution lines, reflect growth particularities. Pre-crisis, the EU-28 average growth rate has been positive and around 3.5%, increasing from 2% to over 4% roughly in 2001-2006 (Figure 3). A large fall to near zero is seen in 2007-2008, ending in a surprising -6% rate in 2009 and followed by a recovery to the 2008 level just one year later. However, with European economies mostly stabilising post-crisis, average growth since 2010 has not exceeded 2%. Individual growth rates also cluster in country groups, mostly based on their range of variation in time (Figure 4; Figure 13 in Appendix): the Baltics are in unison, the Balkans behave in similar fashion, the South exhibits the most negative rates during the early '10s, the West and part of the Centre show the least fluctuation.

Future GDP p.c. levels are highly correlated with their past selves at first sight (Figure 5) and Spearman's rho is calculated at 0.98 with a p-value less than 1% for the 2000-2013 GDP p.c. pairs in the EU-28 sample. However, looking closer at the data, there are hints that the poorest do seem to grow faster on average than the richest in the European Union, with higher mean growth rates (especially ignoring the crises; see Fig. 4), and higher-sloped "aggregate" 2013 GDPs pc. against their corresponding interval of 2000 GDP p.c. (Fig. 5). Economists have alluded to this by commenting, for example, on how quickly Central and Eastern Europe (CEE) countries, the least-grown and newest EU members, have converged to older EU counterparts and have recuperated after 2009 (Leitner & Römisch, 2015; European Commission, 2015; EIB, 2016). Although what really explains growth idiosyncracies in the EU appears to be a mix of initial, domestic policy and external conditions (Balcerowicz et al., 2013, Leitner & Römisch, 2015), worse-off EU economies are still likely to be moving nearer better-off economies over longer periods as growth rates seem to be negatively related to initial outputs (Figure 6). Thus, convergence is an actual possibility and the use of Structural Funds could be prolonged if these are found to have had a beneficial role in it.

Figure 1: Average GDP per capita (thousand EUR, chain-linked volumes, base year 2005) for the 28 EU MS, Luxemburg included (line) or not (dots); 1999 HR, LU, MT values missing henceforth. Data: Eurostat, nama_gdp_k & nama_10_pe tables, 2016.

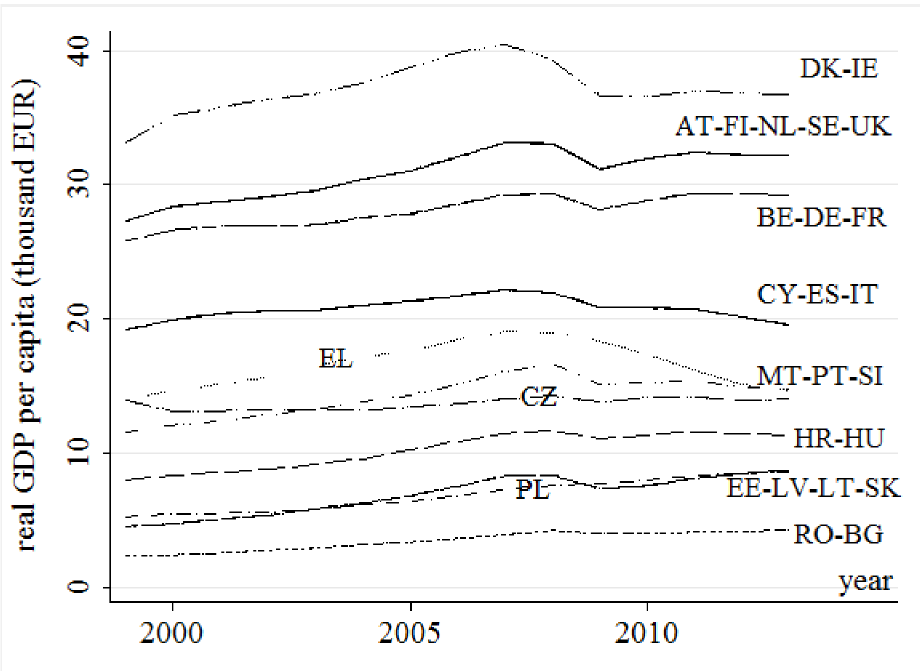

Figure 2: Average GDP per capita (thousand EUR, chain-linked volumes, base year 2005) per group of the 28 countries comprising the European Union in 2013 excluding Luxemburg. Data: Eurostat, nama_gdp_k & nama_10_pe tables, 2016.

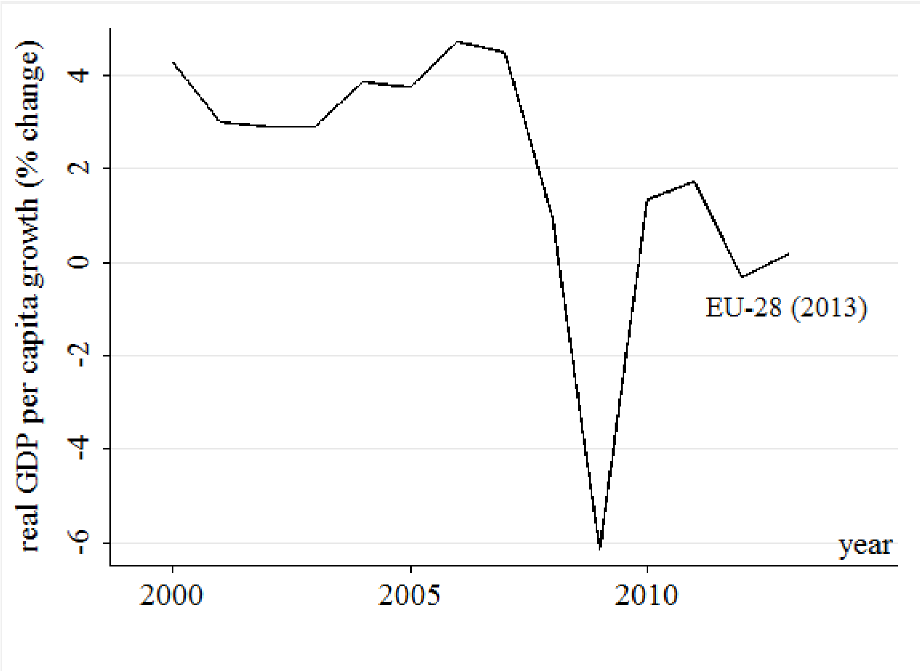

Figure 3: Average GDP p.c. growth rate (percentage change over the previous year; GDP in chain-linked volumes, base year 2005), for the 28 EU countries. Data: Eurostat, nama_gdp_k & nama_10_pe tables, 2016.

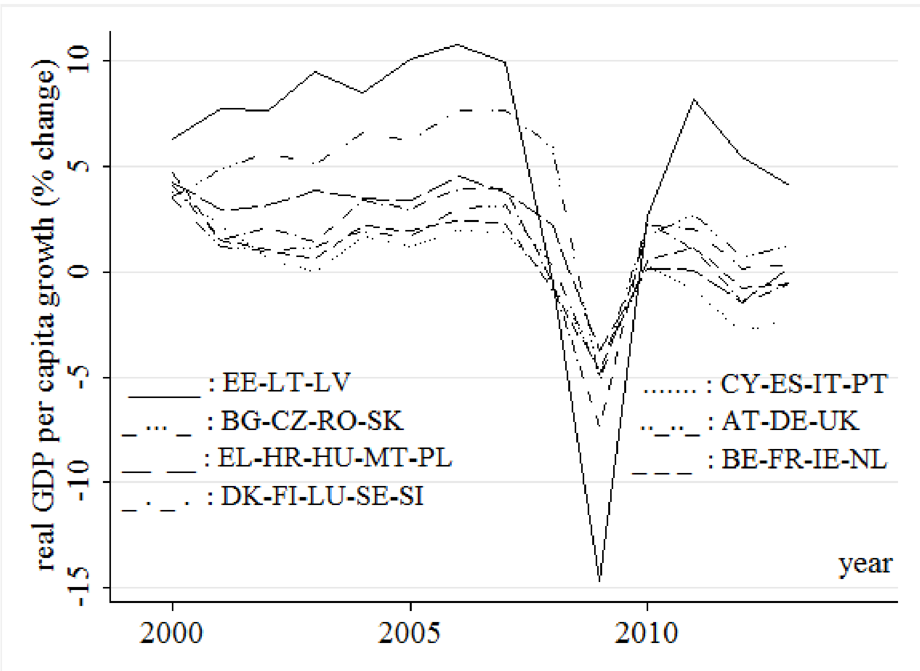

Figure 4: Average GDP p.c. growth rate for the 28 MS of the EU in groups, 2000-2013. Data: Eurostat, nama_gdp_k & nama_10_pe tables, 2016.

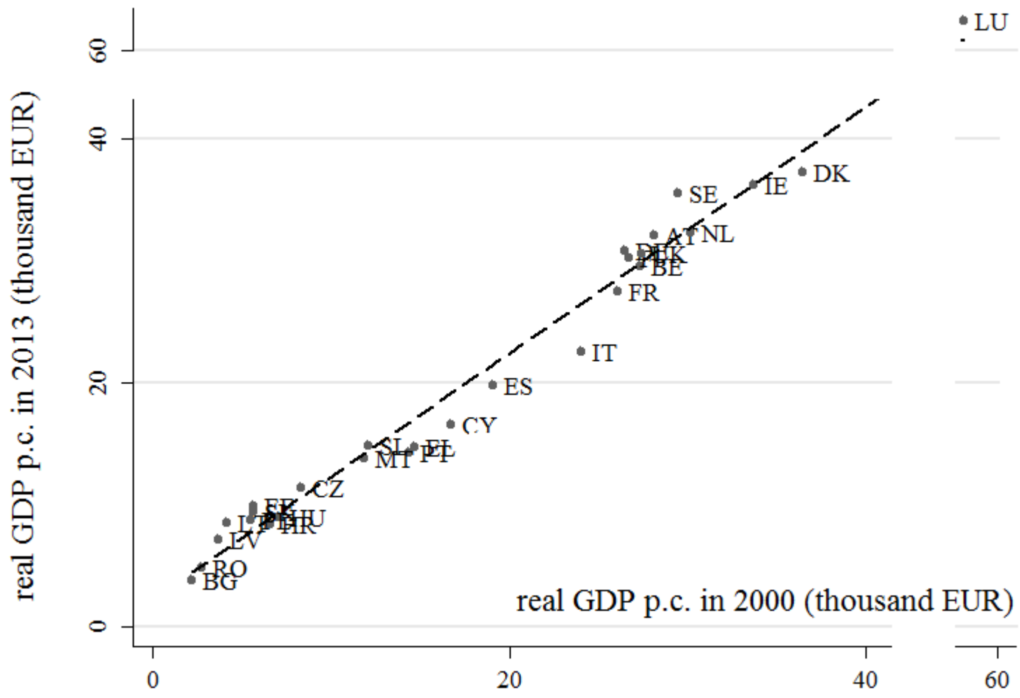

Figure 5: GDP per capita by EU MS: 2000 versus 2013, plus fitted line for the set of points. Data: Eurostat, nama_gdp_k & nama_10_pe tables, 2016.

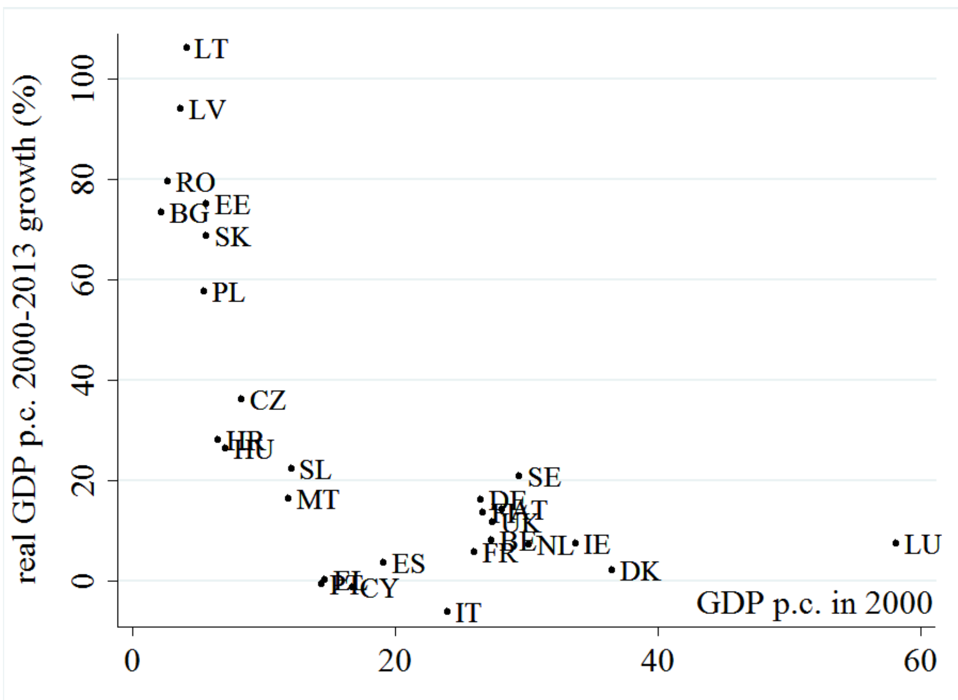

Figure 6: Convergence in the EU? GDP p.c. 2000-2013 growth rate against 2000 level. The negative connection between positive growth rates and initial levels of GDP p.c. implies a catching-up of poorer to richer economies. Data: Eurostat, nama_gdp_k & nama_10_pe tables, 2016.

Theory and Literature

On growth and convergence in brief

How is the GDP increase observed in the previous section explained and why should we expect the inequalities between states regarding GDP per capita to fade? Although the economics of growth and convergence in general are largely an empirical topic, based on factual observations of the real world rather than abstract causal relationships, a series of theoretical models have been developed over the years to account for research findings and to justify expectations for the effects of economic policies such as the use of Structural Funds mentioned earlier (Ederveen et al., 2002).

The usual starting point for any discussion of the matter is the neo-classical Solow-Swan model (1956), which suggests that economies grow through a process of "capital accumulation": what remains from previous production efforts, after accounting for what has been consumed already and adjusting for eventual losses or gains, is invested as capital (equipment, broadly) in new efforts to produce. This process, however, is only temporary, as returns to capital are diminishing, ie. the more capital is used in production, the harder it is to have the same added benefits from its use. Assuming constant exogenous rates of savings, capital depreciation and population growth, economies finally reach steady states, where new investments only suffice to counteract equipment deterioriation and the magnifying needs of an increasing fully-employed labour force; then output per worker may only grow with exogenous technological progress. Thus, a double concept of convergence emerges here: ceteris paribus, an economy accumulating capital shall reach its steady state regardless of its initial capital endowments; further, poor, capital-scarce economies tend to catch up with richer ones regarding their output per worker as long as they all share similar features defining their production regimes and their steady states, eg. investment and fertility rates.

Due to its convenient mathematical properties and its consequent prediction of convergence in terms of per capita output, the Solow Swan model, itself an extension of the Harrod-Domar growth model (1936 and 1949), has inspired several other neoclassical extensions (eg. Mankiw-Romer-Weil, 1992) and modifications (eg. Ramsey-Cass-Koopmans, 1928 and 1965), under which said convergence is possible. It does not explain, however, what can cause the change in technology which is necessary, all else equal, for advancing economic steady states. New-growth models compensate for this by trying to present technological progress as a result of endogenous changes. New-growth models generally assume that returns to scale are not constant and economic divergence is most likely the rule. Indeed, capital may be human (eg. Arrow, 1962;

Romer, 1986; Lucas, 1988), public (Barro, 1990) or technological (Schumpeter, 1934; Grossman-Helpman, 1991) as well as physical, and can be accumulated at decreasing costs, setting the ground for inequalities among differently-endowed economies. Education, public infrastructure, R&D and innovations exhibit positive externalities and give richer countries a production edge.

The technology gap theory (Fagerberg, 1987), in its own right, suggests that, as long as less advanced economies succesfully adopt foreign know-how at negligible costs, they can increase their growth potential and reach more advanced economies. Of course, this is in line with convergence predictions from neo-classical models and modified new-growth models based on non-increasing capital returns. Economic geography and regional economics, on the other hand, provide mixed results on convergence possibilities. For example, Williamson (1965) predicts convergence after overconcentration of economic activity at certain growth poles; Dixon and Thirlwall (1975), based on works by Verdoorn (1949), Myrdal (1956) and Kaldor (1970), claim that export-led growth can account for persistent economic differences; Krugman (1991) points to the emergence of densely-populated commercial poles under scale economies for trade; Braunerhjelm et al. (2000) study the balance of local comparative advantages, agglomeration effects and labour mobility in a European context.

None of the growth models appearing so far in economics explains everything, so choosing one over the rest in order to decide whether to anticipate convergence or not is not straightforward. Rather, it can be argued that both for mathematical and historical reasons, including early success in fitting data, the Solow-Swan model has prevailed in inspiring empirical research on the tendency of economic disparities to lessen in selected samples. Other theories mostly contribute by suggesting conditions under which divergence is less probable in practice.

Predicting convergence: the Solow-Swan model of growth

According to the Solow-Swan model and in standard economic terminology, assuming a single-sector production function F of a homogeneous good Y from "ingredients" K and L in a closed economy without government spending or technological change, the following relations hold:

$$Y(t) = F[K(t), L(t)] \qquad \textit{output production} \qquad (1)$$

$$Y(t) = C(t) + I(t) \qquad \textit{output - expenditure approach} \qquad (2)$$

$$Y(t) = C(t) + S(t) \qquad \textit{output - income approach} \qquad (3)$$

where t denotes time, K is physical capital and L is labour as inputs, C is consumption, I is investment, S is savings and the specific form of F implies the actual technology, ie the way inputs are combined to yield what the economy is able to make.

Equating total income with total expenditure in the economy, isolating investment and differentiating with respect to time, a simple process $\dot{K} \equiv \partial K/\partial t$ of *capital accumulation* is derived:

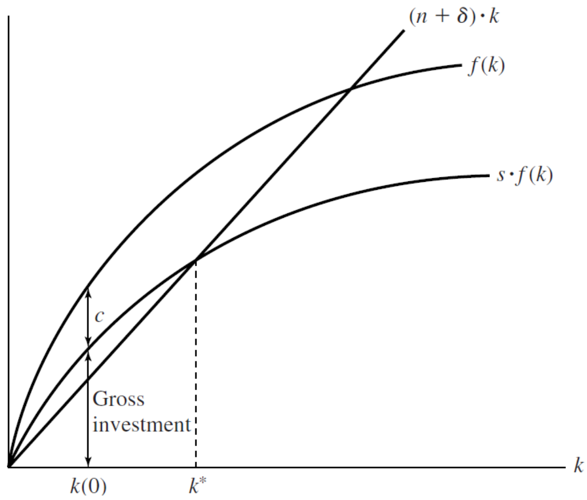

Figure 7: The Solow–Swan model. Gross investment, s·f(k), is proportional to the production function, f(k), and meets effective depreciation, (n+δ)·k, at point k* (steady state). The vertical distance between f(k) and s·f(k) corresponds to per capita consumption. Source: Barro and Sala-i-Martin, 2004.

$$I = S \qquad \text{with} \quad S = sY, \quad 0 \leq s \leq 1 \tag{4}$$
$$\dot{K} \equiv I - \delta \cdot K \qquad \text{with} \quad 0 \leq \delta \leq 1 \tag{5}$$
$$\dot{K} = s \cdot Y - \delta \cdot K \qquad \textit{(capital accumulation process)} \tag{6}$$

where the t index is dropped while δ is the depreciation rate and s is the savings rate in the economy, both constant and exogenous (ie. "given"). Essentially, any output in excess of consumption is used to increase capital stock against eventual losses.

Meanwhile, function F is neoclassical, satisfying a series of properties:

$$F(\lambda K, \lambda L) = \lambda \cdot F(K, L), \qquad \forall \lambda > 0 \qquad \textit{constant returns to scale} \tag{7}$$
$$\partial F/\partial K > 0, \qquad \partial F/\partial L > 0 \qquad \textit{positive marginal products} \tag{8}$$
$$\partial^2 F/\partial K^2 > 0, \qquad \partial^2 F/\partial L^2 > 0 \qquad \textit{diminishing marg. returns} \tag{9}$$
$$\lim_{X\to 0} F_X = \infty, \qquad \lim_{X\to\infty} F_X = 0, \quad X \in \{K, L\} \qquad \textit{Inada conditions} \tag{10}$$

Since constant returns to scale apply, assuming full employment and identifying labour with population, capital accumulation can be expressed in per capita terms as:

$$\dot{k} \equiv \partial(K/L)/\partial t = \dot{K}/L - n \cdot k = s \cdot f(k) - (n + \delta) \cdot k \tag{11}$$

where n is the population growth rate (n $\equiv \dot{L}/L$) and lower-case notation implies division by L; rate n is also constant and exogenous. This equation depends only on k.

Because of diminishing marginal returns, at some point $\dot{k}$ becomes 0 and a steady state is reached, where growth ceases and k and y remain constant at values k^* and y^*, respectively (Figure 7). Instantaneous shifts in s, n or δ will affect k^* and y^* permanently but growth will simply adjust to the change. For example, if the government motivates households to save at a higher rate, savings per capita will exceed effective depreciation at the old k^*, encouraging investment up to a new steady state,

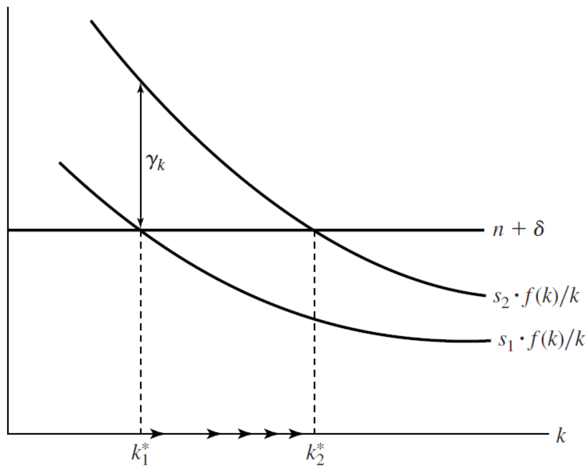

Figure 8: Beginning at steady-state k_1^*, increasing s from s_1 to s_2 moves the investment curve $s \cdot f(k)/k$ to the right, rendering the growth rate of k, γ_k, positive and pushing the economy to a new steady state at $k_2^* > k_1^*$. Source: Barro and Sala-i-Martin, 2004.

where savings are just enough to cover for depreciated capital (Figure 8). In an analogous manner, a discouragement to a lower steady state will occur if fertility is raised and population grows faster, but decline will stop in the end.

The actual mechanism of the adjustment of growth is derived below:

$$\dot{k}/k = s \cdot f(k)/k - (n + \delta) \tag{12}$$

$$\dot{y}/y = f'(k) \cdot \dot{k}/f(k) = [k \cdot f'(k)/f(k)] \cdot (\dot{k}/k) \tag{13}$$

$$\dot{y}/y = s \cdot f'(k) - (n + \delta) \cdot [k \cdot f'(k)/f(k)] \tag{14}$$

$$\frac{\partial(\dot{y}/y)}{\partial k} = \left[\frac{f''(k) \cdot k}{f(k)}\right] \cdot \frac{\dot{k}}{k} - \frac{(n + \delta) \cdot f'(k)}{f(k)} \cdot \left[1 - \frac{k \cdot f'(k)}{f(k)}\right], \quad 0 \leq \frac{k \cdot f'(k)}{f(k)} \leq 1 \tag{15}$$

As shown, $\dot{y}/y$ depends negatively on $\dot{k}/k$ if $\dot{k}/k$ is positive or when the economy is close enough to its steady state; interdependence is always negative for a Cobb-Douglas production function (see Barro and Sala-i-Martin, 2004, for details). Thinking of $\dot{y}/y$ as a growth rate, it follows from Equation 15 that, the less endowed with K an economy is, the faster it grows towards its steady state. This implies a catch-up effect for economies with the same parameters: "poorer" countries in terms of k grow faster than "richer" counterparts and eventually converge to them (Figure 9).

Testing for convergence: from theory to practice

In the context of the previous analysis and using a Cobb-Douglas production function, it can be shown (Barro and Sala-i-Martin, 1990) that the connection between initial, steady-state and subsequent per capita outputs is given by:

$$ln(y_t) = ln(y_0) \cdot e^{-bt} + ln(y^*) \cdot (1 - e^{-bt}), \quad \text{or} \tag{16}$$

$$ln(y_t) - ln(y_0) = ln(y_t/y_0) = -ln(y_0/y^*) \cdot (1 - e^{-bt}) \tag{17}$$

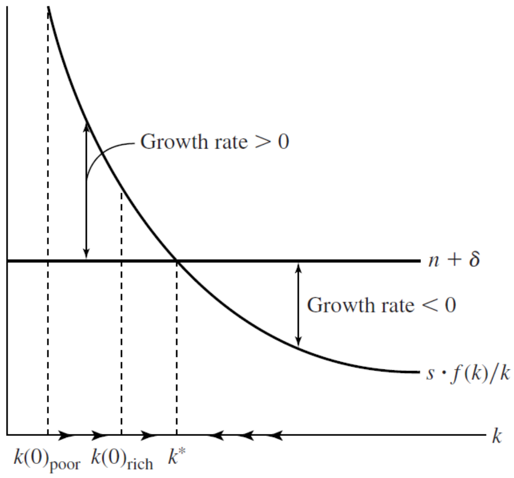

Figure 9: Dynamics of the Solow–Swan model. Per capita K tends to increase towards k^* if k < k^* and decrease to it if k > k^*. Greater endowments in k are linked to lower growth potential for k (and y). Source: Barro and Sala-i-Martin, 2004.

where b is a subunitary positive constant depending on the parameters of the underlying economic model and $ln(y_t/y_0)/T$ represents on average the growth rate of y, $\dot{y}/y$, as long as the Taylor approximation $ln(1 + x) \approx x$ applies (x ≤ 1). Time t does not enter the equations as a variable if growth is examined over equal time intervals.

Empirical tests of the convergence hypothesis are hence primarily based on econometric estimations of the *log-linearized growth regressions*:

$$\frac{1}{T} \cdot ln\left(\frac{y_{t+T}}{y_t}\right) = \alpha + \beta \cdot ln(y_t) + \Sigma_{j=1}^{J} w_j \cdot x_j + u_{t+T}, \quad \text{or, equivalently,} \tag{18}$$

$$ln(y_{t+1}) - ln(y_t) = \alpha + \beta \cdot ln(y_t) + \Sigma_{j=1}^{J} w_j \cdot x_j + u_{t+1} \tag{19}$$

where x_j are J control variables accounting for possible different steady states across observed units (see Appendix for some insight) and w_j are their corresponding weights, while disturbance terms u_t pick up temporary shocks to the production process. It is expected that $-1 \leq \beta \leq 0$. This is the concept of *beta-convergence*: economies "poorer" in per capita terms grow at greater rates than their "richer" counterparts. If $w_j = 0 \ \forall j$, this convergence is said to be *absolute*, otherwise it is *conditional*. Evidence on absolute convergence receives mixed reviews, while evidence on conditional convergence tends to be more encouraging (Durlauf and Quah (1998), Barro (2012)).

A complementary concept examined in relevant literature is that of *sigma - convergence*, supposed to be testable in the form:

$$D_t = D^* + (1 + \beta)^2 \cdot (D_{t-1} - D^*) = D^* + (1 + \beta)^{2t} \cdot (D_0 - D^*) \tag{20}$$

where D_t is the dispersion (ie. variance, sigma^2, σ^2) of ln(y) in a cross-economy sample of size $N >> 1$ at time t, D^* is its steady state and β comes from Eq. 19 in its absolute convergence form. It is true that:

$$D_t \equiv \frac{1}{N} \cdot \Sigma_{i=1}^{N}[ln(y_{it}) - \Sigma_{i=1}^{N} ln(y_{it})/N]^2 \quad (21)$$

$$D^* = \sigma_u^2/[1 - (1+\beta)^2] \quad \text{and} \quad (22)$$

$$D_t \approx (1+\beta)^2 \cdot D_{t-1} + \sigma_u^2 \quad (23)$$

where $u_i \sim (0, \sigma_u^2)$, independently distributed over time and across economies. These imply that beta-convergence is a prerequisite for sigma-convergence but not the opposite. Since $0 \leq 1 + \beta \leq 1$, D_t monotonically approaches its steady-state value, D^*, but whether it rises or falls depends on whether D begins below or above D^*. Quite often, if the cross-economy dispersion of lny_{it} is shown to fall in time, no further test is done.

A final concept when looking for convergence is that of *club convergence*, where countries are more likely to converge to each other when they are similar not only structurally (in preferences, technologies, policies etc) but also in initial conditions, eg in average GDP per capita (Baumol, 1986; Dowrick and Nguyen, 1989; Galor, 1996). Tests for club convergence can be performed on the basis of Eq. 19 either by regressing over reasonably selected economy sub-samples (for direct estimation of β) or by including appropriate dummy variables, interaction terms and square terms in the set of control regressors (to assess "bonus" effects of club membership on growth rates; see Barro and Sala-i-Martin, 2004). The use of clustering algorithms and spatial techniques is also possible (Durlauf, 2005; Simionescu, 2015).

Conditioning on determinants of growth

It is well documented that regressions like Eq. 19 suffer from *model uncertainty* (Brock et al. (2003); Barro & Sala-i-Martin, 2004; Durlauf et al., 2005; Barro, 2012): not only do most existing growth theories suggest different controls x_j, they also rarely specify how these can be measured or proxied and in what form they should be included in equations - an example is human capital, the know-how of workers that raises their productivity (Becker, 1962). Analysts are usually forced to try plausible regressors from a wide selection of variables which may have statistical significance alone but not at the presence of certain covariates. Extreme Bounds Analysis, general-to-specific algorithms and Bayesian Model Averaging have been applied to find the most useful candidates, blurring distinctions between *long-run* and *short-run* or *fundamental* and *proximate* causes of growth (Temple, 2000; Barro & Sala-i-Martin, 2004; Acemoglu, 2009).

Many research papers seem to cite work on the determinants of growth predating 2000 (for indicative lists of regressors, see Levine & Renelt, 1992; Barro & Sala-i-Martin, 2004; Durlauf et al., 2005). Most recognise capital investment as a major growth factor. Positive effects on growth have been found for physical capital (fixed assets) by Dowrick & Nguyen (1989), Barro (1991), De Long & Summers (1991), Levine & Renelt (1992), Mankiw et al. (1992) and Sachs & Warner (1995), among others. Positive effects have also been found for infrastructure (transportation, energy and so on) by Hulten (1996), Easterly & Levine (1997) and Esfahani & Ramirez (2003). The impact of human capital has been debated: depending on specification (literacy, educational attainment, skills, test scores, life expectancy, teaching /medical wages, other expenditures) it appears positive in Barro (1991), Mankiw et al. (1992), Azariadis & Drazen (1990), Levine & Renelt (1992), Islam (1995), Easterly & Levine (1997) and so on, while it is statistically insignificant or negative (eg. for female education and degrees in humanities) in Murphy, Shleifer and Vishny (1991), Barro & Lee (1994), Benhabib & Spiegel (1994) and Sachs & Warner (1995).

Technology, innovation and R&D activities -which may largely explain capital formation- are also thought to contribute to growth. Proxied by measures such as R&D expenditure, percentage of employees in high-tech fields and number of patents (OECD, 2005), their positive influence has been confirmed in Fagerberg (1987), Lichtenberg (1992) and Ulku (2004), for example. Foreign direct investments (FDI), on the other hand, regarded as a channel of technology diffusion and other benefits, are not guaranteed to promote growth. Romer (1993), Li & Liu (2005), Blonigen & Wang (2004) detect positive associations, Brecher (1983) and Boyd & Smith (1999) find a negative effect, while Ram & Zhang (2002) do not find clear linkages. Foreign aid is found to be useful by Hadjimichael et al. (1995), Durbarry et al. (1998) and Lensink & White (1999). Burnside & Dollar (2000), though, suggest that good policies are a prerequisite for the effectiveness of foreign aid, and this may apply to FDI as well.

Macroeconomic policies and conditions, especially those fostering certainty and trust in conducting business, are regarded as having significant impact on growth. Inflation, government consumption, debts and tax burdens are detrimental to growth usually over a lower threshold, as found by Barro and Lee (1994), Sachs & Warner (1995), Bassanini et al. (2001) and Soukiazis & Castro (2005). The influence of institutions, meant as the formal and informal rules of human interaction (North, 1990) has been examined empirically by Kormendi & Meguire (1985), Knack & Keefer (1995), Grier & Tullock (1989), Feldstein (1997), Hall & Jones (1999), Lesink (2001), Rodrik et al. (2002) and Acemoglu et al. (2002, 2005). Property rights, labour-market regulations, political stability, degree of democracy and capitalism are thought to promote the functioning of markets for inputs and outputs, while corruption and bureaucracy slow-down operation of infrastructure and magnify budgetary deficits in several cases. Negative effects of low-quality institutions have been found in Colclough & Manor (1991), Murphy et al. (1993), Ayal & Karras (1996), Monte & Papagni (2001), Meon & Sekkat (2005) and Chowdhury (2006), while other studies find the opposite effect.

Openness to trade is another plausibly significant determinant of growth, especially for small countries. Mostly measured as the ratio of exports plus imports to GDP (Sachs & Warner, 1995), and possibly filtered by population and area to account for economy size effects, it is linked to technological advances, the level of human capital, exposure to demand and competitiveness. Its positive relation with growth has been shown by Dollar (1992), Sachs & Warner (1995), Edwards (1998) and Dollar & Kraay (2000), even though it has been criticized on methodological grounds, eg. by Levine & Renelt (1992) and Rodriguez & Rodrik (1999). Terms of trade, measured as the ratio of export prices to import prices, is a trade indicator of similar effect, as found by Frankel et al. (1996) and Bassanini et al. (2001).

Population indicators like fertility, density, composition and migration seem to play an important role in growth through various channels, as found in Kormendi &

Meguire (1985), Grier & Tullock (1989); Barro & Lee, 1994, Bloom & Sachs (1998) and Kelley & Schmidt (1995). Geographic factors like natural resources, location and climate are also taken into account, for example in Sala-i-Martin (1997), Bloom & Sachs (1998) and Bloom et al. (2003). Socio-cultural indicators such as ethno-linguistic fragmentation, religion and beliefs are accounted for in Sala-i-Martin (1997), Easterly & Levine (1997), Alesina et al. (2003), Barro & McCleary (2003), with mixed results.

Adjusting for the impact of SF on growth and convergence

But how do Structural Funds fit in the Solow-Swan model and growth - convergence regressions? According to the additionality principle governing Structural Funds, recipient countries are supposed to use this financing for investment projects in conjuction with own funds, hopefully without "crowding-out" the latter or misspending any of the former on public or private consumption. In other words, SF should function as a supplementary source of capital accumulation; hence they are classified as "investment grants" under the European System of Accounts (ESA 1995 & 2010) and combine with gross fixed capital formation and other elements to form capital expenditure (a generalised version of investment). Accounted SF payments include cash transfers made by the EU to Member States both in lump sums for concurrent use in capital formation and in installments compensating for the acquisition of fixed assets in earlier periods.

Reading from the latest Cohesion Report of the European Commission (2014), up until the crisis of 2008-2009, Member States seemed to converge to each other, with some divergence observed mainly in capital regions of newly integrated countries; post-crisis, disparities increased, at least temporarily. However, it is not very clear to what degree any convergence can be attributed to Structural Funds. In line with the empirics of growth, many researchers have used equations like Eq. 19 in order to estimate the impact of SF (as ratios to GDP or dummies) on GDP growth per capita (or worker). Regressors usually include population growth, fixed capital investments, human capital, R&D or other technology variables, infrastructure and quality of government. There are several papers explicitly controlling for *absorption rates*, mainly meaning the degree to which macroeconomic and institutional conditions lead to fund mismanagement; results are then interpreted as in the foreign aid case.

Most econometric studies during the last 15 years or so find a positive but small impact of Structural Funds on growth in the EU, particularly in less advanced regions (Pieńkowski & Berkowitz, 2015). Some studies show varied results for different administrative areas, while a few studies find no significant impact in general or, even, a negative impact. The lack of conclusive results is largely explained by the differences in methods, aggregation level, time-spans and variables used in the regression analyses. For example, some authors work on country instead of regional data, others only examine one or two SF programming periods and a few test for various lagged SF effects.

Among the most frequently-cited studies that find no significant statistical relationship between Structural Funds and growth, Boldrin and Canova (2000) only see a small convergence speed in labour productivity, Rodríguez-Pose and Fratesi (2004) suggest steering SF away from agriculture towards human capital projects and Dall'erba and Le Gallo (2008) observe failure of SF to counteract agglomeration tendencies. Esposti and Busoletti (2008) show a small positive effect of SF on Objective 1 regions and negative effects in other regions, while Le Gallo et al. (2011) notice important spatial spillovers and varied (positive to negative) response to SF across different regions. Ederveen et al. (2006) find negative impacts of Structural Funds on growth at the country level and suggest allocation of funds towards building and improving institutions first. Bähr (2008) conditions the success of SF on decentralisation.

Another group of highly-cited work finds better results. Cappelen et al. (2003) regionally and Beugelsdijk & Eijffinger (2005) nationally detect positive effects of SF on growth. Puigcerver-Peñalver (2007) observes a positive impact of SF on growth, stronger in 1989-1993 than in 1994-1999. Moll and Hagen (2010) obtain positive results in Objective 1 regions, but nothing definite in a mixed-Objectives sample. Becker (2010) finds a 2% positive "treatment" effect of Objective 1 funds, points to optimal SF-to-GDP intensities (2012) and links SF effectiveness to human capital and government quality (2012). Rodríguez-Pose and Novak (2013) find a positive impact of SF in 2000-2006 and no impact in 1994-1999. Crescenzi and Giua (2014) find positive impacts for the EU regional policy. Tomova et al. (2013) at the country level and Maynou et al. (2014) at the regional level detect significant positive effects on growth and development (however, the former use a composite SocioEconomic Development Index as the dependent variable).

Several papers have used *instrumental variables* to control for endogeneity, ie growth parameters determined inside the growth model and not imposed on it. By means of spatial lags and weight matrices, a few, often oversimplifying, attempts have been made to capture regional inter-dependencies: SF aid in eligible areas may spill over into other areas as people, capital, goods and services are free to flow between open economies. Panel data methods are quite preferred, but additional techniques have emerged, such as regression discontinuity design, generalised propensity scoring and other non-parametric tools.

Data absence plays a crucial role in research: several indicators are not available at the regional level and some papers take depreciation and technological progress rates to be constant at 5% (following Mankiw et al., 1992). Omission of data is also important: business-cycle effects and national growth-affecting policies (eg. labour legislation and fund redistribution) are not included in a series of studies examined by a reviewing European Commission report (Pieńkowski & Berkowitz, 2015). Finally, given that the neo-classical model of convergence assumes full employment, the implications of high unemployment rates observed locally are not adequately explained.

Because of these problems in empirical findings and the inherent complexity of interpreting econometrics, drawing policy recommendations on the basis of regression literature is difficult. The European Union itself seems inclined to communicate data on the success of SF by using descriptive statistics, case studies and multiplier values (EUROPA, 2016). Comprehensible information is necessary to policy makers and supporters, especially as new information regarding misspending of SF is revealed from time to time (eg. by the Bureau of Investigative Journalism, 2010).

Methodology

Selecting the analysis framework

As stated in the Introduction section of this dissertation, here the effects of Structural Funds on growth and convergence in the EU Member States are estimated econometrically on panel data for years 2000-2013 at the country level.

While estimations on regional data seem most appropriate given the regional policy character of Structural Funds, statistics on variables such as openness and schooling at this level of aggregation are often unavailable or unreliable, so typical growth regressions cannot be run. Also, as investment benefits in a region are very likely to "spill over" to neighbouring locations in a number of ways (eg. demand for production inputs, public-good properties of infrastructure, slow-down due to increased competition), economic interactions should be accounted for, which is complex and affected by data sparsity. Moreover, it is possible that recipient regions are more exposed to "crowding-out" (and a non-exogenous change in investment rates domestically) if central governments prefer to re-allocate national funds to less needy areas after securing structural aid. Finally, endogeneity intensifies as most Funds are explicitly directed to relatively poor regions and a distinction between their roles as causes or effects of growth cannot be clearly made (Ederveen, 2003; Becker et al., 2010, opposing).

As regards the time-period selected, there is inherent relevance due to the recency of the data and its coincidence with the first decade of the European Monetary Union (1991-2001 onwards) and the latest EU Enlargements (2004 & 2007), both being steps to a fuller integration and cohesion situation among European states. Also, the event of the financial crisis in the meantime treats roughly half the sample of observations with a crisis-aftermath effect which is worthy of investigation. The evolution of the Internet and the discourse on data transparency has led the EU to publish more details on its budget online, providing open access to statistics and documents since 2004 (Cystat, 2016) and launching the European Transparency Initiative in 2005 (European Commission, 2013).

While cross-section and time-series analyses have their own benefits and disadvantages (Durlauf et al., 2005), they are better suited to large samples; a rule of thumb is to use sample sizes S>30 (Corder & Foreman, 2009), while an S≡T=30 for time-series and an S≡N=100 for cross-sections are considered moderate (Durlauf et al., 2005, Barro, 2012). Since N=28 and T=14 in this study, the so-called *panel regressions* are preferred, which benefit from data variability both across units and over time to "multiply" observations (S=NxT), reduce collinearity and fit complicated models

(Greene, 2003; Baltagi, 2005). Panel regressions account for unobserved unit-specific heterogeneity and time correlation, both reasonably expected given the growth patterns in the EU-28 and the dependence between present and future output values per country already seen; they can capture the effect of unusual time periods with dummy variables, too. *Generalized-Method-of-Moments* (GMM) *panel regressions* (Holtz-Eakin et al., 1988, Arellano & Bond, 1991; Arellano & Bover, 1995, Blundell & Bond, 1998) are well-suited to growth analysis (Caselli et al., 1996; Borys et al. 2008) since they are designed to deal with dynamic relationships and endogeneity, as explained below.

Method discussion

Growth regressions of the form of Eq. 19 can be re-written as:

$$ln(y_{i,t}) = \alpha + (\beta + 1) \cdot ln(y_{i,t-1}) + \Sigma_{j=1}^{J} w_j \cdot x_{j,i,t} + u_{i,t}, \quad \text{with} \quad u_{i,t} = \mu_i + \gamma_t + \epsilon_{i,t} \quad (24)$$

where, to clarify, for each economy i=1...N and time t=1...T, y is the GDP p.c. and x_j are growth determinants weighted by their respective coefficients w_j. Parameters α and β are assumed to be constant all over the sample with β expected to be negative, while error terms $u_{i,t}$ represent unexplained influences on y and are further broken down to an economy-specific component μ_i (allowing for permanent differences in y between countries), a time-specific component γ_t and a generic term $\epsilon_{i,t}$. Since y_t depends on its previous realization, y_{t-1}, Eq. 24 is a dynamic relationship.

The dynamicity in Eq. 24 causes μ_i, for which at least $E(\mu_i) \neq$ holds, to be correlated with regressor y_{t-1}, since their covariance is:

$$E[\mu_i, ln(y_{t-1})] = E[\mu_i, \alpha + (\beta + 1) \cdot ln(y_{i,t-2}) + \Sigma_{j=1}^{J} w_j x_{j,i,t-1} + \mu_i + \gamma_{t-1} + \epsilon_{i,t-1}] \quad (25)$$

where E denotes expected value, $E[\mu_i, \alpha]$=$E[\mu_i, \gamma_t]$=0 by construction, $E[\mu_i, x_{j,t-2})] = 0$ if the various x_j are exogenous and $E[\mu_i, ln(y_{t-2})] > 0$ generally as μ_i helps proxy for the steady-state GDP p.c., y^* (Caselli et al., 1996). Given that μ_i cannot be fully controlled for, a bias is introduced and the convergence speed $|\beta|$ is underestimated. *Random-effects regressions* (RE) are thus ineligible for estimation, since they require total exogeneity, ie. absence of correlation, between μ_i and all regressors. *Fixed-effects regressions* (FE) eliminate μ_i by time-demeaning all variables, but some considerable "bias" remains for small T (T~10) as past values of ϵ enter its mean (Nickell, 1981).

Even worse, endogeneity is frequently unavoidable when discussing growth, given that it makes sense to accept the existence of measurement errors, confounders (uncontrolled variables affecting both explanatory and explained variables) and feedback effects /causality loops (Greene, 2003; Baltagi, 2005). For example, the rates of investment in physical or human capital, s_k and s_h, might be determined simultaneously with the rate of growth, as faster-developing economies can afford to allocate less resources to consumption. Also, both output growth and political stability, seen as a growth determinant since it reduces entrepreneurial risk and favours production, might be influenced by a set of hard-to-model institutions or historical events. Practically, every variable that represents behaviour (which is true about rates to GDP in general) is subject to endogeneity.

The most widely-used approach to the problem (Durlauf et al., 2005) is to difference Eq. 24 to eliminate the per-unit fixed effects, and then use two-stage least squares (2SLS) or GMM to address both endogeneity and dynamicity:

$$ln(y_{i,t}) - ln(y_{i,t-1}) \equiv \Delta(lny_{i,t}) = (\beta + 1) \cdot \Delta ln(y_{i,t-1}) + \Sigma_{j=1}^{J} w_j \cdot \Delta x_{j,i,t} + \Delta u_{i,t} \qquad (26)$$

(here, the time-specific error components can be conveniently overlooked or accounted for by adding appropriate regressors to the model, depending on the case).

Without improbable error structures, at least one regressor in Eq. 26 is correlated with the disturbances, and *instruments* should be used to get consistent estimators. Valid instruments are variables that do not appear in the explanatory equation but are uncorrelated with the error terms and conditionally correlated with endogenous explanatory variables in the model, thus affecting the dependent variable only through these regressors. If they are used at a *first stage* to predict regressor values, then, at a *second stage*, regressions are run on these predicted rather than the starting values to get estimates that get closer to the true numbers as the sample size increases. The *difference-GMM* approach, in particular, uses lagged levels of the series as suitable instruments for lagged first differences (as in Eq. 26), on the assumption of specific moment conditions and a lack of serial correlation in the error terms of the growth equation before differencing.

When explanatory variables are highly persistent (largely dependent on their past values, or, better, tested to have *unit roots*), as is regarded to be generally true of output, lags can be weak instruments for first differences, introducing biases when N>T (Bond et al., 2001). Monte Carlo simulations show that the *system-GMM* approach, which additionally uses lagged differences as instruments for an equation in levels second to Eq. 26, is more reliable in small samples (Soto, 2006). Empirically, the validity of the new instruments can be examined with standard Sargan tests of over-identifying restrictions, or difference Sargan or Hausman comparisons between the first-differenced GMM and system GMM results (Roodman, 2009). The problem of parameter heterogeneity (common estimations only in sub-samples) can be resolved by grouping observations by regional location or level of development (Durlauf et al., 2005).

Variable selection and some descriptive statistics

For reasons of robustness and compliance to theory alike, two versions of Eq. 24 will be GMM-tested: one explaining the current level of GDP p.c. (conforming to the original derivation of the equation) and another explaining the current GDP p.c. growth (using lagged growth and lagged output as regressors simultaneously); the exact specifications will be shown in conjunction with estimation results. Tests for absolute beta-convergence will be conducted first, in comparison with pooled Ordinary Least Squares (OLS) and FE regressions, and then tests for conditional beta convergence will follow, with SF always present, by objective and by fund. Lagged instruments for the GMM methods will mostly be up to three periods before, to avoid the negative effects of instrument proliferation and overfitting (Roodman, 2007).

Following previous notation, estimations will be performed for variants of:

$$ln(y_{i,t}) - ln(y_{i,t-1}) = \alpha + \beta \cdot ln(y_{i,t-1}) + \Sigma_{j=1}^{J} w_j \cdot x_{j,i,t} + u_{i,t}, \quad (27)$$

ie Eq. 19, where convergence controls $x_{j,i,t}$ basically include SF payments, the national savings ratio, the degree of economic openness, the level of technology, government consumption, institutional quality and appropriate interaction terms of all these for individual economies. Time dummies may mark periods of interest, eg crisis years.

In any case, output per capita is calculated as the ratio of GDP to the population of each of the EU-28 countries, where GDP and its components are measured in chain-linked volumes (base year 2005, ESA 1995) to adjust for inflation. Some researchers argue for the use of GDP per worker to relate more closely to theory including labour as a production factor and to counteract the distortion that the informal sector produces to the standards of living (eg. Durlauf et al., 2005); others take unemployment into account (eg. Bräuninger & Pannenberg, 2000). Here, though, it is accepted that governments act to raise GDP in benefit of all residents in a state and not just the employed, the labour force, voting-right citizens and so on.

Structural Funds, interpreted as the object of a special growth-inducing savings-investment relationship, are taken in natural logarithms of the sum of yearly payments to nominal GDP, StrFn, plus 1 (to allow for zero SF values) and are expected to have positive effects on growth as a whole. Taken separately by component Fund or Objective served, they should appear beneficial at least in the case of Objective 1 (lagging regions - convergence) and the ERDF, which channel the bulk of regional policy funding and coincide the most with its original aim of disparity reduction. Interacted with openness or institution indicators, they could seem more helpful the more extroverted or well-run economies are. Lagged values might test for delayed impacts on annual growth rates, which is natural for large infrastructure and other investment projects.

After the discussion on growth determinants, physical capital savings rates are proxied through the ratios of gross fixed capital formation to GDP (GFCFr) and investments in human capital are gauged by the percentage of working-age population (25-64 years of age) with upper secondary or tertiary educational attainment (ISCED levels 3-6; Hp). Openness, "investment" in international trade, is captured by the fraction of the sum of national imports and exports to GDP (OPENr). Investment in R&D and innovation should be reflected in the share of high-technology exports in manufactured exports (ie. share of computers, pharmaceuticals, electrical machinery etc; HTXp). All these, also taken in natural logarithms, are expected to positively influence growth.

Macroeconomic and institutional conditions can be expressed through the logarithm of the share of government consumption in GDP (GCONSr) and the World Bank Government Effectiveness rank indicator (GE); the latter reflects relative positions of countries after surveying perceptions of their quality of public and civil services, their degrees of government independence from political pressures, their quality of policies and their commitment to said policies. The effect of government consumption on growth is ambiguous in principle: while it can fund public goods (eg. education) and boost demand by "putting money into people's pockets" (Mitchell, 2015), it can remove valuable resources from investment opportunities. A high government effectiveness rank, on the other hand, implies better environments for capital accumulation.

Most data are drawn from the Eurostat online database (ec.europa.eu/eurostat, tables nama_gdp_k, nama_10 _pe, nama_gdp_c, edat_lfse_13). Data on Structural Fund payments were taken directly from the European Commission (available online at ec.europa.eu [digital links 1 and 2]). Data on high-tech exports and government effectiveness were found through the World Bank online database (data.worldbank.org). Basic descriptive statistics are given in Table 2:

Variable	Variation	**Mean**	**Std. Dev.**	**Min**	**Max**	**Sample**
real GDP	overall	20.33	13.74	2.18	70.43	S = 392
per capita	between		13.90	3.16	63.58	N = 28
: y (EUR k)	within		1.37	14.88	27.19	T = 14
real GDP	overall	1.96	3.89	-16.32	11.99	S = 389
p.c. y-o-y	between		1.77	-.18	5.81	N = 28
growth (%)	within		3.48	-19.94	9.95	$\bar{T}$ = 13.89
StrFn (payments / nominal GDP, %)	overall	0.61	0.89	0.00	4.41	S = 392
	between		0.60	<0.01	1.96	N = 28
	within		0.66	<0.01	3.39	T = 14
GFCFr	overall	21.41	4.10	12.35	36.53	S = 392
(%)	between		3.06	16.05	28.91	N = 28
	within		2.79	13.22	31.18	T = 14
Hp	overall	71.80	16.62	18.1	93.4	S = 390
(%)	between		16.32	27.39	90.03	N = 28
	within		4.17	61.88	85.01	$\bar{T}$ = 13.92
OPENr	overall	112.25	53.36	48.49	335.83	S = 392
(%)	between		52.27	53.00	300.36	N = 28
	within		14.37	65.70	166.64	T = 14
HTXp	overall	14.68	11.23	1.67	71.74	S = 392
(%)	between		10.51	4.58	53.57	N = 28
	within		4.39	-.34	34.95	T = 14
GCONSr	overall	20.19	3.09	14.33	28.85	S = 392
(%)	between		2.84	16.60	26.84	N = 28
	within		1.32	17.28	26.99	T = 14
GE	overall	82.13	13.16	39.02	100.00	S = 392
(rank)	between		13.06	46.13	99.50	N = 28
	within		2.86	69.67	91.32	T = 14

Table 2: Descriptive statistics for features of the EU-28 economies, 2000-2013 (annual observations, taking into account 1999 data where appropriate). The panel is strongly balanced (values for GE in 2001 where linearly interpolated between 2000 and 2002 values). Data: Eurostat, European Commission, World Bank (2016).

Caveat: unit root testing

A frequent concern in economic growth studies is the possibility of *spurious regressions*, ie regressions that erroneously provide evidence of relationships between actually unlinked variables, owing to coincidence or common unobservable factors as economic phenomena evolve in time. Spurious regressions result from *non-stationarity* (time-variant statistical distribution features) and are often identified with the presence of *unit roots*, which hinder time processes from reverting to their means after random shocks and from converging together (Greene, 2003; Baltagi, 2005). In fact, unit root series, often found in GDP components, mislead the usual inference tests of estimation significance, as they do, for example, with standard GMM estimators (Baltagi, 2005).

Several methods have emerged to tackle this challenge either for time or panel data. While *co-integration* (the stationarity of linear combinations of non-stationary regression variables) is desirable, in most cases, successfully rejecting the null hypothesis of a unit root in the underlying time-series is enough to continue with estimation as usual. However, in short panels (small T), one should allow for "sudden" events and "breaks" (such as in crisis periods), or else tests might fail to reject false unit root hypotheses (Baltagi, 2005; Durlauf et al., 2005). To check whether growth in the sense of Eq. 19 is stationary, the Zivot-Andrews (1992) test is employed (see Baum, 2005).

In Table 3, the null hypothesis of a unit root in the growth rate of GDP p.c. is rejected for about half the economies in the sample at a significance level a=10% (somewhat fewer at a=5%), with one extraordinary event detected around 2008-2009, which is well-known to correspond to the crises mentioned in this dissertation. This hints to some overall stationarity, which should best be explored by checking the stationarity of regressors individually and the existence of co-integration relationships.

Unit	**Min. t-stat.**	**Break**	**Unit**	**Min. t-stat.**	**Break**	**Unit**	**Min. t-stat.**	**Break**
AT	-4.595	2009	FI	-4.185	2009	NL	-4.877	2009
BE	-4.981	2009	FR	-4.968	2008	PL	-3.735	2009
BG	-9.581	2009	HR	-5.084	2009	PT	-4.317	2009
CY	-4.267	2009	HU	-4.157	2007	RO	-8.586	2009
CZ	-3.980	2009	IE	-3.896	2008	SE	-4.407	2008
DE	-4.008	2009	IT	-4.885	2009	SI	-8.053	2009
DK	-4.220	2008	LT	-3.690	2008	SK	-6.833	2009
EE	-5.024	2008	LU	-4.695	2008	UK	-3.945	2008
EL	-2.934	2009	LV	-4.563	2008			
ES	-3.583	2008	MT	-7.198	2009			
Critical values:		1%: -5.34		5%: -4.80		10%: -4.58		

Table 3: Zivot-Andrews test results for the EU-28 GDP p.c. growth rates, 2000-2013 (allowing for break in intercept with 0 lags of the differenced variable included). Accepting a single anomaly around 2008-2009, unit roots are absent from half the sample.

Research Results

On absolute beta-convergence and sigma-convergence

While theoretical analysis points to convergence which is conditional on several growth factors (the omission of which would cause biased estimates), naive pooled OLS and RE checks yield an average convergence speed of about 2% per year, as shown in Table 4; this coincides with the so-called Barro *iron law of convergence* found in cross-section samples (Barro, 2012). However, a simple FE estimation leads to a higher convergence speed of about 12%, and the corresponding Hausman test (Hausman, 1978) rejects the null hypothesis that RE estimates are consistent; both results are expected given the convergence literature. In contrast, the implied difference-GMM speed of about 20% is deemed too large; the OLS and (within-group) FE estimates are known to be biased in opposing directions, so, ceteris paribus, a consistent convergence speed estimate should lie in-between (Nerlove, 1999).

	dependent variable: $lny_t - lny_{t-1}$			dep. variable: lny_t
	pooled OLS (1)	**RE** (2)	**FE** (3)	**diff. GMM** (4)
lny_{t-1}	-0.0200 ***	-0.0206	-0.1235 ***	0.8088 ***
	(0.0023)	(0.0025)	(0.0138)	(0.1346)
_cons	0.0732 ***	0.0750 ***	0.3563 ***	0.5413***
	(0.0066)	(0.0073)	(0.3770)	(0.0369)
S	389	389	389	361
R^2	0.1625	0.1625	0.1625	
model test	F(1,387)	Wald $\chi^2(1)$	F(1,360)	Wald $\chi^2(1)$
p-value	0.0000	0.0000	0.0000	0.0000

For (2) & (3): R^2 within = 0.1825, R^2 between = 0.6609, Hausman p>χ^2 = 0.0000.
For (4): lags of the independent as instruments for the differenced equation, constant for the level equation. ***: Significance at 1% level.

Table 4: Evidence of Absolute Convergence in the EU-28, 2000-2013

Any way, given the already-discussed conditionality of convergence, finding the appropriate regression method is not required here. The scatter plot for model 1 (pooled OLS) in Table 4 suggests a negative relationship between annual growth and initial GDP

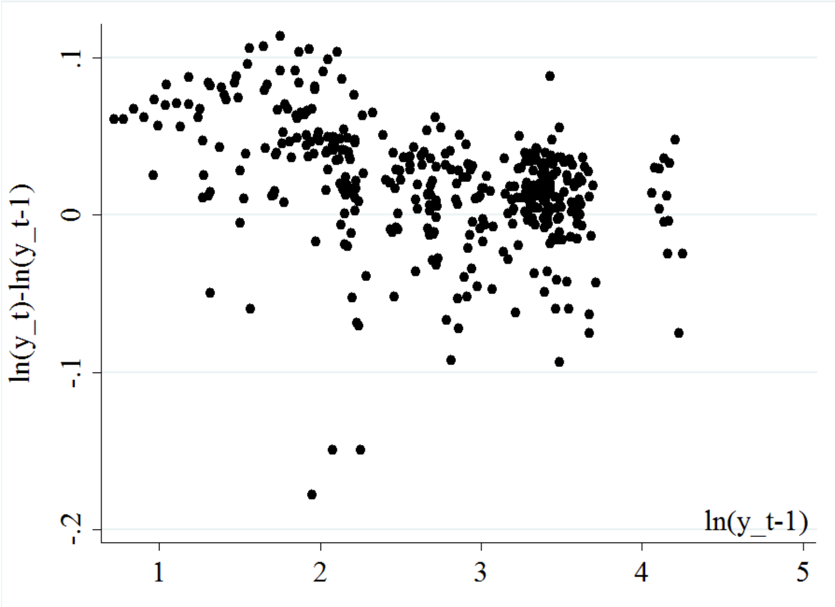

Figure 10: Pooled OLS absolute GDP p.c. convergence scatter plot, EU-28, 2000-2013

p.c. level (in logarithms) alluding to a catch-up process, even though the link is not very linear (as fitted with OLS) and subject to outliers (Figure 10). As regards sigma-convergence, a look at the respective graph (Figure 11) confirms that the cross-sectional dispersion of ln(GDP p.c.) does decrease over time; not surprisingly, a break appears in 2008-2009. Since the main interest of this dissertation is the possibility of conditional beta-convergence under the positive influence of Structural Funds, sigma-convergence will not be further examined.

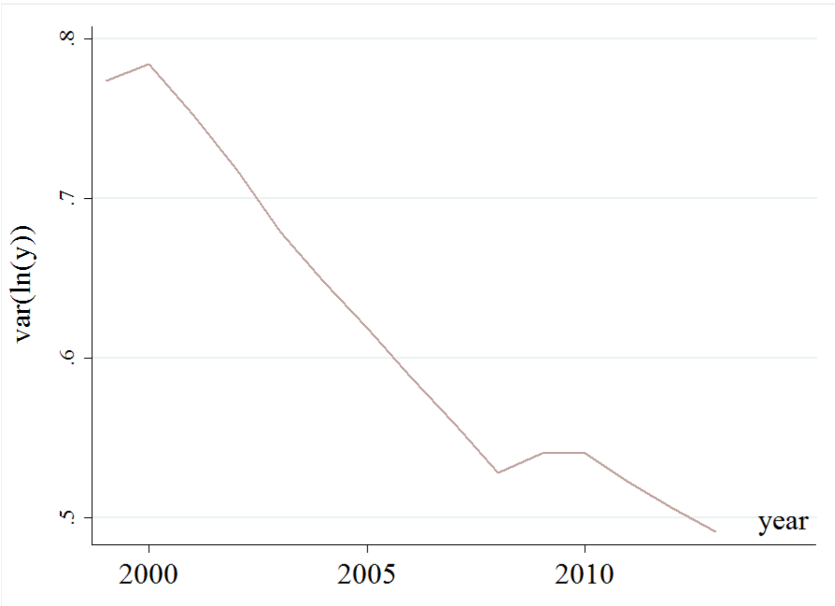

Figure 11: Absolute GDP p.c. sigma convergence, EU-28, 2000-2013. Based on Eq. 23, pooled OLS for 2000-2013 suggest convergence between 2.0% and 3.0% per year.

On beta-convergence conditional on Structural Funds

Preliminary regressions do not confirm expectations: StrFn has a negative statistically significant effect on the dependent variable, even though its inclusion raises the coefficient of determination (R^2) for pooled OLS, RE and FE, and reduces the implied convergence speed to 15% in a simple difference-GMM model, as shown in Table 5.

Insisting on GMM methods does not improve results. StrFn still has a negative statistically significant effect on the dependent variable and difference-GMM estimators still yield convergence speeds close to 15%, while system-GMM estimators bring the speeds below 4%, as seen in Table 6 (details on the instruments are given in Table 14 in the Appendix). Regressing on lagged growth in (1) and (2) helps apply GMM to explain growth directly. Even though the null hypothesis of all estimated coefficients being simultaneously zero is rejected for all models, the "perfection" of the Sargan /Hansen test statistics for overidentifying restrictions and the rejection of the no second-order serial correlation hypothesis for the regression residuals in differences indicate that there is a *problem with instrumentation or /and specification* (StataCorp, 2013; Roodman, 2009).

In draft regressions, adding deeper lags to instruments or limiting them often renders both lagged growth and StrFn statistically insignificant, while assuming StrFn to be *predetermined* instead of *endogenous* (StataCorp, 2013) does not essentially change the signs and magnitudes of estimated coefficients. Instrumenting on deeper lags only does not help with autocorrelation, which is expected to be of up to order 1 in the first-differenced errors for the moment conditions behind GMM to hold (StataCorp, 2013). Experimenting with regressors, it seems useful to add at least twice-lagged growth in the growth equation (Eq. 27) or twice- and thrice- lagged *lny* in the level equation (Eq. 24); this agrees with advice in the time-series literature when persistence lingers in calculations (StataList.org, 2014) and probably deals effectively with the partial non-stationarity detected for growth with the Andrews-Zivot test earlier. But, before this modification (which results in larger observation "losses" the more lags are inserted in the model), other variables will be included first.

On beta-convergence conditional on Structural Funds & selected variables

When variables GFCFr, GCONSr, Hp, HTXp, OPENr and GE are inserted in "simple" regressions as previously discussed, they usually appear to have the expected signs, demonstrated in Table 6. Estimated coefficients are positive and significant for GFCFr and GE, negative significant for GCONSr (confirming previous empirical findings), positive when significant for Hp and OPENr and positive insignificant for HTXp. Model explanatory power is generally increased compared to the absolute and SF-conditional convergence cases, since the coefficient of determination R^2 (generally for OLS, within for FE) has grown with additional regressors. Interestingly, regressing lny_t instead of $lny_t - lny_{t-1}$ (growth at time t) on lny_{t-1} produces exactly the same coefficients for all regressors except lny_{t-1} (naturally), and R^2 approaches unity (relevant results are omitted for economy of space).

	dependent variable: $lny_t - lny_{t-1}$			dep. var.: lny_t
	pooled OLS (1)	**RE** (2)	**FE** (3)	**diff. GMM** (4)
lny_{t-1}	-0.0237 ***	-0.0244 ***	-0.1012 ***	0.8469 ***
	(0.0023)	(0.0026)	(0.0188)	(0.0190)
ln(1+StrFn)	-1.1009 ***	-1.1896 ***	-0.6042 *	-1.0103 ***
	(0.2075)	(0.2140)	(0.3475)	(0.3529)
_cons	0.0900 ***	0.0925 ***	0.2990 ***	0.4433 ***
	(0.0071)	(0.0078)	(0.0500)	(0.0504)
S	389	389	389	361
R^2	0.2195	0.2193	0.1746	-
model test	F(2,386)	Wald $\chi^2(2)$	F(2,359)	Wald $\chi^2(2)$
p-value	0.0000	0.0000	0.0000	0.0000

For (2) & (3): R^2 within = 0.1590, R^2 between = 0.5802, Hausman p>χ^2 = 0.0000.
One-step estimator for (4). ***, *: Significance at 1%, 10% level.

Table 5: Convergence given Structural Funding, EU-28, 2000-2013

dep. var.:	⊢ $lny_t - lny_{t-1}$	⊣	⊢	lny_t	⊣
GMM:	**diff.** (1)	**sys.** (2)	**diff.** (3)	**sys.** (4)	**sys.** (5)
lny_{t-1}	-0.1620 ***	-0.0235 ***	0.8376 ***	0.9633 ***	0.9652 ***
	(0.3112)	(0.0064)	(0.1467)	(0.0060)	(0.0027)
ln(1+StrFn)	-1.1689 **	-1.1637 ***	-1.6512	-1.4471 ***	-
	(0.5797)	(0.2764)	(1.5029)	(0.2220)	
$growth_{t-1}$	0.1198 *	0.2926 ***	-	-	-
	(0.0632)	(0.0582)			
_cons	0.4694 ***	0.0827 ***	0.4714	0.1275 ***	0.1139 ***
	(0.9307)	(0.0207)	(0.4098)	(0.0188)	(0.0074)
S	333	361	361	389	389
instruments	49	109	51	100	50
model test	Wald $\chi^2(3)$	Wald $\chi^2(3)$	Wald $\chi^2(2)$	Wald $\chi^2(2)$	Wald $\chi^2(1)$
p-value	0.0000	0.0000	0.0000	0.0000	0.0000
AR(1) p	0.0024	0.001	0.1542	0.000	0.001
AR(2) p	0.0032	0.004	0.0096	0.002	0.000

Windmeijer-corrected standard errors. Two-step estimators except for model (5)
Sargan tests for (2), (4), (5) and Difference-in-Sargan test for (5): p-value 0.000
Hansen tests and Difference-in-Hansen tests for (2), (4): p-value 1.000
Up to 3 lags when instrumenting. ***, **, *: Significance at 1%, 5%, 10% level.

Table 6: Convergence given Structural Funding, EU-28, 2000-2013: GMM

dep. var.:	$lny_t - lny_{t-1}$			
	pooled OLS (1)	**FE** (2)	**pooled OLS** (3)	**FE** (4)
lny_{t-1}	-0.0379 ***	-0.3371 ***	-0.0256 ***	-0.1999 ***
	(0.0039)	(0.0378)	(0.0033)	(0.0524)
ln(1+StrFn)	-1.2652 ***	-0.2664	-0.5590	-3.7604
	(0.3414)	(0.5510)	-20.933	(2.7387)
lnGFCFr	0.0407 ***	0.0983 ***	0.0232 **	0.0705 **
	(0.0092)	(0.0188)	(0.0080)	(0.0229)
lnGCONSr	-0.0490 ***	-0.2270 ***	-0.0232 **	-0.1120 **
	(0.0125)	(0.0586)	(0.0081)	(0.0532)
lnHp	0.0019	0.0546 *	0.0123 **	0.0374
	(0.0046)	(0.0299)	(0.0048)	(0.0255)
lnHTXp	0.0020	0.0043	0.0012	0.0043
	(0.0025)	(0.0053)	(0.0019)	(0.0055)
lnOPENr	-0.0007	0.1447 ***	0.0041 *	0.1043 **
	(0.0034)	(0.0299)	(0.0024)	(0.0326)
GE	0.0014 ***	0.0019 **	0.0007 **	0.0013 **
	(0.0003)	(0.0007)	(0.0002)	(0.0006)
GE*ln_{StrFn}	-	-	0.0012	0.0449
			(0.0277)	(0.0332)
y2001	-	-	-0.0132 **	-0.0086 *
			(0.0050)	(0.0042)
y2002	-	-	-0.0128 **	-0.0039
			(0.0050)	(0.0060)
y2003	-	-	-0.0131 **	-0.0028
			(0.0053)	(0.0075)
y2004	-	-	-0.0041	0.0020
			(0.0049)	(0.0088)
y2005	-	-	-0.0050	0.0027
			(0.0049)	(0.0100)
y2006	-	-	0.0042	0.0087
			(0.0051)	(0.0127)
y2007	-	-	0.0030	0.0092
			(0.0056)	(0.0141)
y2008	-	-	-0.0300 ***	-0.0159
			(0.0064)	(0.0156)
y2009	-	-	-0.0972 ***	-0.0599 ***
			(0.0088)	(0.0125)
y2010	-	-	-0.0212 **	-0.0031
			(0.0069)	(0.0132)
y2011	-	-	-0.0176 **	-0.0032
			(0.0064)	(0.0161)
y2012	-	-	-0.0361 ***	-0.0193

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dep. var.:	$\vdash$	$lny_t - lny_{t-1} = g_t$		$\dashv$
	pooled OLS (1)	**FE** (2)	**pooled OLS** (3)	**FE** (4)
			(0.0063)	(0.0170)
y2013	-	-	-0.0302 ***	-0.0141
			(0.0064)	(0.0177)
_cons	-0.0135	0.3280 *	-0.0026	0.2279
	(0.0363)	(0.1767)	(0.0299)	(0.1831)
S	388	388	388	388
R^2	0.3340	0.1925	0.6923	0.2605
model test	F(8,379)	F(8,27)	F(22,365)	F(22,27)
p value	0.0000	0.0000	0.0000	0.0000

For (2): R^2 within = 0.6011, R^2 between = 0.7517
For (4): R^2 within = 0.7501, R^2 between = 0.7555
Standard Errors robust (pooled OLS) /adjusted for the 28 clusters (FE)

Table 7: Convergence given various growth factors, EU-28, 2000-2013

However, there are obvious problems since (i) the FE estimates are systematically larger than their pooled-OLS counterparts (as regularly observed empirically, eg. in Ederveen et al., 2006; see also Barro, 2004), (ii) the impact of Structural Funds appears to be negative no matter the significance level and (iii) the impact of human capital, technology and openness does not always seem to be statistically strong. The third flaw likely means that Hp, OPENr and HTXp are weak proxies for the respective growth factors, at least in their logarithmic single-term form; undoubtedly, defining and measuring such variables so that changes in them predict growth "one-to-one" is harder than in the case of the Solow-Swan physical capital and labour, also difficult to demarcate in economic sense. For example, OPENr does not uniquely represent the effects of openness as it can be equally high for net exporters, which benefit from international trade, and net importers, which borrow to fund consumption at the expense of investment.

The second flaw might have to do with the timing of Structural Funds and their specification more than with any truly growth-dampening properties of theirs, eg. distorting investment motives / being squandered. As Structural Fund payments reflect both past and future investment projects which are normally completed in the course of many years, it is not clear how fast an immediate (e.g. annual) change in their intensity shifts economic steady states (the reasoning so far has been that, on average, some expectations can be formed well in advance on what funding each country can get and what one can do with it to generate wealth, so economic activity has adjusted accordingly to some extent until the actual payout). For similar reasons, regressing on lagged SF variables may not result in consistently positive significant effects on growth after some "needed" time. In fact, this inconsistency can be seen among variations of such models run on the current sample (estimations are left out once again, to focus on the main outcome and avoid the need for suitable adjustments to theory).

Additionally, both the first and second flaws might relate to further variable-omission and endogeneity problems. It makes sense to argue, for example, that, the richer economies are, the more they can afford to invest in growth-promoting projects; since SF payments are typically a small fraction of national GDPs, they may not be sufficient to take poor economies out of *poverty traps* and any positive effect hides.

Leaving this aside, the inclusion of annual dummies does detect changes in growth patterns common to all countries in the EU-28 over time (models 3 and 4 in Table 6), enhancing R^2 more. Even though most dummies are statistically insignificant, the dummy for 2009, y2009, has the most negative and significant effect on growth in relation to year 2000, as expected due to the European debt crisis then, and is followed by the dummies for years 2012, 2013, 2008 and 2009; the 2004-2007 interval (coinciding with the latest EU enlargements), on the other hand, indicates a positive growth environment, in contrast with the 2008-2013 period in general. At the presence of time dummies, the estimated coefficients for lnGFCFr, lnGCONSr and GE fall at varying rates, while an added ln(1+StrFn)*GE interaction term, though positive, is comparatively small and statistically insignificant, so it is excluded from later regressions. (Furthermore, if significant, this term would not offset the ln(1+StrFn) impact even with GE=100. Similarly, Bahr's (2008) significant positive ln(1+StrF.ratio)*ln(1+decentralisation) term does not fully counteract a negative ln(1+StrF.ratio) term, even with 100% decentralisation).

Distinguishing between objectives and between funds of the EU Cohesion Policy, little changes, as evident in Table 8. On the positive side, R^2 values become a bit higher, the convergence speeds stabilise (around 2.5% for the pooled OLS models and closer to 20% for the FE models) and controls besides Structural Funds tend to keep their signs, significance and order of magnitude. On the negative side, results for Structural Funds are rather unreasonable: dividing annual payments per Objective (Obj) or Fund (F) with nominal GDP, adding 1 and taking the logarithm as with the total of annual Structural Fund payments (StrF) per country, negative statistically significant effects are found for Objective 2, ERDF and Objective 1, while positive effects are found for EAGGF, FIFG and Objective 3. On the same table, robustness is not guaranteed, given the small magnitude and change of sign for most fund variables between specifications 3 and 4, and given the apparent positive effect of only Objective 3 funds when Objectives 2 and 3 are both supported by ERDF and ESF. Perhaps working at a less aggregated level (eg with regional data, growth per industry /sector in the economy or Fund composition per Objective) clearer connections can be derived.

dep. var.:	$lny_t - lny_{t-1} = g_t$			
	pooled OLS (1)	**FE** (2)	**pooled OLS** (3)	**FE** (4)
lny_{t-1}	-0.0263 ***	-0.2206 ***	-0.0240 ***	-0.1994 ***
	(0.0031)	(0.0544)	(0.0039)	(0.0409)
ln(1+Obj1n)	-0.6302 *	-0.1373	-	-
	(0.3352)	(0.5890)		

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dep. var.:	$lny_t - lny_{t-1}$			
	pooled OLS (1)	**FE** (2)	**pooled OLS** (3)	**FE** (4)
ln(1+Obj2n)	-5.5424 **	-5.1642 **	-	-
	-21.164	-16.667		
ln(1+Obj3n)	13.6279 *	33.953	-	-
	-72.911	-52.630		
ln(1+F1n)	-	-	-0.0044 ***	-0.0022 *
			(0.0013)	(0.0011)
ln(1+F2n)	-	-	0.0016	-0.0005
			(0.0011)	(0.0010)
ln(1+F3n)	-	-	0.0031 **	0.0032 **
			(0.0010)	(0.0009)
ln(1+F4n)	-	-	0.0019 **	0.0003
			(0.0010)	(0.0016)
ln(1+F5n)	-	-	-0.0001	0.0023 **
			(0.0006)	(0.0009)
lnGFCFr	0.0200 **	0.0688 **	0.0189 **	0.0648 **
	(0.0079)	(0.0240)	(0.0089)	(0.0201)
lnGCONSr	-0.0246 **	-0.1109 **	-0.0235 **	-0.1134 **
	(0.0080)	(0.0446)	(0.0079)	(0.0426)
lnHp	0.0145 ***	0.0407	0.0183 ***	0.0325
	(0.0041)	(0.0259)	(0.0038)	(0.0240)
lnHTXp	0.0019	0.0043	0.0031	0.0019
	(0.0019)	(0.0047)	(0.0019)	(0.0051)
lnOPENr	0.0031	0.0959 **	0.0077 **	0.0937 **
	(0.0024)	(0.0296)	(0.0029)	(0.0320)
GE	0.0008 ***	0.0017 **	0.0005 **	0.0011 *
	(0.0002)	(0.0005)	(0.0002)	(0.0006)
y2001	-0.0127 **	-0.0085 **	-0.0106 **	-0.0134 **
	(0.0051)	(0.0041)	(0.0052)	(0.0038)
y2002	-0.0121 **	-0.0033	-0.0099 *	-0.0084 *
	(0.0051)	(0.0057)	(0.0052)	(0.0042)
y2003	-0.0121 **	-0.0012	-0.0122 **	-0.0073
	(0.0054)	(0.0073)	(0.0055)	(0.0053)
y2004	-0.0035	0.0045	-0.0046	-0.0026
	(0.0049)	(0.0087)	(0.0054)	(0.0057)
y2005	-0.0048	0.0059	-0.0064	-0.0033
	(0.0050)	(0.0101)	(0.0052)	(0.0067)
y2006	0.0051	0.0130	0.0018	0.0018
	(0.0052)	(0.0125)	(0.0054)	(0.0090)
y2007	0.0045	0.0144	0.0022	0.0032
	(0.0058)	(0.0135)	(0.0059)	(0.0104)

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dep. var.:	$lny_t - lny_{t-1}$			
	pooled OLS (1)	**FE** (2)	**pooled OLS** (3)	**FE** (4)
y2008	-0.0288 ***	-0.0098	-0.0271 ***	-0.0195 *
	(0.0063)	(0.0150)	(0.0071)	(0.0113)
y2009	-0.0951 ***	-0.0550 ***	-0.0841 ***	-0.0564 ***
	(0.0087)	(0.0122)	(0.0082)	(0.0095)
y2010	-0.0191 **	0.0011	-0.0062	0.0022
	(0.0071)	(0.0124)	(0.0084)	(0.0119)
y2011	-0.0155 **	0.0017	-0.0071	-0.0022
	(0.0063)	(0.0155)	(0.0075)	(0.0134)
y2012	-0.0351 ***	-0.0157	-0.0215 **	-0.0142
	(0.0064)	(0.0162)	(0.0081)	(0.0147)
y2013	-0.0282 ***	-0.0100	-0.0161 **	-0.0085
	(0.0062)	(0.0164)	(0.0079)	(0.0149)
_cons	-0.0237	0.2352	-0.0277	0.2540
	(0.0293)	(0.1962)	(0.0296)	(0.1497)
S	388	388	3888	388
R^2	0.6998	0.2530	0.7080	0.2547
model test	F(23,364)	F(25,27)	F(25,362)	F(22,27)
p value	0.0000	0.0000	0.0000	0.0000

For (2) [(4)]: R^2 within = 0.7512 [0.7622], R^2 between = 0.763 [0.7453]
Standard Errors robust (pooled OLS) /adjusted for the 28 clusters (FE)
F1 = ERDF, F2 = ESF, F3 = EAGGF, F4 = FIFG, F5 = CF

Table 8: Convergence given SF distinctions and controls, EU-28, 2000-2013

After these estimations, it is to wonder what kind of results the GMM may yield, especially since (i) controlling for endogenous variables requires using more instruments, endangering econometric validity, and (ii) typical GMM instruments are made from the present variables rather than external sources (which should then be acknowledged somehow to better describe growth). Indeed, in another set of draft regressions for this dissertation, and for various choices of covariates, lags, and instruments, statistical significance exists for "convergence" in levels or growth rates in several cases, but not for almost any control (including Structural Funds and Gross Fixed Capital Formation as a traditional proxy for savings rates), the required exogeneity of instruments and the lack of second or higher-order differenced error autocorrelation simultaneously. To demonstrate the extent of this challenge, ignoring decomposition of Structural Funds by Fund and Objective, a "very fairly" correct GMM model for the impact of SF on EU growth is presented in Table 9 along with problematic "augmented" versions, without comments. Attention is drawn to the sensitivity of estimations to the exact specification: signs and magnitudes may change dramatically at the slightest change. Readers of the present work are most welcome to suggest demonstrably valid alternatives or explanations why such solutions cannot be provided.

dep. var.:	lny_t		$lny_t - lny_{t-1}$	
GMM:	**sys.** (1)	**diff.** (2)	**sys.** (3)	**diff.** (4)
lny_{t-1}	0.9332 ***	0.8024 ***	-0.0326	-0.3355 ***
	(0.0378)	(0.0053)	(0.0228)	(0.0933)
ln(1+StrFn)	24.81 *	-0.1928	-3.8100 ***	-1.2491
	(12.5944)	(0.1498)	(0.9667)	(1.2594)
lnGFCFr	-0.1452	0.1372 ***	0.0638	0.1015 *
	(0.2018)	(0.0043)	(0.0476)	(0.0612)
g_{t-1}	-	-	0.0339	-0.0094
			(0.1030)	(0.1373)
lnCONSr	-	-	-0.0670	-0.3003
			(0.1377)	(0.2226)
lnHp	-	-	-0.0992	0.0709
			(0.1150)	(0.0849)
lnHTXp	-	-	0.0092	-0.0035
			(0.0292)	(0.0161)
lnOPENr	-	-	0.1497	0.1398 **
			(0.0988)	(0.0623)
GE	-	-	0.0002	0.0002
			(0.0011)	(0.0024)
y2007	-	-	0.0025	0.0014
			(0.0075)	(0.0071)
y2008	-	-	-0.0320 ***	-0.0140 *
			(0.0079)	(0.0081)
y2009	-	-	-0.0650 ***	-0.0321 **
			(0.0102)	(0.0116)
y2010	-	-	0.0070	0.0094
			(0.0077)	(0.0126)
_cons	-0.0842	0.7753 ***	0.5033	0.3240
	(0.2781)	(0.0231)	(0.5238)	(0.4322)
N	193	361	361	333
instruments	5	39	56	91
model test	F(3,27)	Wald $\chi^2(3)$	Wald $\chi^2(13)$	Wald $\chi^{13}(2)$
p-value	0.0000	0.0000	0.0000	0.0000
AR(1) p	0.545	0.000	0.014	0.205
AR(2) p	0.373	0.001	0.185	0.081

For (1): one-step estimation, robust errors, small-sample correction, year<2007
Sargan/Hansen/Difference-in-Hansen difference tests: p-value > 0.600
For (2): two-step estimation, Sargan test: p-value 0.812
For (3): one-step estimation, Sargan test: p-value 0.000, rest: 1.0 >= p-value > 0.1
For (4): two-step estimation, robust errors

Table 9: Convergence given various growth factors, EU-28, 2000-2013: GMM

Group	Countries
North	AT, BE, DE, DK, FI, FR, IE, LU, NL, SE, UK
CEE	BG, CZ, EE, HR, HU, LT, LV, PL, RO, SI, SK
South	CY, ES, GR, IT, MT, PT

Table 10: EU-28 MS subgroups by region, as used in the European Investment Bank paper of 2016 titled "Restoring EU competitiveness - 2016 updated version".

On beta-convergence in clubs and parameter heterogeneity

If the assumption that a common growth equation describes the whole set of EU-28 countries is relaxed, it is possible to look for different convergence speeds $|\beta|$ in subgroups within which economies are more likely to exhibit similar behaviours and relatively homogeneous production function parameters. An approach is to divide the sample by location, automatically accounting for fixed and non-fixed effects of geography on growth, eg. parallel responses to common shocks (Durlauf, 2005). Coincidentally, as observed in the Introduction section, separating Member States into three broad geographical areas - North, South, Central & Eastern Europe (CEE) - means grouping them into income tiers - high, middle and low GDP p.c., respectively. This can help examine club convergence in the sense of the *scale* of initial GDP p.c. (and of the factors behind it) actually influencing β estimates (contrary to the typical Solow-Swan predictions that economies can converge conditionally at the same rate regardless of initial wealth). Also, it accounts for other group-specific traits; for example, part of the general growth of CEE countries has been attributed to outward migration rather than productivity increases (Leitner & Römisch, 2015), while the South is said to have functioned with institutions and policies which adversely influenced its response to the 2008-2010 crises (Balcerowicz et al., 2013).

Even if some would prefer to cluster countries based on purely statistical methods (eg. with machine learning algorithms confirming resemblance of features like variables GFCFr, Hp, population growth rates, bilateral trade relationships and so on), the spatial classification in Table 10 is used instead to run the pooled OLS and FE regressions shown in Table 11.

Two remarks that can be immediately made when looking at Table 11 are that (i) convergence speed $|\beta|$ appears greater for CEE countries than for the North, while Southern economies tend to diverge, and ii) Structural Funds seem to be of positive impact on growth. Also, panel variables have the expected signs when statistically significant, R^2 values are very high and the variable for year 2009 has the most negative and statistically significant effect of all time dummies. However, looking at the signs of the majority of time dummies and, mainly, the sub-sample sizes, over-fitting is most probable here (ie. the proposed model fits the data too well and thus is not flexible to fit other samples). Reducing the number of regressors, eg. by including only one time-dummy for the 2008-2010 period, would change the picture. GMM regressions would fail anyway just because observations per country group are too few to generate meaningful instruments (given the autocorrelation and endogeneity problems encountered in previous segments). Still, club convergence is worth further investigation.

dep. var.:	$lny_t - lny_{t-1} = g_t$				
	p. OLS (1)	**FE** (2)	**p. OLS** (3)	**FE** (4)	**p. OLS** (5)
lny_{t-1}	-0.0062	-0.1663 **	-0.0345 ***	-0.3762 **	0.0258
	(0.0068)	(0.0503)	(0.0071)	(0.1045)	(0.0303)
ln(1+StrFn)	5.2580 **	4.6863 **	0.0524	0.8459	1.0515 *
	(-1.5759)	(-2.0755)	(0.4574)	(0.8633)	(0.5387)
lnGFCFr	-0.0125	0.0113	0.0307 *	0.0586 **	0.0141
	(0.0099)	(0.0198)	(0.0185)	(0.0504)	(0.0225)
lnGCONSr	-0.0052	-0.1080 *	-0.0537 **	-0.1272 **	.0542
	(0.0081)	(0.0567)	(0.0262)	(0.0516)	(0.0508)
lnHp	-0.0004	-0.0388	0.0788 **	-0.2828	0.0164 *
	(0.0132)	(0.0456)	(0.0298)	(0.1745)	(0.0095)
lnHTXp	0.0005	0.0161 **	0.0047	0.0290 **	-.0002
	(0.0034)	(0.0040)	(0.0047)	(0.0098)	(0.0028)
lnOPENr	0.0018	0.0218	-0.0005	-0.0054	0.0505 *
	(0.0039)	(0.0477)	(0.0109)	(0.0534)	(0.0193)
GE	0.0007	-0.0005	0.0005	0.0013	-0.0004
	(0.0005)	(0.0009)	(0.0004)	(0.0009)	(0.0004)
y2001	-0.0217 ***	-0.0143 **	0.0026	0.0156 **	-0.0191 **
	(0.0029)	(0.0032)	(0.0086)	(0.0068)	(0.0085)
y2002	-0.0236 ***	-0.0103 *	0.0069	0.0403 **	-0.0263 ***
	(0.0038)	(0.0053)	(0.0086)	(0.0151)	(0.0082)
y2003	-0.0271 ***	-0.0097	0.0103	0.0595 **	-0.0347 ***
	(0.0040)	(0.0072)	(0.0077)	(0.0194)	(0.0129)
y2004	-0.0134 **	0.0033	0.0112	0.0742 **	-0.0317 ***
	(0.0040)	(0.0082)	(0.0076)	(0.0249)	(0.0102)
y2005	-0.0149 ***	0.0036	0.0101	0.0914 **	-0.0329 ***
	(0.0039)	(0.0115)	(0.0081)	(0.0274)	(0.0079)
y2006	-0.0051	0.0134	0.0178 **	0.1145 **	-0.0295 ***
	(0.0037)	(0.0117)	(0.0081)	(0.0351)	(0.0108)
y2007	-0.0039	0.0201	0.0121	0.1300 **	-0.0367 ***
	(0.0044)	(0.0157)	(0.0113)	(0.0409)	(0.0113)
y2008	-0.0393 ***	-0.0079	-0.0263 *	0.1137 **	-0.0563 ***
	(0.0058)	(0.0134)	(0.0138)	(0.0450)	(0.0119)
y2009	-0.0900 ***	-0.0489 **	-0.1291 ***	0.0353	-0.0908 ***
	(0.0076)	(0.0114)	(0.0177)	(0.0449)	(0.0105)
y2010	-0.0152 **	0.0154	-0.0330 **	0.1087 **	-0.0510 ***
	(0.0061)	(0.0120)	(0.0125)	(0.0443)	(0.0150)
y2011	-0.0193 ***	0.0117	-0.0143	0.1298 **	-0.0630 ***
	(0.0045)	(0.0141)	(0.0130)	(0.0478)	(0.0141)
y2012	-0.0393 ***	-0.0051	-0.0381 **	0.1193 **	-0.0735 ***
	(0.0045)	(0.0149)	(0.0134)	(0.0527)	(0.0099)
y2013	-0.0361 ***	-0.0015	-0.0350 **	0.1279 **	-0.05840 ***

(*continued on next page...*)

(...*continued from previous page*)

dep. var.:	$lny_t - lny_{t-1}$				
	p. OLS (1)	**FE** (2)	**p. OLS** (3)	**FE** (4)	**p. OLS** (5)
	(0.0054)	(0.0160)	(0.0134)	(0.0548)	(0.0096)
_cons	-0.0423	0.6110 *	-0.3203 *	1.7105 *	0.1282
	(0.0467)	(0.2903)	(0.1623)	(0.8293)	(0.1065)
S	153	153	152	152	83
R^2	0.8132	0.7780	0.7577	0.7577	0.7025
model test	F(21,131)	-	F(21,130)	-	F(21,61)
p value	0.0000		0.0000		0.0000

For (2): R^2 within = 0.8464, R^2 between = 0.1168 (models (1)-(2): North)
For (4): R^2 within = 0.7519, R^2 between = 0.8423 (models (3)-(4): CEE)
An appropriate FE model (6) for South (model 5) is omitted (R^2 within = 0.7119)
Standard Errors robust (pooled OLS) /adjusted for the 28 clusters (FE)

Table 11: Convergence in country groups, EU-28, 2000-2013

Conclusion

Summary of findings and discussion of results

Starting with a Solow-Swan model of economic growth and controlling for variables empirically shown to affect GDP per capita across economies and over time, no positive statistically significant effect has been found for contemporaneous payments from Structural Funds, the main financial tool of the European Union for reducing disparities between its regions. Still, in the latest EU integration stages, which saw European economies experiencing growth and then being suddenly hit by the crisis years to slowly begin recovering afterwards, a negative correlation of initial GDP p.c. with subsequent growth rates is observed on an annual basis on average. Indeed, "convergence speeds" of 2.0% and above on absolute terms and 2.4% and above under certain conditions are observed for the whole sample of 28 Member States, improving hopes that poorer countries can catch-up to richer countries eventually. Some hints that countries tend to cluster regarding their economic performance also appear, while there is clear evidence that the dispersion of GDP p.c. among Member States has narrowed.

Unfortunately, the panel-data single-equation estimation techniques used to derive most of these outcomes cause as many problems as they solve. First, their theoretical basis of capital accumulation is only one of the possible mechanisms of growth, and there could be alternatives to perceiving SF as an individual production factor (eg. SF could be instruments to K and H themselves. Hagen & Mohl in 2009 refer to the channels of total factor productivity and employment and the possibility of "bad controls".). Also, the assumption that the same variable coefficients hold on average for all economies under study may not be very accurate. Quah (1996) has even suggested that repeated empirical findings of convergence speeds $|\beta|$ around 2% (up until his writing of the relevant paper, at least) are quite likely due to the presence of unit roots in the data rather than actual growth-inducing factors and policies to manage these factors; he also draws attention to the need for analysing the *dynamics of evolving distributions* (in other words, σ-convergence). Against this scepticism, though, one could claim that finding $|\beta|$s substantially different to 2% (eg. of reverse sign or double the value) indicates real growth changes and not just statistical effects. And as long as the selected covariates have the expected signs and significance, success in modelling growth can be inferred.

A second concern is that each regression method (OLS, RE, FE, GMM, and other solutions, like Non-Linear Least Squares) introduces its own distortions in estimations: OLS strategies are said to bias convergence speeds down, FE tactics are regularly seen to "inflate" coefficients and instrument-based models, which are supposed to deal with endogeneity, need to satisfy certain often hard-to-achieve "constraints", depending on specification; also, the complications of autocorrelation are not always fully remedied. Consequently, one cannot be sure about how fast different economies may approach each other. Finally, despite tremendous progress over the recent decades in maintaining statistics databases, limited sample sizes, measurement errors and weak proxies for variables at the chosen aggregation level are frequent, and any interactions between economic units with effects on growth often cannot be adequately described.

As much as different samples can produce similar estimates, results in this dissertation do not really contradict a series of scientific articles referenced here, especially with GMM. Esposti & Bussoletti (2008) find negative insignificant effects of three-year moving-average regional SF-"treatments" on subsequent growth. Mohl & Hagen (2010) find a lot of negative or positive insignificant results in their specifications. Beugelsdijk & Eiffinger (2005) mostly find positive insignificant impacts of lagged SF variables in models with growth lags, unchecked for autocorrelation beyond order 2 and with "too-perfect" Sargan-test p-values of 1. P. Breidenbach, T. Mitze and C. Schmidt, in a report titled "EU Structural Funds and Regional Income Convergence – A sobering experience" (Ruhr Economic Papers, N. 608, 2016), also detect some "negativity". The last two papers present $|\beta|$s which are helpfully high (as explained in the Appendix) at about 15%; the second one does so for non-GMM models, and the first one gives various $|\beta|$s up to about 10%. Roodman (2009), explaining the adoption of GMM in Stata, talks about a "black box" and a danger of invalid estimates upon misuse of GMM commands.

The issue is that Structural Funds may have been very useful even though this has not been revealed. For instance, it is estimated that about 395,000 jobs were created up to the end of 2011 as a direct result of ERDF support within the 2007-2013 framework (Ward et al., 2013). Notwithstanding controversies about the cost-effectiveness of SF-financed activities, some positive influence of the Cohesion Policy could exist. Would things be better if no redistribution took place in the European Union? this cannot be verified. It is the author's opinion that the EU auditing system should monitor budgets even more carefully and that single-equation estimations should be viewed in conjunction with detailed descriptive statistics in order to make informed decisions.

Ideally, a few parsimonious equations would suffice to describe the process of growth universally, facilitating the exposure of any positive impacts of policies like Structural Funding meanwhile. But as Durlauf (2005) aptly notes, "*those who are only satisfied with the specification and estimation of a structural model, in which parameters are either 'deep' or correspond to precisely defined causal effects within a coherent theoretical framework, will be permanently disappointed*" and "*this reflects the shortcomings of economic theory as well as those of data and econometric analysis*".

This does not prevent the interested from testing the importance of different growth regressors in various functional forms; however, chances are that new statistical patterns will emerge in growth empirics before befitting theories are developed to guide policy makers. With phenomena like *big data* and *open data* in today's world, it should be possible to trace growth factors which may not be conventional in traditionally economic sense. Until then, "normal" growth /convergence equations can be applied not just on GDP p.c. but other indicators of economic and social development too, with analysis focusing on their distribution characteristics in space and time.

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Appendix

Introduction: The EU Member States in short

Here are two tables with useful information on the EU countries:

Country	Code	Country	Code	Country	Code
Austria	AT	Great Britain	GB [UK]	Malta	MT
Belgium	BE	Greece	GR [EL]	Netherlands	NL
Bulgaria	BG	Croatia	HR	Poland	PL
Cyprus	CY	Hungary	HU	Portugal	PT
Czech Republic	CZ	Ireland	IE	Romania	RO
Denmark	DK	Italy	IT	Sweden	SE
Estonia	EE	Lithuania	LT	Slovenia	SI
Spain	ES	Luxembourg	LU	Slovakia	SK
Finland	FI	Latvia	LV		
France	FR	Lithuania	LT		

Table 12: Abbreviation standards for the 28 EU Member States. Codes in brackets are preferred in the EU context, else the corresponding ISO 3166-1 alpha-2 codes are used. The protocol name order is different and based on the country names in Latin (EU Interinstitutional Style Guide, 2011).

MS	Accesion	Euro	MS	Accesion	Euro	MS	Accesion	Euro
AT	1995	yes	DE	1958	yes	MT	2004	yes
BE	1958	yes	UK	1973	no	NL	1958	yes
BG	2007	no	EL	1981	yes	PL	2004	no
CY	2004	yes	HR	2007	no	PT	1986	yes
CZ	2004	yes	HU	2004	no	RO	2007	no
DK	1973	yes	IE	1973	yes	SE	1995	no
EE	2004	yes	IT	1958	yes	SI	2004	yes
ES	1986	yes	LV	2004	yes	SK	2004	yes
FI	1995	yes	LT	2004	yes			
FR	1958	yes	LU	1958	yes			

Table 13: Accession year and Eurozone membership for the 28 EU Member States (Europa.eu, 2016).

Here are the GDP p.c. paths for the 28 Member States of the EU during years 2000-2013

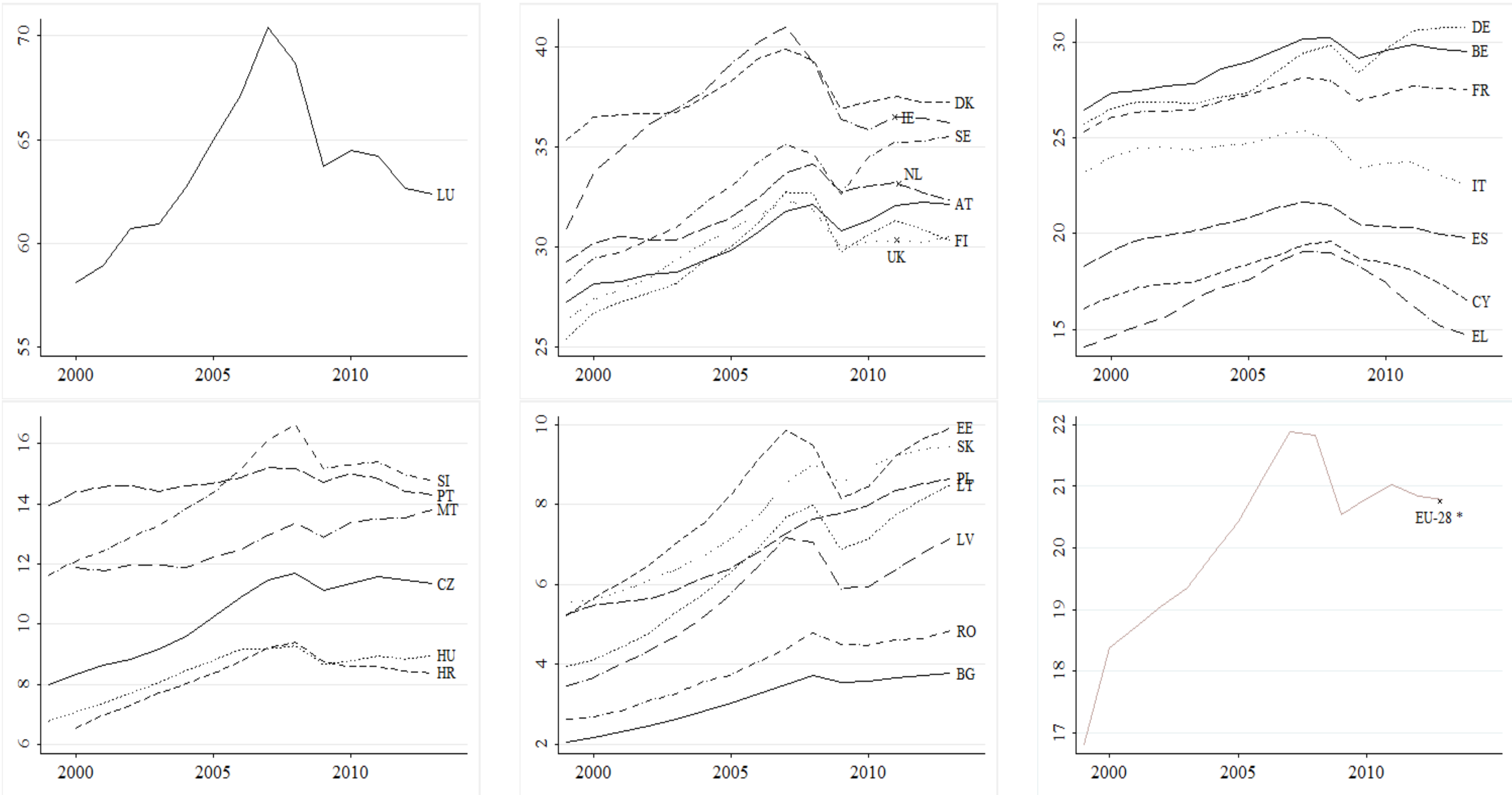

Figure 12: GDP per capita (thousand EUR, chain-linked volumes, reference year 2005) for the 28 Member States of the EU, years 2000-2013. Data: Eurostat, nama_gdp_k and nama_10_pe tables, 2016.

Here are the GDP p.c. growth rate paths for the 28 Member States of the EU during years 2000-2013

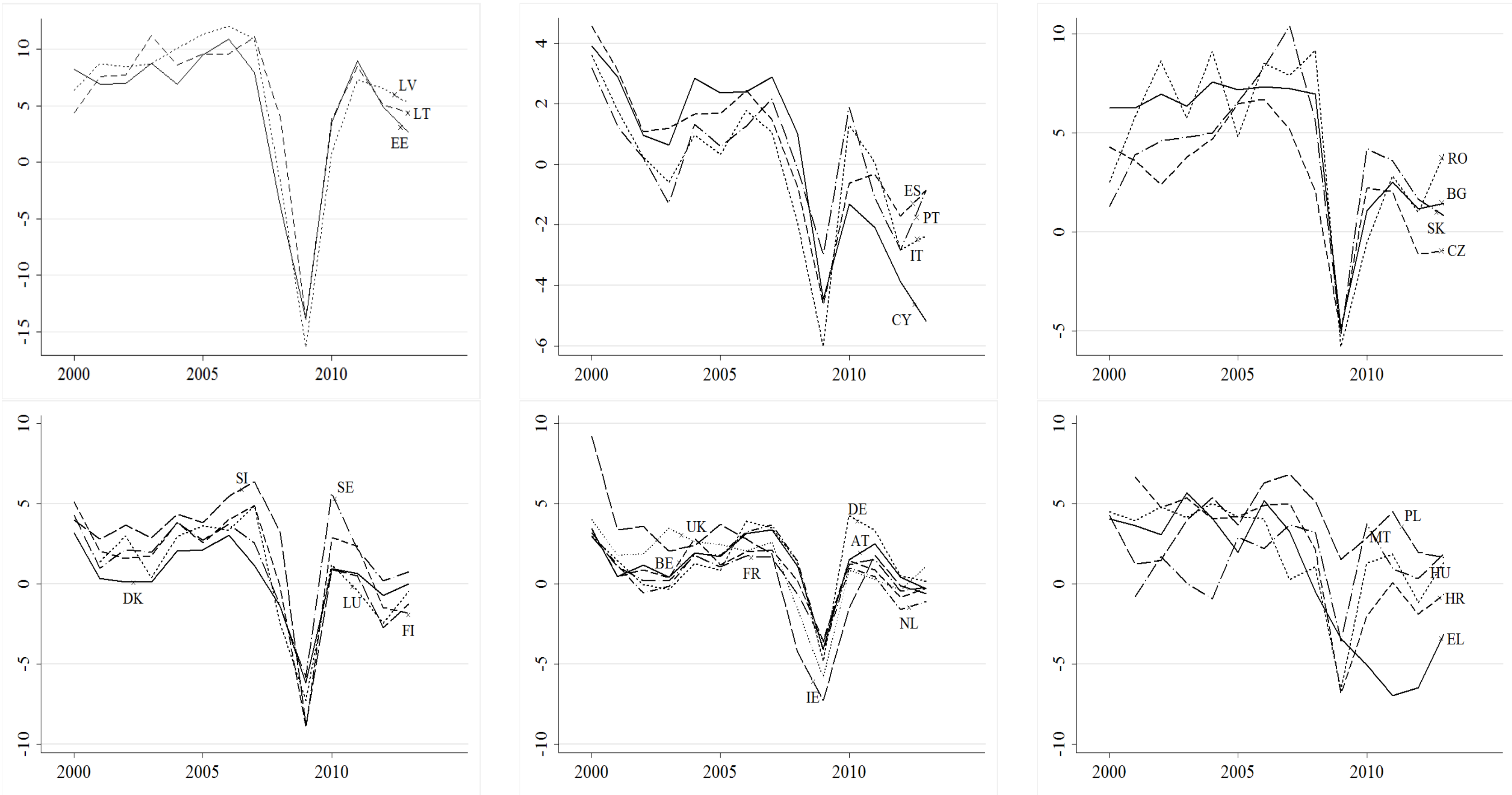

Figure 13: GDP per capita growth rates (% change over the previous year; GDP p.c. in thousand EUR, chain-linked volumes, reference year 2005) for the 28 EU MS, years 2000-2013. Data: Eurostat, nama_gdp_k and nama_10_pe tables, 2016.

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«The Union's aim is to promote peace, its values and the well-being of its peoples. The Union ... shall promote economic, social and territorial cohesion, and solidarity among Member States.» (Articles 1-3 of the New Treaty on European Union)

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Theory: A frequent formulation of the Solow-Swan production model

The most widely used formula for describing neo-classical growth is the Cobb-Douglas production function. This formula expresses in a simple mathematical way the plausible assumption of increasing difficulty when substituting more of a certain input for another, while, of course, emboding the neo-classical requirement of constant returns to scale. So constructed, when fitted to real-world data, it allows for direct estimation of elasticities (scaled responsiveness of output to changes in inputs) with little evidence opposing its validity (Burnside, 1995; European Commission, 2010).

Cobb-Douglas production functions typically appear as:

$$Y(t) = AK(t)^a L(t)^{1-a} \qquad 0 < a < 1 \tag{28}$$

where Y is output, A is a constant expressing technology, K is physical capital, L is labour and a is a parameter, as is known. Eq. 28 naturally satisfies the Inada conditions and exhibits positive marginal returns to input and constant returns.

Mankiw, Romer and Weil (1992) have had success fitting a modified version of Eq. 28 to cross-country data and have thus influenced how the Solow-Swan model is regularly seen in literature, namely a growth model with *labour-augmenting technology and human capital*. Their work yields the following:

$$Y(t) = K(t)^a H(t)^b [A(t)L(t)]^{1-a-b} \qquad 0 < a, b < 1 \tag{29}$$

$$y(t) = k(t)^a \cdot h(t)^b \qquad \text{(dividing with AL)} \tag{30}$$

$$\dot{x}(t) = s_x \cdot y(t) - (n + g + \delta) \cdot x(t) \qquad x \in \{K, H\} \tag{31}$$

$$k^* \equiv k_{\dot{k}(t)=0} = \left(\frac{s_k^{1-b} s_h^b}{n + g + \delta} \right)^{1-a-b} \qquad h^* \equiv h_{\dot{h}(t)=0} = \left(\frac{s_h^{1-a} s_k^a}{n + g + \delta} \right)^{1-a-b} \tag{32}$$

where AL can be thought of as effective labour, g $\equiv \dot{A}/A$, n $\equiv \dot{L}/L$, δ is the depreciation rate and s is the savings rate for the corresponding type of capital, physical (K) or human (H); both are equally depreciable and can be accumulated at decreasing marginal benefits. Parameters a and b represent each factor's "share of income" under perfect competition. Asterisks stand for the steady state.

Substituting the steady-state capital endowments into the production function and taking natural logarithms, there hold:

$$ln\left[\frac{Y(t)}{L(t)}\right] = lnA(0) + gt + \frac{-(a + b) \cdot (n + g + \delta) + a \cdot ln(s_k) + b \cdot ln(s_h)}{1 - a - b}, \qquad \text{or} \tag{33}$$

$$ln\left[\frac{Y(t)}{L(t)}\right] = lnA(0) + gt - \frac{a}{1 - a} ln(n + g + \delta) + \frac{a}{1 - a} ln(s_k) + \frac{b}{1 - a} ln(h^*) \tag{34}$$

which give an idea of how steady-state alternative capital forms are correlated with output per capita at any given moment; the same equations would be valid when economies save (invest) in education or health or R&D and so on like they do for physical capital. A problem, though, as noted by the authors, is whether available data suit more one of the two equations presented above or another.

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Research Results: List of instruments for GMM models

Two-step GMM equation instruments by Table and Model
(T = Table, M = Model, L = lag, D = difference, (/) = order, col = collapsed):

T4.M4: differences, GMM-type: L(2/.).y // levels, standard: _cons

T5.M4: differences, GMM-type: L(2/.).y // differences, standard: D.ln(1+StrFn) // levels: _cons

T6.M1: differences, GMM-type: L(2/3).growth, L(2/3).ln(1+StrFn) // differences, standard: LD.y, D.ln(1+StrFn) // levels, standard: _cons

T6.M2: differences, GMM-type: L(1/3).(L.growth L.y ln(1+StrFn) // levels, GMM-type: D.(L.growth L.y ln(1+StrFn)) // levels, standard: _cons

T6.M3: differences, GMM-type: L(2/3).y L(2/3).ln(1+StrFn) // differences, standard: LD.y D.ln(1+StrFn) // levels, standard: _cons

T6.M4: differences, GMM-type: L(1/3).(L.y ln(1+StrFn)) // levels, GMM-type: D.(L.y ln(1+StrFn)) // levels, standard: _cons

T6.M5: differences, GMM-type: L(1/3).L.y // differences, standard: D. L.y // levels, standard: _cons

T9.M1: differences, GMM-type: L(2/4).y col // levels, standard: _cons // levels, GMM-type: DL.y col

T9.M2: differences, GMM-type: L(2/4).y // differences, standard: D.ln(1+StrFn) D.lnGFCFr // levels, standard: _cons

T9.M3: differences, GMM-type: L(2/.).growth col, L(2/.).y col, L(1/.).(ln(1+StrFn) lnGFCFr) collapsed // levels, standard: _cons // levels, GMM-type: DL.growth col DL.y col, D.(ln(1+StrFn) lnGFCFr) col

T9.M4: differences, GMM-type: L(2/.).growth // differences, standard: LD.growth LD.y D.ln(1+StrFn) D.lnGFCFr D.lnGCONSr D.lnHp D.lnHTXp D.lnOPENr D.GE D.y2007 D.y2008 D.y2009 D.y2010 // levels, standard: _cons

Table 14: Instruments used in GMM models in the Research Results section

Conclusion: A comment on the meaning of convergence speed estimates

Barro (2012) calculates that a convergence speed $|\beta|$ of 2% per year corresponds to elimination of 50% of the initial gap in lny within 35 years (half-life) and 90% of the same gap at 115 years. Thus, higher convergence speeds help eliminate the initial distance from the steady state in shorter amounts of time. (To be precise, Barro defines b in Eq. 16 as the convergence speed. But, as $e^x \sim$1+x in Taylor expansion, $1 - e^{-bt} \sim 1 - (1 - bt) = -bt$ and, annually, when b~0.02, then $\beta \sim$0.02).

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Thank You for reading