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The Knowledge-Based Economy, Convergence and Economic Growth: Evidence from the European Union

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CENTRE OF PLANNING AND ECONOMIC RESEARCH

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ABSTRACT

The aim of this study is to estimate the effect that the knowledge-based economy objective may have on economic growth; which is the ultimate objective of the EU's Lisbon Strategy (LS). In particular we are interested in identifying whether policies and investments linked with the transition to a knowledge-based economy (R&D effort, quality of human resources, innovation capacity, IT diffusion, access to finance & information society) are related to higher economic growth. In order to approach the above research hypothesis, a growth equation is used, based on Barro & Sala-i-Martin (1995), for the 1990-2003 period. It includes a panel data set consisting of the annual growth rates of GDP per capita (PPS) for the 15 EU member-states and a group of indicators that define the knowledge-based economy. The GMM-DIFF Arellano-Bond estimator is applied in this dynamic panel data model. The existence of absolute convergence is estimated as well, as are the effects and significance that indicators of the knowledge-based policy have in the growth equation. Growth empirics were estimated regarding the full sample, as well as two sub-groups consisting of high and low-income member-states. Results suggest that R&D expenditure originating from abroad affect significantly and positive GDP rates, while human capital educational characteristics (youth educational attainment levels) and investments in ICT (IT equipment) also affect significantly and positive GDP rates.

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1. Introduction

Over the recent years, the macroeconomic performance of the European Union (EU) has been conspicuously weak, with low growth and high unemployment, in absolute and relative term to the rest of the world (Savva-Balfoussias et al, 2006). While many EU countries are understandably preoccupied with extricating their economies from the relatively prolonged short run downturn, it is widely acknowledged that many of the solutions to this slow growth problem require a longer term policy objective (EC, 2005). The launch of the Lisbon Strategy (LS) (2000) by the European government leaders signalled the initiation of an agenda aiming at introducing employment and productivity enhancing reforms in order for Europe "*…to become the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion...*". This strategy is implemented through a combination of policies, aiming at boosting the information society and R&D, accelerating structural reforms for competitiveness, enhancing innovation and completing the internal market, while modernising the European social model. Simultaneously to the above, a macroeconomic policy mix that favours growth is applied. This mixture of ambitious objectives and policies has an implementation period from 2000 until 2010.

In light of the above, the purpose of this paper is to estimate the effect that the knowledge-based economy objective may have on the growth process which is the ultimate objective of the strategy. In other words, our objective is to access whether policies and investments linked with the transition to a knowledge-based economy such as R&D effort, the quality of human resources used, the innovation capacity, the diffusion of ICT and the information society are related to higher economic growth rates.

In order to achieve this, the second section of the paper defines the economic significance of the knowledge society and its wider implications for growth, with a presentation of the main objectives of the Lisbon Agenda. The third section briefly reviews the associated growth theories and relevant empirical studies. The fourth section describes the empirical model, its theoretical foundations and the data. Finally, the fifth section presents the estimation results with respect to the full sample and two sub-groups consisting of high and low-income member-states; while the closing part offers some conclusions and policy considerations.

2. The Lisbon Strategy and the Knowledge-Based Economy (KBE)

In the Lisbon European Council (2000), the European Union (EU) adopted the ambition to transform itself into the most competitive and dynamic economy in the world, based on knowledge and sustainability, with higher employment rates and increased social cohesion (EC, 2000a). In order to achieve this, the Council decided to launch a 10-year strategy (from 2000 to 2010) focused on reaching a leading economic position in dynamic and competitive terms, based on four axes[1], namely (a) *Reaching a knowledge-based economy*, after (b) *Modernising the European social model*; (c) *Developing a framework of appropriate and stability-oriented macroeconomic policies*; and (d) *Achieving sustainable development* (EC, 2001). According to the Commission (EC, 2000b), the implementation of these policies would result in a sustainable and non-inflationist growth, with lower unemployment rates and more sustainability of public finances. These axes are also quantified in structural indicators, in order to guarantee the deliverance of clear, simple and focused policy messages for the evaluation of the evolution of the overall strategy (EC, 2003).[2]

But why is the knowledge-based economy (KBE) model a central element of the EU's strategic agenda? To understand knowledge as an economic driver, we must first define its importance in the modern society. According to the British Department of Trade and Industry (DTI, 1998) "…it is an economy in which the generation and the exploitation of knowledge have come to play the predominant part in the creation of wealth. It's not simply about pushing back the frontiers of knowledge; it is also about the more effective use and exploitation of all types of knowledge in all manner of economic activity…". So, considering the economic consequences of the knowledge society, understanding the so called 'tacit' nature of knowledge is often the basis of competitive advantage. Furthermore, it is not only important to extend the frontiers of knowledge, but also to diffuse and exploit the existing ones in order to improve current practices (Stiglitz, 1999).

Nowadays, economies are rapidly moving towards being more knowledge based, supporting the force of knowledge as a vital component of productivity and economic growth. As D. Coates & K. Warvick (1998) argue, four important

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[1] The Lisbon Strategy is extended to the New Member Sates of the European Union and the objectives implemented initially by the 15 Member States are also applied to the 10 new members as well.

[2] The selected indicators are mainly provided by the European Statistical System (Eurostat), so data sets can be mutually consistent, timely available and comparable across the Member - States.

influences can be identified as actors in increasing the pace of change. Firstly, revolutionary changes in Information and Communication Technology (ICT) have a striking impact in the overall productivity performance of individual countries. Secondly, more rapid scientific and technological advance emerged through large increases in the resources devoted to R&D from both enterprises and the government. Thirdly, competition is becoming more global as a result of falling tariffs, liberalisation of capital controls and lower transportation and transaction costs. Finally, changing demands and increased income are both potentially important drivers of the knowledge economy. Production is increasingly oriented towards quality, services and activities linked with rising incomes and changing tastes.

Regarding the EU's knowledge economy ambitions, the controversial issue lies in the knowledge creation and absorption system, with particular features of the EU's innovation model urgently requiring re-assessment. As it's evident from the Table 2 in the Appendix, dispersion exists among member-states regarding R&D investment and its different types (from the government or abroad). A sizable dispersion in information society and innovation capacity indicators is again particularly noticeable among the four largest countries and Portugal, Italy, Greece and Spain (see Table 3 in the Appendix). Finally, investment in capital ICT equipment, although increasing in growth rates, is overall modest (see Table 4 in the Appendix).

3. Growth Theory, Convergence and Knowledge

3.1. Theoretical issues

Growth theories have been classified as either neoclassical or endogenous. According to the neoclassical model (Solow, 1956; Swan, 1956), the convergence process is based on the existence of decreasing returns in capital accumulation. So, increases in capital lead to increases less than proportional in product. This condition explains the existence of a steady state level for the main magnitudes, such as product per unit of employment, to which the economy will lean after any transitory shock. Thus, poor economies will grow at higher rates than rich ones, guaranteeing convergence across all of them.

On the contrary, endogenous growth models incorporate mechanisms that determine the non-appearance of convergence. Initially, the fact of not imposing decreasing returns to capital (Romer, 1986 & 1990; Lucas, 1988) and mechanisms in which technological growth is a non decreasing function of some factors lead to models of non steady state or long run equilibrium. Hence, increases in output can be sustained in the long run through knowledge-related investments that are not subject to diminishing returns at the aggregate level. Such investments give rise to beneficial external effects which offset the limiting consequences of increasing capital per worker within a given firm; hence, while investments by individual firms remain subject to diminishing returns, there is no decline in the overall marginal product of capital.

New growth theories have shown that new knowledge is an especially valuable factor of production, by taking account the unique characteristics of information and, in particular, its ability to be passed from user to user without losing its usefulness (i.e. its non-rival character). Investments in equipment embodying new technological developments, and in education, invention, and related knowledge-enhancing activities are seen to be the key to overcoming the impact of the diminishing returns that come into play as workers are equipped with increased capital. Technological progress makes it possible to extract greater value from limited resources and sustain the economy's growth over the long-term (Romer, 1986, 1990; and Lucas, 1988).

Finally, the new theories argue that the characteristics that make knowledge a highly valuable and productive commodity also make it difficult to establish an efficient knowledge market — that is, a market that provides incentives for both the production of knowledge and its distribution to all those who can benefit from it (Lamberton, 1999).

3.2. Empirical review

The empirical growth literature emphasizes knowledge and the creation of knowledge via the activities of firms, households and the government in both R&D and education, as significant drivers for enhancing the level of technology (total factor productivity) (EC, 2005). According to the European Commission (EC, 2003), a combination of regulatory reforms and a substantial increase in EU knowledge production (though investments in R&D and education) could boost EU potential growth rates by between ½ to ¾ of a percentage point annually over a 5-10 year horizon.

The present section attempts to categorise the immense empirical literature relating economic growth with (a) technology diffusion, R&D and innovation investments, (b) human resource development and (c) ICT investments and infrastructure. In the first group of studies, cross-country empirics investigate the link between R&D, innovation and international differences in growth rates. These studies indicate that high-income and high-productivity countries tend to be intensive in the use of knowledge and technology and their output is often characterised by innovative high-technology products and services (OECD, 1996, OECD 2000a, and OECD 2001a). Also, Porter (1999) argues that economies that have been more innovative have tended to achieve higher levels of GDP per capita. Many other cross-country empirics have showed that technological differences are the prime cause for differences in GDP per capita (i.e. Mankiw, Romer & Weil, 1992), indicating that the potential for catching-up exist for countries that have "social capability" and manage to mobilise the resources such as investments, education and R&D (Fagerberg, 1994). Additionally, Total Factor Productivity (TFP) studies also confirm the importance of capital-embodied technical change for productivity growth (Hulten, 1992; Wolff, 1996; Gera et al.1999).

Concentrating on the relation between R&D and economic performance, a consensus has emerged that innovation has a significant effect on output at the level of the firm, industry and country[3]. Although the role of R&D may differ between small and large economies (Griffith, Redding & Van Reenen, 1998), significant R&D and specifically knowledge spillovers between countries, firms and industries also exist (Cameron, 1998). Finally, the impact of technology diffusion and the use of new products is also emphasized in generating economic benefits amounting to more than fifty percent of productivity growth (OECD, 1990).

In the second group of studies, human capital is included in the productivity estimations as "…knowledge, skills, competencies and other attributes embodied in individuals that are relevant to economic activity…" (OECD, 1998). According to Benhabib & Speigal (1994), countries that invest in education and skill development are better positioned to identify new opportunities, and to develop and adopt new technology, as human capital is important in raising productivity because it serves to facilitate knowledge spillovers and the adoption of new technology (Harris, 1999). In their micro-level study Black & Lynch (1996) showed that, a 10% increase in average

[3] see the reviews by Cameron (1998) and Temple (1999).

education led to an 8.5% increase in manufacturing productivity and a 12.7% increase in non-manufacturing productivity.

Finally, in the third group of studies, a consensus exists in the important contribution of advanced ICT infrastructure in facilitating access to knowledge and promoting the spread of ideas. Firm-level studies strongly support the view that investment in ICTs, when accompanied by organisational change and higher worker skills, has had strong impacts on firm productivity in the manufacturing and in many service sectors (Broersma and McGuckin, 1999). In addition, Gera et al. (1999) argue that international R&D spillovers embodied in IT imports have a positive and significant impact on labour productivity growth. Regarding the EU and the exploitation of ICT it has been reported that its member-states, in general have not exploited the ICT growth potentials, as opposed to the U.S.A. (Daveri, 2002; OECD 2002).

4. Empirical Model

4.1. Theoretical background and data

The estimated model is derived from growth theory. In its fundamental form the neoclassical Solow-Swan model (1956) establishes that:

$$Y(t) = FK((t), L(t), t) \quad (1)$$

$$k = s \cdot f(k(t)) - n \cdot k(t) \quad (2)$$

where, Y(t) is the total output at time t, F(.) is a first degree homogeneous production function, K(t) is the stock of physical capital at time t, L(t) is the labour force at time t, and t gives the effects of technological progress, k(t)=K(t)/L(t) is capital per capita at time t, k =k (t) / dt is the derivative of k(t) with respect to time, s is the constant saving rate, f(k(t)) is production per capita, and n is population growth rate. It can be shown that this setting leads to the following per capita production growth rate γ_t ,

$$\gamma_t = -\varphi(k(t))\, y(t) + \varphi(k(t))\, y^*, \ \text{where } \gamma_t \equiv \frac{y}{y(t)} \quad (3)$$

and *y(t)* is output per capita at date t. The steady state y^* depends on several variables, including the constant saving rate s and the population growth rate *n*. The form of the function *φ*(.) depends on the production function *F(.)* and on the parameters of the equation system (1) - (2). In the special case where *F*(.) is a Cobb-Douglas function

$\varphi(k)$ is equal to $\varphi(1-\theta)$, where θ is the share of capital in total production. In that case, (3) is a differential equation with the solution

$$y(t) = e^{-\lambda t} y(0) + (1 - e^{-\lambda t})\, y^* \tag{4}$$

where $\lambda = \varphi(1-\theta)$. So, λ is the convergence speed parameter. For a given steady state, the larger the parameter λ, the faster the economy converges to its steady state. If λ is 0, there is no convergence and the economy remains stuck at its initial output level y (0). If λ goes to infinity, the economy reaches its steady state instantaneously.

In order to estimate the described scheme in panel data regressions we use the empirical framework suggested by Barro and Sala-I-Martin (1995). This framework relates real per capita growth rate to initial levels of state variables, such as the stock of physical capital and the stock of human capital, and to control variables. The control variables determine the steady-state level of output in the Solow-Swan model. Following Barro and Sala-I-Martin (1995), we assume that a higher level of initial per capita GDP reflects a greater stock of physical capital per capita. Following Soto (2000), we also assume that the initial stock of human capital is reflected in the lagged value of per capita output in the short-run. The Solow-Swan model predicts that, for given values of the control variables, an equiproportionate increase in the initial levels of state variables reduces the growth rate. Thus we can write the model of output per capita growth rate for our panel data set as

$$\frac{y_{it} - y_{i,t-1}}{y_{i,t-1}} \approx a y_{i,t-1} + X_{it}\beta + v_i + \tau_t + \varepsilon_{it} \tag{5}$$

where, y_{it} is per capita gross domestic product (GDP) in member-country i ($i=1,\dots,15$) during the period t ($t=1990,\dots,2003$), $y_{i,t-1}$ is the (initial) per capita GDP in region i in period t-1, a is a negative parameter reflecting the convergence speed, X_{it}, is a row vector of control variables in region i during period t with associated parameters β, v_i is a region-specific effect, τ_t is a period-specific effect common to all regions, and ε_{it} is the model's error term. If we assume that $\frac{y_{it} - y_{i,t-1}}{y_{i,t-1}} \approx \ln(y_{it} / y_{i,t-1})$ we can approximate equation (5) as

$$\ln (y_{it} / y_{i,t-1}) = a \ln y_{i,t-1} + \ln X_{it}\, \beta + v_i + \tau_t + \varepsilon_{it}. \tag{6}$$

Moving ln y_{it} from right-hand side to left-hand side, we obtain the dynamic panel data model

$$\ln y_{it} = (a+1) \ln y_{i,t-1} + \ln X_{it}\beta + v_i + \tau_t + \varepsilon_{it} \quad (7)$$

The possible control variables suggested by Barro & Sala-I-Martin (2004) include measures of market distortions, domestic investment, degree of openness of the economy, financial development, and political instability. Following Soto (2000) it is assumed that variations in the measures of market distortions, financial development and political instability are small during the relatively short time span. Thus the effects of these variables will not be revealed in the time dimension, but will appear in the cross-region dimension. However these effects will be embodied in the country-specific effect, which disappears in the difference variable estimation methodology.

Regarding this study we use three control variables suggested by Barro & Sala-I-Martin (2004), which can be viewed as important factors in the economic development of the EU's member-states in the analysed period. First, we include a measure of international openness[4], applied in its natural logarithm form. This variable is included to predict the positive contribution of the degree of openness of the economy to economic growth. The second variable is the natural logarithm of the ratio of real gross domestic investment to real GDP[5]. According to the existing theory and most empirical findings, this variable is expected to be positively related to the dependent variable. Finally, the third variable is the natural logarithm of the ratio of government consumption to GDP[6], as a proxy of the state's role in the growth of the economy.

In order to answer the main question of this paper we estimate the three control variables with the six groups of Knowledge-Based Economy (KBE) indicators individually, as defined and presented by the European Commission and the structural indicators of the LS (EC, 2003).

The groups of variables and a short description is presented in Table 1. Using the R&D group of variables we can distinguish two specifications of model (6): one with the aggregated R&D expenditure (variable 1) and one with the three variables for

[4] see Appendix A, Table 1 for a complete definition of this control variable.
[5] at 2000 prices. See Appendix A, Table 1 for a complete definition of this control variable.
[6] the variable nets out the outlays on defence and education. See appendix A, Table 1 for a complete definition of this control variable.

R&D types of expenditure (originating from the industry, from the government side and from abroad) (variables 2, 3, & 4). The same applies to the share of ICT investment in Gross Fixed Capital Formation (GFCF) (variable 15) and its disaggregated specification (Information Technologies, Communication Equipment and Software) (variables 12,13 and 14). A complete list of the variables, together with their definitions and sources is presented in Table 1 of the Annex.

Table 1. List of Knowledge-Based Economy Indicators Applied

KBE Objective	Indicators	
R&D Effort	**1.**	Gross domestic expenditure on R&D (GERD) - Total
	2.	Gross domestic expenditure on R&D (GERD) - Industry
	3.	Gross domestic expenditure on R&D (GERD) - Government
	4.	Gross domestic expenditure on R&D (GERD) - Abroad
Quality of Human Resources	**5.**	Youth educational attainment level
	6.	Spending on human resources
	7.	Science and technology graduates – Total
Information Society	**8.**	Internet users per 100 population
	9.	Personal computers per 100 population
Innovation Capacity	**10.**	EPO – patents
	11.	USPTO – patents
Diffusion of ICT	**12.**	Percentage share of ICT investment in GFCF – IT equipment
	13.	Percentage share of ICT investment in GFCF – Communication Equipment
	14.	Percentage share of ICT investment in GFCF – Software
	15.	Percentage share of ICT investment in GFCF – Total ICT
Access to Finances	**16.**	Venture Capital Investments - Early Stage
	17.	Venture Capital Investments - Expansion & Replacement

4.2. Econometric methods

Empirical panel data studies on growth are generally carried out for periods of around 30 years, with five-year average observations (see e.g. Barro and Lee, 1994; Caselli, Esquivel and Lefort, 1996). Because of the relatively short data availability the time period of the study is limited to 13 years (1990-2003). Because of the short length of the sample, we use annual data instead of five-year averages.

The Ordinary Least Squares (OLS), the Fixed Effects (FE) and the Random Effects (RE) estimations of the panel data model produce biased coefficient estimates with small samples. The above rule applies unless the number of time periods is large (Baltagi, 2002). In order to cope with the above mentioned problems estimators based on the General Method of Moments (GMM) are employed, which are consistent for $N \to \infty$ with fixed T. We exploit the GMM-DIFF procedure of Arellano and Bond (1991), which calls for first differencing and using lags of the dependent and explanatory variables as instruments for the lagged dependent variable as a regressor. By first-differencing the dynamic model (7), we obtain

$$\Delta \ln y_{it} = (a+1)\, \Delta \ln y_{i,t-1} + \Delta \ln X_{it}\, \beta + \Delta v_i + \Delta \tau_t + \Delta \varepsilon_{it} \qquad (8)$$

where, Δ=0, $\Delta\tau_t = \tau$ (constant), and Δ denotes first difference. As the Arellano-Bond GMM-DIFF estimation results are identical for both specifications (6) and (7) only the results for model (6) are reported.

5. Estimation Results

Regressions are performed on an unbalanced pooled cross section times-series data set consisting of the 15 member-states of the EU for the 1990-2003 period. The growth of GDP per capita (PPS, EU-15=100) is regressed with the variables which correspond to the six group of the KBE objectives (see table 2 above), so six independent regression estimates are reported in the Appendix (tables 1 to 8). The estimation of model (6) is taking place, in which we can test the existence of absolute convergence as predicted in neoclassical models. The panel data estimators used are the OLS and the GMM Arellano & Bond. As analysed earlier, the GMM estimator uses as instruments the lagged level of the dependent variable as well as the lagged values of some explanatory variables in a differences regression equation. In the present analysis these explanatory variables are treated as predetermined, in that we suppose that past values of the error term have some impact on their future realisations. In our case a maximum of two lags in the dependent variable and one lags in the explanatory variables is used, in order to retain a sufficient number of observations, necessary to derive reliable conclusions.

5.1. Evidence From the Groups of KBE Indicators (Full Sample Results)

Initially, the calculated parameter α is negative in all regression estimates, which indicates conditional convergence (see tables 5 to 10 in the Appendix). The convergence reported is conditional, as it predicts higher growth in response to lower starting GDP per capita when the other explanatory variables are held constant. This estimation concurs the result that has been reported in various studies[7]. Regarding the three control variables defined earlier we can conclude that the most important one in the analysed period is investments rato (public an private). This result is positively significant at the 1% level and consistent in all estimates. This is typical in the

[7] see Barro & Sala-i-Martin (2004) Barro (1991) and Mankiw, Romer & Weil (1992).

theoretical and empirical literature. The international openness variable offers only weak statistical evidence regarding its relation to growth, an estimation result also reported by Barro & Sala-i-Martin (2002, p.529). No other control variables exhibit any significant impact on the dependent variable.

The estimation results of the R&D effort indicators in their aggregated and disaggregated form are presented in Table 5 in the Appendix. In its aggregated form, total R&D expenditure affect growth positively but not significantly. On the other hand, the disaggregated R&D expenditure estimation results reveal that such spending originating from abroad is significantly and positively related to economic growth. The above conclusion is robust as it emerges from both estimation results. This finding could be interpreted as a sign of economic efficiency from foreign R&D investments.

Continuing with the second group of interest, the estimation results regarding the indicators relating to the quality of human resources are reported in Table 6 of the Appendix. As we can notice, from the three relevant variables only the youth educational attainment level is highly positive and significant (at 1% level) in both estimators (OLS & GMM). The human resources expenditure and the science and technology graduates variables are both estimated in the OLS results to be significant with negative and positive effects respectively. However, these estimates could be partly affected by endogeneity problems as well as unobserved heterogeneity.

Estimation results on the information society objective indicate that the number of personal computer users has a highly positive and significant impact on growth, according to the GMM estimator (Table 7). Most empirics confirm this direct relation between information exploitation and economic performance. Regarding the patents variables that were used as a proxy for the innovation capacity objective, no evidence of significance appeared (Table 8). This could be explained by the fact that more lagging years are required for the estimated effects to appear on growth. With respect to the ICT diffusion objective (disaggregated model), only the investments on IT equipment display the expected positive and highly significant impact on both estimators (Table 9). This suggests that knowledge, by means of ICT, has a positive effect on economic growth through investments in IT and the use of PC’s, as it was revealed above. Again, a consensus exists in the empirics regarding the relation between ICT investments, their utilisation and productivity and growth.

Finally, estimations on the relationship between venture capital investments and the dependent variable are reported in Table 10 of the Appendix. For this group of KBE indicators that reflects the access to finance objective, it appears that the two indicators (early stage and expansion and replacement venture capital investments) do not have a significant affect on economic growth. This estimate is in conflict with the related empirics.

As a concluding exercise of this section, indicators with significant impact over the dependent variable, together with the three control variables, were further regressed with GDP pc growth, at a step-wise manner. This estimation is again based on the same group of countries (EU-15), and covers the 1990-2003 period. Also, random effects estimator results are reported instead of the previously used OLS[8]. The estimation results are reported in Table 2 below.

Table 2. Estimation of the Growth Equation Over the Significant KBE Variables

	Random Effects Estimates				Arrelano – Bond Estimates[4]			
Explanatory Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Constant	0.142*** (2.09)	0.089 (1.10)	0.072 (0.84)	0.079 (0.91)	-0.000 (-0.65)	-0.000 (-0.73)	0.001 (0.75)	0.001 (0.79)
GDP Initial [1]	-0.044*** (-3.05)	-0.006*** (-2.96)	-0.005*** (-2.28)	-0.003*** (-2.02)	-0.006*** (-2.96)	-0.041*** (-2.98)	-0.005*** (-2.26)	-0.038*** (-3.07)
International Openness	-0.002 (-0.72)	-0.003 (-1.05)	-0.002 (-0.65)	-0.002 (-0.60)	-0.028 (-0.95)	-0.036 (-1.20)	-0.024 (-0.76)	-0.026 (-0.79)
Domestic Investments	0.061*** (4.18)	0.061*** (4.09)	0.067*** (4.25)	0.070*** (4.41)	0.173*** (5.67)	0.174*** (5.74)	0.179*** (5.86)	0.179*** (5.83)
Government Consumption	0.005** (2.01)	0.003 (1.42)	0.004* (1.66)	0.004 (1.36)	0.457*** (2.68)	0.049*** (2.89)	0.053*** (3.13)	0.052*** (0.002)
R&D Abroad	0.004* (1.77)	0.003 (1.20)	0.004 (1.45)	0.003 (1.22)	0.021*** (4.04)	0.018*** (3.25)	0.017*** (3.18)	0.017*** (2.99)
Youth Educ. Level		0.004** (1.89)	0.004** (1.75)	0.0271** (1.92)		0.044 (1.58)	0.036 (1.27)	0.035 (1.17)
Personal Comp Users			0.003** (1.10)	0.003** (1.20)			0.239 (1.32)	0.024 (1.33)
ICT investment IT Equipment				0.000 (0.37)				0.002 (0.24)
Obs.	195	195	195	195	165	165	165	165
R^2	0.431	0.457	0.462	0.501				
Sargan Test (p-value)[2]					0.007	0.006	0.005	0.006
Autocovariance test of order 2 (p-value)[3]					0.001	0.000	0.001	0.001

Note: Dependent variable GDPpc (PPS, EU-15=100) in country i (i =1,…,15) in period t (t =1990,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively. Random effects estimates heteroskedasticity-consistent. [1] Initial per Capita GDP (PPS) in Country *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation.[4] Dependent and explanatory variables lagged 1 & 2 periods respectively. All the explanatory variables were used as instruments.

The estimation results of this growth equation confirm the existence of conditional convergence, as well as highly positive and significant elasticities in the

[8] The employment of RE was chosen as after applying the Hausman specification test the results didn't indicated any statistical significance between the FE and the RE. The Hausman statistics is distributed as a x^2 variable with value 2.28 (p-value:0.51) when H_o is that difference in coefficients estimates is not systematic.

domestic investments control variable (columns 1 to 4). Focusing on the selected KBE indicators, estimation results indicate that R&D investment from abroad is positive and significant related to growth (column 1). Yet, augmenting the equation by the youth educational level (column 2) and the remaining indicators (columns 3 & 4) leaves the R&D indicator insignificant. Regarding the rest indicators, robust results exhibit that the youth educational level and the personal computer users indicators have a positive and significant impact on economic growth.

As it was mentioned, some of the coefficients are likely to be affected by endogeneity bias. To account for this, the GMM Arellano & Bond estimator results are presented in columns 5 to 8. According to the results, two control variables present highly positive and significant elasticities: the domestic investments and the government consumption ratio. Note that the latter variable exhibits high significance mainly in the GMM estimator results. This result is new to this study, as it wasn't revealed in the previous estimations. The first variable, R&D investments from abroad, provides a positive and statistically significant coefficient throughout estimation results (columns 5 to 8). Hence, consistent results provide strong evidence on the link between foreign R&D investments and economic growth, implying that such investments are more efficient than the other two types (private and governmental). The remaining indicators exhibits insignificant impact on the dependent variable.

5.2. Evidence from the High-income vs. the Low-income Member – States (Sub-groups Estimates)

According to Blomstrom et al (1994, p.16), due to modest infrastructure lagging countries gain relatively little from foreign influences and international openness. This proposition is difficult to test because it is not clear what characteristics of a country would place it inside or outside the lagging countries. In the study mentioned targeted countries were divided into two sub-groups on the basis of their output. Similarly, in this study the member-states of the EU were divided into two sub-samples, on the basis of their GDP pc (PPS) during the 1990-2003 period. The first sample consists of countries with above average GDP values (higher-income) and the second corresponds to lower-income member-states[9].

[9] *High-income countries*: Belgium, Denmark, Germany, Luxembourg, Netherlands, Austria, Finland, Sweden, United Kingdom. *Low-income countries*: Greece, Spain, France, Ireland, Italy, Portugal.

Hence, the regressions exercise presented in the previous section is repeated in an effort to distinguish the important KBE indicators between the two groups of countries and their effects to growth. The estimated results refer to the six groups of variables and their corresponding indicators presented in Table 1 above. The estimated results are presented in Tables 11 to 16 in the Appendix.

The results confirm once again the importance of the investment variable in all regressions estimates and in both groups of countries. In addition, government consumption is reported to be highly significant and positive only in the high income member-states and relatively insignificant in low-income ones. Note that this indicator nets out the outlays on defence and education. An interesting result is the insignificance of the international openness variable with the dependent variable in the comparatively high and low income countries, although similar empirical studies report contrary effects.

The regression results for the groups of KBE indicators present a number of notable points. Firstly, with respect to the group of indicators relating to R&D, the disaggregated results provide evidence that high-income countries gain from R&D investments from both the state and abroad, as the coefficients turn out to be positive and significant in the GMM estimator (see Table 11 in the Appendix). On the other hand, low-income member-states demonstrated insignificant evidence in the R&D group of indicators. Secondly, the human resources regressions were significant and positive only in the estimations of the youth education level regarding both sub-groups (see Table 12 in the Appendix). This result is in line with the previous estimations performed for the whole sample of countries.

Thirdly, different results than the ones reported for the full sample arise from the regression of the sub-samples in the group of variables relating to information society objective (see Table 13 in the Appendix). In detail, the two groups of countries provide evidence that personal computer users are significantly and positively related to growth. By contrast, the internet users variable exhibits a positive and significant effect on economic growth only for the low-income group. This indicates that such countries benefit more from the use of these technologies, probably because they present higher growth rates of internet users. Fourthly, only low-income countries benefit from innovative patents (see Table 14 in the Appendix). Both OLS and GMM estimators confirm that USPTO patents are positively and significantly related to economic growth. No such evidence appeared with respect to the high-income group of countries.

Regarding the ICT indicators, investments in IT display a positive and significant impact on the dependent variable for both sub-samples, confirming once again the initial results of the complete sample (see Table 14 in the Appendix). An additional feature of this group of estimation results is that a significant and positive link between investments in computer equipment and economic growth exists for the low-income group (reported by the OLS and GMM estimators). This relation confirms the positive impact of the personal computers user variable that was previously observed in this sub-group. Finally, in the group of variables relating to the finance accessibility objective of the KBE, a positive and significant relation between early stage venture capital investments and economic growth is estimated in the low-income group (GMM estimator). In other words, innovative capital investments, offering augmented value added, enhance productivity and output in this group of countries. This estimate is common in the related empirics (Porter, 1999; OECD, 2000; 2001).

6. Conclusions and Policy Considerations

The aim of this study is to estimate and analyse the effects of knowledge based-economy have on the growth process in the EU. The empirics revealed that the R&D investments originating from abroad robustly enhance growth performance. In addition, the educational attainment level of human resources and the diffusion of ICT through IT investments cause a positive effect on the economic performance of EU's member-states. However, specific group estimations indicated that only high-income countries are able to benefit from foreign R&D spillovers while in relatively poorer member-states personal computer utilisation and related investments together with innovative patents and venture capital investments (early stage) positively affect economic growth.

These indications from the empirical analysis provide the opportunity for some tentative conclusions regarding the knowledge-based economy and growth empirics in the EU. The characteristics of human capital, the dissemination of technologies and access to finances can narrow the knowledge gap and enhance the overall growth performance in the EU. Thus, knowledge-based policies are not only dependant on increasing R&D spending and tertiary education level, but are more a matter of the existing framework, conditions and the flanking policies in order to provide adequate incentive structures for the private sector to enhance productivity and overall economic performance.

To conclude, over the long run, these knowledge related investments are the key drivers of the productivity-economic growth chain for the member-states EU, while higher levels of knowledge production and further distribution will be encouraged by both government policies and private incentives.

REFERENCES

Aghion, P. & Howitt, P. (1998) “Endogenous Growth Theory” MIT Press, London.

Arellano, M., Bond, S., (1991) “Some tests of specification or panel data: Monte Carlo evidence and an application to employment equations”, The Review of Economic Studies 58 (2), 277-297.

Barro, R. & Sala-i-Martin, X. (2004) “Economic Growth” 2nd Edition, MIT Press, London.

Benhabib, J. and M.M. Spiegal (1994), “The role of human capital in economic development: evidence from aggregate cross-country data”, Journal of Monetary Economics, Vol. 34, pp. 143-147.

Blomström, M., R. E. Lipsey and M. Zejan (1994) “'What Explains Developing Country Growth?”, NBER Working Paper No. 4132

Broersma, A.B. and R.H. McGuckin (1999), “The Impact of Computers on Productivity in the Trade Sector: Explorations with Dutch Microdata”, Research Memorandum GD-45, Groningen Growth and Development Centre, October.

Cameron, G. (1998), “Innovation and Growth: A Survey of the Empirical Evidence”, Nuffield College, Oxford, July.

Coates, D. & Warwick, K. (1999) “The Knowledge Driven Economy: Analysis and Background” Paper Presented at the “Economics of the Knowledge Driven Economy” conference, organized by DTI & CERP, London 27th January 1999.

Daveri, F., (2002) “The New Economy in Europe 1992-2001”, Oxford Review of Economic Policy 18(3), 345-362.

Department of Trade and Industry (1998) “Our Competitive Future: Building the Knowledge Driven Economy: Analysis & Background” Cm 4176. The Stationary Office, London.

European Commission (2005) “The Lisbon Strategy and the EU's Structural Productivity Problem” European Economy, Economic Papers No 221, DG for Economic & Financial Affairs, February.

European Commission, COM (2004) 14 final, Spring European Council, Thessaloniki Presidency Conclusions.

European Commission, SEC (2003) 25 “Choosing to Grow: Knowledge, Innovation & Growth in a cohesive society” Commission Staff Working Papers.

European Commission, COM (2001) 79 “Realising the European Union's Potential Consolidating and Extending the Lisbon Strategy” Contribution of the European Commission to the Spring European Council Stockholm, 23 - 24th March.

European Commission, COM (2000a) 3 final, “Lisbon Presidency Conclusions” Fall European Council 2000.

European Commission, COM (2000b) 7 “An Agenda of Economic & Social Renewal for Europe” Contribution of the to the Spring European Council Lisbon, 23-24th of March.

Gera, S., W. Gu. and F. C. Lee (1999), "Information Technology and Productivity Growth: An Empirical Analysis for Canada and the United States", Canadian Journal of Economics, Vol. 32, No. 2, April.

Griffith, R., S. Redding and J. Van Reenen (1998), "Productivity Growth in OECD Industries: Identifying the Role of R&D, Skills and Trade", Institute for Fiscal Studies Working Papper 143.

Hausman, J. (1978) "Specification Tests in Econometrics" Econometrica 46(6), 1251-1271.

Harris, R. G. (1999), "Determinants of Canadian Productivity Growth: Issues and Prospects", paper presented at the CSLS-Industry Canada Conference on "Canada in the 21st Century: A Time for Vision" Ottawa, September 17-18.

Lamberton, D.M. (1996) "The Economics of Communication and Information". Cheltenham, U.K.: Edward Elgar Editions.

OECD (1996), "Technology, Productivity and Job Creation – Vol. 2 Analytical Report", Paris.

OECD (1998b), Human Capital Investment – An International Comparison, Paris

OECD (1999), "Innovation and Economic Performance–Developing the Links", DSTI/STP/TIP(99)12, 23 November, Paris.

OECD (2000), "A New Economy: the changing role of innovation and information technology in growth", Paris

OECD (2001), "The New Economy: beyond the hype", (Executive Summary), May Paris

Porter, M.E. (1999), ""Innovative capacity and prosperity: the next competitiveness challenge" in The Global Competitiveness Report 1999, World Economic Forum.

Savva-Balfoussias, St., Athanassiou, E., Karagiannis, St. & Tsouma K. (2006) "Europe and the International Economic Environment in 2005: Recent Developments and Outlook" KEPE Report Series, No. 45.

Solow, R. (1957) "Technical Change and the Aggregate Production Functions" Review of Economics and Statistics, 39.

Soto, M. (2000). "Capital flows and growth in developing countries: recent empirical Evidence", OECD Development Centre Technical Paper No.160, Paris 2000.

Stiglitz, J. (1999) "Knowledge in the Modern Economy" Paper Presented at the "Economics of the Knowledge Driven Economy" conference, organized by DTI & CERP, London 27th January 1999.

Swan, T.W. (1956) "Economic Growth and Capital Accumulation" Economic Record, 32.

Temple, J. (1999) "The New Growth Evidence", Journal of Economic Literature, Vol. 37, March, pp. 112-156.

Wooldridge, M.J. (2002) "Econometric Analysis of Cross Section and Panel Data" MIT, Cambridge, MA.

Appendix Table 1. Description of Variables

Dependent Variable	Description	Source
GDP per capita	EU-15= 100, at 2000 prices; PPS adjusted	AMECO Database – European Commission
Explanatory Variables		
International Openness	Ratio of exports plus imports to GDP;	AMECO Database – European Commission
Investment Ratio	Ratio of real gross domestic investment (private and public) to real GDP	AMECO Database – European Commission
Government Consumption	Ratio of government consumption to GDP; nets out the outlays on defence and education	AMECO Database – European Commission
Gross domestic expenditure on R&D (GERD); total	As a percentage of GDP	Eurostat – Structural Indicators
Gross domestic expenditure on R&D; industry	Percentage of GERD financed by the industry.	Eurostat – Structural Indicators
Gross domestic expenditure on R&D; government	Percentage of GERD financed by the government.	Eurostat – Structural Indicators
Gross domestic expenditure on R&D; abroad	percentage of GERD financed by abroad	Eurostat – Structural Indicators
Youth educational attainment level	percentage of the population aged 20-24 having completed at least upper secondary education	Eurostat – Structural Indicators
Spending on human resources	public expenditure on education as a percentage of GDP	Eurostat – Structural Indicators
Science and technology graduates	tertiary graduates in science and technology per 1000 of population aged 20-29	Eurostat – Structural Indicators
Internet users	www users per 100 population; 1990-1998 period are estimates	International Telecommunications Union – United Nations
Personal computers users	Personal computers users per 100 population; estimates1990-1998 period are estimates	International Telecommunications Union – United Nations
EPO patents	number of patent applications to the European Patent Office (EPO); per million inhabitants	OECD – Main Science Indicators
USPTO patents	number of patent applications to the United States Patents and Trademark Office (USPTO); per million inhabitants.	OECD – Main Science Indicators
Percentage share of ICT investment in GFCF; IT equipment	IT equipment investments as percentage share of total ICT investment in total non-residential Gross Fixed Capital Formation.	OECD – Productivity DB
Percentage share of ICT investment in GFCF; Communication equipment	Communication equipment investments as percentage share of total ICT investment in total non-residential Gross Fixed Capital Formation.	OECD – Productivity DB
Percentage share of ICT investment in GFCF; Software	Software investments as percentage share of total ICT investment in total non-residential Gross Fixed Capital Formation.	OECD – Productivity DB
Percentage share of ICT investment GFCF; Total ICT	Information & Communication Technologies (ICT) investment in total non-residential Gross Fixed Capital Formation	OECD – Productivity DB
Venture Capital Investments; early stage	Percentage; relative to GDP	Eurostat – Structural Indicators
Venture Capital Investments; expansion & replacement	Percentage; relative to GDP	Eurostat – Structural Indicators

Appendix Table 2: Growth and Research and Development (R&D).

	GDPpc			R&D Total			R&D Government			R&D Abroad		
	90-96	96-03	00-03	90-96	96-03	00-03	90-96	96-03	00-03	90-96	96-03	00-03
be	109.1	106.6	107.9	1.7	2.0	1.8	26.0	22.5	24.2	5.7	10.5	8.1
dk	109.6	113.0	111.4	1.7	2.3	2.1	38.8	30.6	34.1	7.3	7.1	7.0
de	109.2	102.0	105.6	2.3	2.4	2.4	36.7	32.6	34.7	1.9	2.3	2.1
gr	65.7	67.2	66.5	0.4	0.6	0.5	53.6	49.0	51.3	22.3	20.8	21.6
es	79.0	84.1	81.6	0.8	0.9	0.9	47.5	40.1	43.8	6.1	6.3	6.2
fr	103.9	103.2	103.5	2.3	2.2	2.3	44.1	38.0	41.1	8.1	7.6	7.9
ie	82.8	113.7	98.2	1.1	1.2	1.2	25.6	24.9	25.2	8.4	8.8	8.6
it	105.6	102.4	104.0	1.1	1.1	1.1	50.7	52.5	51.6	5.3	7.0	6.1
lu	181.4	194.7	188.0	0.9	1.7	1.3	4.9	7.6	6.2	0.8	2.8	1.8
nl	110.8	113.8	112.3	2.0	1.9	1.9	46.0	36.6	41.3	5.3	11.4	8.4
at	114.8	112.1	113.5	1.5	1.9	1.7	46.5	37.5	42.0	4.9	19.6	12.3
pt	68.5	71.3	69.9	0.6	0.8	0.7	61.8	64.8	63.3	11.1	5.3	8.2
fi	93.7	101.8	97.8	2.2	3.2	2.7	37.5	27.7	32.6	2.5	3.5	3.0
se	95.9	105.5	105.7	2.0	3.9	3.5	33.3	23.7	27.7	12.8	4.1	3.4
uk	105.5	103.3	99.6	3.2	1.9	2.0	30.3	29.8	31.5	2.9	17.5	15.2

Appendix Table 3: Human Resources, Information Society & Innovation Capacity.

	Youth Education Level			Internet Users			PC Users			USPTO Patents		
	90-96	96-03	00-03	90-96	96-03	00-03	90-96	96-03	00-03	90-96	96-03	00-03
be	75.9	79.8	77.8	7.1	226.1	116.6	139.1	241.2	190.1	55.3	40.3	47.8
dk	81.4	74.8	78.4	17.3	363.2	190.3	192.4	489.5	338.6	66.2	48.5	60.4
de	80.6	74.0	77.3	10.1	247.2	128.7	135.6	349.7	242.6	104.3	84.7	94.5
gr	72.1	79.1	75.6	4.0	83.7	43.8	25.7	66.8	46.3	1.7	1.2	1.4
es	55.5	64.3	59.9	3.2	126.0	64.6	47.5	149.8	98.6	5.3	5.0	5.1
fr	76.3	80.2	78.3	8.9	183.5	96.2	116.2	298.7	207.4	60.1	40.0	50.0
ie	70.9	82.0	76.5	6.3	176.6	91.4	141.0	349.7	245.4	22.6	26.2	24.4
it	56.5	67.0	61.8	2.8	207.0	104.9	63.8	181.4	122.6	24.8	19.6	22.2
lu	49.5	68.0	58.8	12.0	243.5	127.7	352.3	480.0	416.1	65.8	61.0	63.4
nl	65.2	72.4	68.8	33.6	388.5	211.1	154.8	395.9	275.4	69.6	51.5	60.5
at	77.8	84.0	80.9	17.1	297.2	157.2	112.2	300.3	206.2	51.1	44.9	48.0
pt	39.3	43.5	41.4	8.7	159.4	84.0	42.3	104.8	73.5	0.6	1.0	0.8
fi	80.8	86.2	83.5	59.8	364.6	212.2	164.6	392.1	278.3	107.8	90.4	99.1
se	59.4	86.2	86.7	11.5	452.1	242.2	161.9	509.6	343.8	53.2	101.0	113.9
uk	87.1	74.0	66.7	65.2	288.5	150.0	211.4	338.5	250.2	142.2	36.6	44.9

Appendix Table 4: Diffusion of IT and Access to Finance.

	ICT Invest. - Total			ICT Invest. - IT Equip.			ICT Invest. – Com Equip.			Venture Cap.-Early Stage		
	90-96	96-03	00-03	90-96	96-03	00-03	90-96	96-03	00-03	90-96	96-03	00-03
be	17.7	21.5	19.6	9.4	11.1	10.2	4.2	4.8	4.5	0.010	0.053	0.031
dk	18.0	19.5	18.5	9.0	8.0	8.2	2.0	1.2	1.8	0.003	0.037	0.020
de	13.5	16.3	14.9	4.8	6.0	5.4	4.5	4.1	4.3	0.004	0.038	0.021
gr	10.3	12.1	11.2	3.6	4.1	3.8	5.5	5.6	5.6	0.004	0.010	0.007
es	12.9	13.9	13.4	4.1	3.9	4.0	4.9	5.3	5.1	0.005	0.015	0.010
fr	9.8	13.3	11.6	2.7	3.4	3.0	3.3	3.9	3.6	0.003	0.034	0.019
ie	6.6	10.3	8.5	3.3	4.9	4.1	1.5	3.6	2.6	0.007	0.037	0.022
it	14.6	16.0	15.3	3.7	4.1	3.9	6.8	7.0	6.9	0.005	0.016	0.011
lu	17.8	21.5	19.7	9.2	11.1	10.2	4.3	4.8	4.5	0.010	0.053	0.031
nl	13.2	17.2	15.2	6.3	7.0	6.6	1.2	1.1	1.1	0.014	0.055	0.034
at	12.0	13.7	12.9	4.8	5.0	4.9	5.3	4.3	4.8	0.000	0.013	0.007
pt	11.2	12.8	12.0	6.5	6.1	6.3	3.4	5.2	4.3	0.007	0.018	0.013
fi	20.0	26.2	23.1	5.4	2.6	4.0	3.1	11.5	7.3	0.009	0.065	0.037
se	17.9	27.0	24.0	7.6	8.7	8.6	2.9	4.0	4.1	0.006	0.066	0.034
uk	22.1	23.1	20.5	8.8	9.0	8.3	4.3	4.4	3.6	0.002	0.040	0.023

Appendix Table 5: Estimation Results for R&D Effort Variables.

Explanatory Variables	OLS Estimates		Arrelano – Bond Estimates[4]	
	Aggregated R&D	Disaggregated R&D	Aggregated R&D	Disaggregated R&D
Constant	0.202** (2.40)	0.129 (1.10)	0.000 (0.29)	-0.001 (-1.15)
GDP Initial [1]	-0.006*** (-2.96)	-0.134*** (-6.10)	-0.027*** (-1.95)	-0.006*** (-2.96)
Int'l Openness	0.004 (-0.81)	-0.003 (-0.98)	-0.002 (-0.09)	0.017 (0.68)
Domestic Investments	0.061*** (3.60)	0.053*** (3.57)	0.099*** (3.94)	0.163*** (7.05)
Government Consumption	0.003 (1.20)	0.002 (1.25)	-0.003 (-0.21)	0.033** (2.22)
R&D Total	0.008 (1.41)		-0.015 (-1.15)	
R&D Industry	-	0.018 (1.50)	-	-0.011 (-0.48)
R&D Government	-	-0.004 (-0.47)	-	0.018 (1.13)
R&D Abroad	-	0.006** (2.19)	-	0.014*** (2.86)
Obs.	195	195	165	180
R^2	0.578	0.488		
Sargan Test (p-value)[2]	-	-	0.001	0.001
Autocovariance test of order 2 (p-value)[3]	-	-	0.001	0.000

Note: Dependent variable GDPpc (PPS) in country i (i =1,…,15) in period t (t =1990,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively. OLS estimates heteroskedasticity-consistent. [1] Initial per Capita GDP (PPS) in Country *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] Dependent and explanatory variables lagged 1 & 2 periods respectively. All the explanatory variables were used as instruments.

Appendix Table 6: Estimation Results for Human Resources Variables.

Explanatory Variables	OLS Estimates	Arrelano – Bond Estimates[4]
Constant	0.076 (1.44)	-0.000 (-0.02)
GDP Initial [1]	-0.006*** (-2.96)	-0.009*** (-4.46)
Int'l Openness	-0.005*** (-2.78)	0.130 (-0.44)
Domestic Investments	0.037*** (2.98)	0.094*** (3.39)
Government Consumption	0.002 (1.54)	0.003 (0.16)
Youth Education Level	0.041*** (3.04)	0.091*** (3.51)
Human Resources Exp.	-0.020** (-2.20)	0.026 (0.85)
Science & Tech. Grads	0.020*** (2.15)	-0.012 (-0.98)
Obs.	180	165
R^2	0.488	
Sargan Test (p-value)[2]	-	0.019
Autocovariance test of order 2 (p-value)[3]	-	0.000

Note: Dependent variable GDPpc (PPS) in country i (i =1,…,15) in period t (t =1990,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively. OLS estimates heteroskedasticity-consistent. [1] Initial per Capita GDP (PPS) in Country *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] Dependent and explanatory variables lagged 1 & 2 periods respectively. All the explanatory variables were used as instruments.

Appendix Table 7: Estimation Results for Information Society Variables.

Explanatory Variables	OLS Estimates	Arrelano – Bond Estimates[4]
Constant	0.156** (1.88)	0.002 (1.55)
GDP Initial [1]	-0.005*** (-2.28)	-0.130*** (-5.72)
Int'l Openness	-0.002 (-0.72)	0.009 (0.34)
Domestic Investments	0.052*** (3.74)	0.022*** (6.39)
Government Consumption	0.003 (1.62)	0.145 (2.47)
Internet Users	-0.001 (-0.84)	0.022 (1.43)
Personal Computers Users	0.006 (1.04)	-0.044*** (-3.05)
Obs.	195	180
R^2	0.522	
Sargan Test (p-value)[2]		0.000
Autocovariance test of order 2 (p-value)[3]		0.004

Note: Dependent variable GDPpc (PPS) in country i (i =1,…,15) in period t (t =1990,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively. OLS estimates heteroskedasticity-consistent. [1] Initial per Capita GDP (PPS) in Country *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] Dependent and explanatory variables lagged 1 & 2 periods respectively. All the explanatory variables were used as instruments.

Appendix Table 8: Estimation Results for Innovation Capacity Variables.

Explanatory Variables	OLS Estimates	Arrelano – Bond Estimates[4]
Constant	0.197** (2.19)	0.000 (0.10)
GDP Initial [1]	-0.004*** (-3.24)	-0.044*** -(3.05)
Int'l Openness	-0.002 (-0.75)	0.010 (0.38)
Domestic Investments	0.058*** (3.56)	0.137*** (6.08)
Government Consumption	0.002 (1.39)	0.030** (2.01)
EPO – Patents	0.002 (0.90)	-0.006 (-0.74)
USPTO – Patents	0.000 (0.37)	0.001 (0.53)
Obs.	195	180
R^2	0.531	
Sargan Test (p-value)[2]		0.000
Autocovariance test of order 2 (p-value)[3]		0.001

Note: Dependent variable GDPpc (PPS) in country i (i =1,…,15) in period t (t =1990,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively. OLS estimates heteroskedasticity-consistent. [1] Initial per Capita GDP (PPS) in Country *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] Dependent and explanatory variables lagged 1 & 2 periods respectively. All the explanatory variables were used as instruments.

Appendix Table 9: Estimation Results for Diffusion of ICT Variables.

Explanatory Variables	OLS Estimates		Arrelano – Bond Estimates[4]	
	Aggregated ICT	Disaggregated ICT	Aggregated ICT	Disaggregated ICT
Constant	0.163** (2.01)	0.210 (2.40)	-0.000 (-0.22)	0.000 (0.60)
GDP Initial [1]	-0.005*** (-2.25)	-0.029*** (-2.77)	-0.029*** (-3.04)	-0.029*** (-2.77)
Int'l Openness	-0.001 (-0.45)	-0.001 (-0.46)	0.008 (0.28)	-0.000 (-0.01)
Domestic Investments	0.057*** (3.52)	0.066*** (3.79)	0.134*** (6.05)	0.128*** (5.50)
Government Consumption	0.004** (1.89)	0.004 (1.53)	0.030 (2.02)	0.023 (1.50)
Total ICT Investments	0.004 (0.72)		-0.004 (-0.30)	
IT Equipment		0.008** (2.50)		0.015** (2.02)
Computer Equipment		0.001 (0.27)		-0.006 (-0.84)
Software		0.003** (0.77)		-0.012 (-0.95)
Obs.	195	195	180	180
R^2	0.458	0.489		
Sargan Test (p-value)[2]			0.000	0.000
Autocovariance test of order 2 (p-value)[3]			0.001	0.000

Note: Dependent variable GDPpc (PPS) in country i (i =1,…,15) in period t (t =1990,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively. OLS estimates heteroskedasticity-consistent. [1] Initial per Capita GDP (PPS) in Country *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3]The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] Dependent and explanatory variables lagged 1 & 2 periods respectively. All the explanatory variables were used as instruments.

Appendix Table 10: Estimation Results for Access to Finances Variables.

Explanatory Variables	OLS Estimates	Arrelano – Bond Estimates[4]
Constant	0.086** (1.98)	0.000 (-0.46)
GDP Initial [1]	-0.313*** (-5.00)	-0.009*** (-4.66)
Int'l Openness	0.004 (-0.29)	0.027* (1.71)
Domestic Investments	0.017*** (3.84)	0.022*** (6.87)
Government Consumption	0.002 (1.92)	0.016 (0.67)
Venture Capital Inv. – Early Stage	0.006** (2.19)	0.029** (1.99)
Venture Capital Inv. – Expansion & Replacement	0.002 (1.23)	-0.002 (-1.25)
Obs.	190	174
R^2	0.457	
Sargan Test (p-value)[2]		0.000
Autocovariance test of order 2 (p-value)[3]		0.001

Note: Dependent variable GDPpc (PPS) in country i (i =1,…,15) in period t (t =1990,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% & 1% significance respectively. OLS estimates heteroskedasticity-consistent. [1] Initial per Capita GDP (PPS) in Country *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3]The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation.[4] Dependent and explanatory variables lagged 1 & 2 periods respectively. All the explanatory variables were used as instruments.

Appendix Table 11: Estimation Results for R&D Effort Variables in High and Low Income Member-States.

	OLS Estimates				Arrelano – Bond Estimates[4]			
Explanatory Variables	High income		Low income		High income		Low income	
	Aggregated	Disaggregated	Aggregated	Disaggregated	Aggregated	Disaggregated	Aggregated	Disaggregated
Constant	-0.125 (-1.01)	0.368 (-0.51)	0.185 (1.51)	0.427** (2.13)	0.001 (1.05)	0.000 (-0.07)	0.001** (-3.30)	-0.001*** (-1.83)
GDP Initial [1]	-0.029*** (-3.04)	-0.313*** (-5.01)	-0.029*** (-2.77)	-0.310*** (-4.90)	-0.003*** (-3.29)	-0.006*** (-2.86)	-0.017** (-1.90)	-0.027*** (-1.95)
Int'l Openness	-0.003** (-2.06)	0.001** (-2.55)	-0.007 (-1.39)	0.005 (0.70)	-0.017 (-0.42)	0.022 (0.54)	0.045** (1.82)	0.031 (1.02)
Domestic Invest.	-0.019** (-1.67)	0.061*** (3.60)	0.073*** (4.72)	0.073*** (3.99)	0.120*** (3.21)	0.116*** (3.54)	0.171*** (5.89)	0.186*** (6.39)
Government Consumption.	0.00** (2.21)	0.002** (1.56)	0.004 (2.09)	0.003 (1.55)	0.056** (2.01)	0.577*** (3.52)	0.033 (1.96)	0.030 (1.68)
R&D Total	0.009 (1.05)		0.177*** (3.04)		0.009 (0.90)		-0.005 (-0.27)	
R&D Industry		0.028 (0.63)		-0.013 (-0.58)		-0.010 (-0.24)		-0.037 (-1.20)
R&D Governm.		0.016 (0.26)		0.005 (0.70)		0.051*** (3.36)		0.007 (-0.17)
R&D Abroad		0.003* (1.68)		0.004 (0.43)		0.006*** (1.75)		-0.003 (-0.32)
Obs.	117	117	78	78	108	108	72	72
R^2	0.421	0.447	0.407	0.436				
Sargan Test (p-value)[2]					0.008	0.043	0.029	0.042
Autocovariance test of order 2 (p-value)[3]					0.000	0.000	0.021	0.030

Note: Dependent variable GDPpc (PPS) in low income countries i (i =1,…,6) and high income countries i (i =1,…,9) in period t (t =1990,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% and 1% significance respectively. OLS estimates heteroskedasticity-consistent [1] Initial per Capita GDP (PPS) in Country *i* in period *t-1.* [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] Dependent and explanatory variables lagged 1 and 2 periods respectively. All the explanatory variables were used as instruments.

Appendix Table 12: Estimation Results for Human Resources Variables in High and Low Income Member-States.

	OLS Estimates		Arrelano – Bond Estimates[4]	
Explanatory Variables	High income	Low income	High income	Low income
Constant	-0.190 (-0.80)	-0.028 (-0.21)	-0.008 (-0.44)	-0.002 (-1.41)
GDP Initial [1]	-0.909*** (-9.38)	-0.313*** (-5.02)	-0.028*** (-1.93)	-0.017** (-1.96)
Int'l Openness	-0.004 (-1.16)	0.000 (0.06)	-0.001 (-0.02)	0.013 (0.45)
Domestic Investments	0.053** (3.57)	0.105*** (6.54)	0.122*** (3.41)	0.216*** (5.73)
Government Consumption	0.006** (2.19)	0.081 (3.46)	0.061*** (3.60)	0.028 (1.42)
Youth Education Level	0.044*** (3.25)	0.023*** (3.46)	0.513*** (3.36)	0.120*** (3.21)
Human Resource Expenditure	-0.010 (-0.39)	0.078 (2.98)	0.024 (0.55)	0.006 (0.23)
Science & Tech. Grads	0.005 (1.01)	0.009 (-1.50)	0.018 (1.34)	0.014 (-0.92)
Obs.	108	72	99	66
R^2	0.451	0.471		
Sargan Test (p-value)[2]			0.064	0.078
Autocovariance test of order 2 (p-value)[3]			0.000	0.035

Note: Dependent variable GDPpc (PPS) in low income countries i (i =1,…,6) and high income countries i (i =1,…,9) in period t (t =1990,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% and 1% significance respectively. OLS estimates heteroskedasticity-consistent [1] Initial per Capita GDP (PPS) in Country *i* in period *t-1.* [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] Dependent and explanatory variables lagged 1 and 2 periods respectively. All the explanatory variables were used as instruments.

Appendix Table 13: Estimation Results for Information Society Variables in High and Low Income Member-States.

	OLS Estimates		Arrelano – Bond Estimates[4]	
Explanatory Variables	High income	Low income	High income	Low income
Constant	-0.074 (-0.67)	0.103 (0.93)	0.003* (1.78)	-0.010*** (-2.52)
GDP Initial [1]	-0.029*** (-2.95)	-0.029*** (-2.77)	-0.017*** (-1.95)	-0.003*** (-3.51)
Int'l Openness	-0.003 (-1.97)	-0.006 (-1.18)	0.026 (0.68)	-0.002 (-0.09)
Domestic Investments	0.145*** (6.39)	0.069*** (5.46)	0.123*** (3.52)	0.188*** (6.47)
Government Consumption	0.061*** (3.20)	0.002 (0.96)	0.006** (2.19)	0.049*** (2.69)
Internet Users	0.001 (0.52)	0.020** (2.15)	-0.000 (-0.21)	0.010** (2.19)
Personal Computers Users	0.005* (1.68)	0.018*** (3.00)	0.029** (2.00)	0.027** (1.95)
Obs.	117	78	108	72
R^2	0.589	0.576		
Sargan Test (p-value)[2]			0.006	0.067
Autocovariance test of order 2 (p-value)[3]			0.000	0.036

Note: Dependent variable GDPpc (PPS) in low income countries i (i =1,…,6) and high income countries i (i =1,…,9) in period t (t =1990,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% and 1% significance respectively. OLS estimates heteroskedasticity-consistent [1] Initial per Capita GDP (PPS) in Country *i* in period *t-1.* [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] Dependent and explanatory variables lagged 1 and 2 periods respectively. All the explanatory variables were used as instruments.

Appendix Table 14: Estimation Results for Innovation Capacity Variables in High and Low Income Member-States.

	OLS Estimates		Arrelano – Bond Estimates[4]	
Explanatory Variables	High income	Low income	High income	Low income
Constant	-0.059 (-0.61)	0.310*** (3.18)	0.000 (0.28)	-0.00 (-0.59)
GDP Initial [1]	-0.029*** (-2.76)	-0.028*** (-2.80)	-0.003*** (-3.52)	-0.044*** (-3.05)
Int'l Openness	-0.003 (-2.00)	-0.014*** (-2.66)	0.017 (0.40)	0.024 (0.85)
Domestic Investments	0.045*** (3.53)	0.097*** (7.09)	0.139*** (4.09)	0.192*** (6.67)
Government Consumption	0.061*** (3.60)	0.001 (0.61)	0.052*** (3.74)	0.024 (1.48)
EPO – Patents	0.001 (0.36)	0.009 (0.25)	-0.000 (-0.03)	0.016 (-1.62)
USPTO – Patents	-0.001 (-0.80)	0.004** (2.11)	-0.002 (-0.64)	0.006** (2.01)
Obs.	117	78	108	72
R^2	0.462	0.478		
Sargan Test (p-value)[2]			0.005	0.0473
Autocovariance test of order 2 (p-value)[3]			0.000	0.032

Note: Dependent variable GDPpc (PPS) in low income countries i (i =1,…,6) and high income countries i (i =1,…,9) in period t (t =1990,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% and 1% significance respectively. OLS estimates heteroskedasticity-consistent [1] Initial per Capita GDP (PPS) in Country *i* in period *t-1.* [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] Dependent and explanatory variables lagged 1 and 2 periods respectively. All the explanatory variables were used as instruments.

Appendix Table 15: Estimation Results for Diffusion of ICT Variables in High and Low Income Member-States.

	OLS Estimates				Arrelano – Bond Estimates[4]			
Explanatory Variables	High income		Low income		High income		Low income	
	Aggregated	Disaggregated	Aggregated	Disaggregated	Aggregated	Disaggregated	Aggregated	Disaggregated
Constant	-0.071 (-0.76)	-0.000 (-0.00)	0.192 (1.55)	-0.031 (-0.17)	0.001 (0.91)	0.002 (1.14)	-0.003** (-3.40)	-0.002*** (-2.62)
GDP Initial [1]	-0.029*** (-2.77)	-0.313*** (-5.00)	-0.028*** (-2.70)	-0.017** (-2.03)	-0.001*** (-3.40)	-0.006*** (-2.96)	-0.003*** (-3.35)	-0.041*** (-3.01)
Int'l Openness	-0.002 (-1.75)	0.004 (2.43)	0.002 (0.39)	0.001 (0.98)	0.009 (0.22)	0.005 (0.13)	0.046 (1.58)	0.041 (1.06)
Domestic Investments	0.061*** (3.60)	0.057*** (3.25)	0.080*** (5.58)	0.074*** (3.40)	0.132*** (3.91)	0.130*** (3.77)	0.173*** (6.33)	0.156*** (5.44)
Government Consumption	0.058*** (3.56)	0.577*** (3.52)	0.004 (1.77)	0.001 (0.32)	0.030*** (1.02)	0.058*** (3.56)	0.003 (0.12)	0.024 (1.37)
Total ICT Investments	0.011 (1.25)		0.041*** (3.03)		-0.010 (-0.54)		-0.004 (-0.26)	
IT Equipment		0.008* (1.73)		0.004* (2.09)		0.060** (2.30)		0.021** (1.98)
Computer Equipment		0.000 (0.45)		0.006** (2.26)		0.175 (0.68)		0.038** (2.47)
Software		0.006 (1.42)		0.006 (0.47)		-0.015 (-1.02)		-0.008 (-0.52)
Obs.	117	117	78	78	108	108	72	72
R^2	0.398	0.434	0.370	0.395				
Sargan Test (p-value)[2]					0.006	0.004	0.003	0.003
Autocovariance test of order 2 (p-value)[3]					0.000	0.000	0.028	0.008

Note: Dependent variable GDPpc (PPS) in low income countries i (i =1,…,6) and high income countries i (i =1,…,9) in period t (t =1990,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% and 1% significance respectively. OLS estimates heteroskedasticity-consistent [1] Initial per Capita GDP (PPS) in Country *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] Dependent and explanatory variables lagged 1 and 2 periods respectively. All the explanatory variables were used as instruments.

Appendix Table 16: Estimation Results for Access to Finance Variables in High and Low Income Member-States.

	OLS Estimates		Arrelano – Bond Estimates[4]	
Explanatory Variables	High income	Low income	High income	Low income
Constant	-0.013 (-0.13)	0.000 (0.21)	0.000 (0.48)	-0.003*** (-3.67)
GDP Initial [1]	-0.029*** (-2.77)	-0.017** (-2.03)	-0.003*** (-3.40)	-0.003*** (-2.02)
Int'l Openness	-0.004 (-1.63)	-0.004 (-0.76)	0.053 (1.13)	0.175 (0.68)
Domestic Investments	0.057*** (3.26)	0.087*** (4.56)	0.156*** (4.35)	0.200*** (7.94)
Government Consumption	0.052*** (3.74)	0.006 (1.04)	0.001** (0.11)	0.018 (1.19)
Venture Cap. Inv. – Early Stage	0.000 (0.17)	-0.005 (-1.65)	-0.002 (-0.78)	0.049*** (2.69)
Venture Cap. Inv. – Expansion& Replacement	0.002 (0.66)	0.000 (0.03)	-0.004 (-1.24)	-0.003 (-1.02)
Obs.	112	78	102	72
R^2	0.421	0.378		
Sargan Test (p-value)[2]			0.017	0.044
Autocovariance test of order 2 (p-value)[3]			0.000	0.026

Note: Dependent variable GDPpc (PPS) in low income countries i (i =1,…,6) and high income countries i (i =1,…,9) in period t (t =1990,…,2003). z-statistics in parentheses; *, **, *** denote 10%, 5% and 1% significance respectively. OLS estimates heteroskedasticity-consistent [1] Initial per Capita GDP (PPS) in Country *i* in period *t-1*. [2] The null hypothesis is that the instruments used are not correlated with the residuals. [3] The null hypothesis is that the errors in the first-differenced regression exhibit no second order serial correlation. [4] Dependent and explanatory variables lagged 1 and 2 periods respectively. All the explanatory variables were used as instruments.

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