Education Quality and Economic Performance in Europe

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Abstract: The paper reflects on the role played by human capital in the continued diversity of growth dynamics in Europe. Given the increasing convergence in terms of the average years of schooling, we claim that it is the quality more than the quantity of education that matters for economic growth in advanced countries.
Using EU27 country data to estimate a growth regression model, we test for the significance of several human capital measures drawing on education level and quality. Average years of schooling and the percentage of labour force with tertiary education are used to measure education stock. For education quality we use the share of graduates in higher education by educational field and the PISA mean scores in reading, maths and science.
Our research findings indicate that particular kinds of human capital seem to be more important than others in explaining the growth rates of EU countries from 2000 to 2010. Although positively related to GDP *per capita* growth, higher education levels were not statistically significant. Specific kinds of higher education, such as science, maths and computers, appear to be more relevant; on the other hand, PISA scores do not seem to have a significant impact on growth.
These results suggest relevant policy implications as research, innovation and education are core elements of the European growth strategy. A larger proportion of the workforce with tertiary education and also a diversified pool of qualifications could be of benefit to Europe's economic performance. In particular, high qualifications in science and technology appear as very relevant for innovative performance. The quality of education systems, measured by PISA scores, may have a delayed and indirect effect on economic growth. Progress can be made in higher education, and especially in science and technology, by systematically improving cognitive skills at school, notably mathematics and science literacy.

Key words: human capital; education quality; cognitive skills; innovation; economic growth.

1. Introduction

Literature has provided empirical evidence of the role human capital and innovation play in growth. While many studies have specifically sought to improve the robustness of the models and the reliability of the estimates, interesting qualitative results have also been made available. One is that the effect of the accumulation of education on growth can vary greatly depending on the country's level of development. In advanced countries, the economic returns on additional years of education have been lower than in less developed countries especially in recent decades. Another is that human capital is fundamental to economic growth because it not only affects a country's capacity for domestic innovation but also facilitates the adoption of superior technologies from abroad. In this case, the stock of human capital, notably higher education and skills in science and technology, proved to be more important than the accumulation of years of schooling. Finally, there is evidence that the quality of education, measured by the cognitive skills acquired at school like maths and science literacy, is more significant in explaining economic growth than the number of years of schooling.
In light of this, our research will try to understand why economic performance in Europe is so distinct, although education levels have been converging. We assume that it is the quality of human capital that distinguishes countries and may significantly contribute to their economic performance rather than the amount of human capital available. Notwithstanding, attention in both academic and policy fields has focused predominantly on measures addressing the quantity rather than the quality of human capital.
We start the paper by reviewing the literature on how human capital and innovation interact in economic growth models (section 2) and then present our research hypotheses (section 3). Section 4 will introduce the data and results from a preliminary analysis. The main research findings will be presented and discussed in section 5. Finally some relevant conclusions and policy implications will be proposed.

2. Literature review

Since the neoclassical growth accounting studies, the importance of the quality of labour to the high productivity gains made by the major capitalist economies since the early 20th century has gradually been recognised. But it was only with the endogenous growth models from the 1980s that human capital assumed a prominent role in the explanation of economic growth. The accumulation of human capital, i.e. the period of time devoted to education, in Lucas (1988), and the existence of a stock of workers dedicated to research activities, in Romer (1990), began to be formally included in the models as drivers of long term economic growth.

The way human capital and innovation interact in growth-maximising contexts has been the subject of interesting research and debate. Human capital not only facilitates adaptation to advanced technologies, but also enables the achievement of cutting-edge innovations (Nelson and Phelps, 1966; Romer, 1990; Benhabib and Spiegel, 1994). This interaction effect, rather than labour and capital accumulation, has made a large contribution to the explanation of total productivity growth. In the convergence literature, a minimum level of education initial stock is a pre-condition for countries lagging behind the leaders to take 'advantages of their backwardness'. Barro's growth regressions (Barro, 1996; Barro and Lee, 1996; Barro, 2000) have broadly confirmed the *threshold effect* of education, although results are sensitive to several other structural, institutional and political variables. Following a Schumpeterian approach to economic growth, technology gap models (Fagerberg, 1987; Verspagen, 1991) consider education as part of a country's capability - its *intrinsic learning capability* (Verspagen, 1991) - which is essential for catching-up as well as for innovation.

But education does not seem to affect imitation and innovation uniformly. According to Acemoglu, Aghion and Zilibotti (2002), higher education investment should have a greater effect on a country's ability to create cutting-edge innovations, whereas primary and secondary education are more likely to make a difference in terms of the country's ability to implement existing technologies. As a country moves closer to the technology frontier, tertiary education is expected to become increasingly important for growth as opposed to primary and secondary education. The impact of the various levels of education depends on each country's level of development. While primary and secondary education are related to economic growth in the poor and intermediate developing countries respectively, it is tertiary education that is important in OECD developed economies. In fact, both the initial level and the subsequent accumulation of tertiary education were found to be positively and significantly related to *per capita* income growth in the most developed OECD countries (Barro and Sala-i-Martin, 1995; Gemmel, 1996). Moreover, a high proportion of higher education as well as scientists and engineers in research activities are found to make a significant contribution to economic growth in developed economies (Wolff and Gittleman, 1993; Gittleman and Wolff, 1995; Wolff, 2000).

Over the past fifteen years, pioneering empirical research on growth by Hanushek and Kim (1995, 2000), Lee and Lee (1995) and Lee and Barro (1997) has demonstrated the robust and strong influence of cognitive skills on economic growth. Not only is the magnitude of the impact of the years of schooling on growth reduced considerably when direct measures of school-based cognitive skills - student performance in international tests of academic achievement - as proxies for education quality are used, but the predicted growth rates are improved significantly particularly at the high and low ends of the distribution (Hanushek and Kim, 1995, 2000). Lee and Lee (1995) findings were similar and showed that quantitative measures of education do not have a significant effect on growth. Lee and Barro (1997) found that while both the quantity of schooling and test scores matter for economic growth, the latter were much more important.

3. Research hypotheses

The research presented herein endeavours to explain differences in the recent growth of GDP *per capita* in European countries through the way countries perform in human capital. The central assumption is that what distinguishes countries and may significantly contribute to their economic performance is predominantly the quality of human capital rather than the amount of human capital available. The research hypotheses are that (1) certain kinds of higher education are fundamental for economic growth, namely science and engineering as they are more complementary with innovation; (2) the quality of the education system, as assessed by PISA scores and particularly its continuous improvement may also contribute to explaining income growth differences.

4. Data and preliminary analysis

Our study focuses on the EU27 except Luxembourg (which was removed because it is an outlier in terms of GDP *per capita*). This set includes countries with a relatively homogeneous institutional framework but also with diverse levels of *per capita* income. In 2000, we have the Netherlands at one extreme with an index of GDP *per capita* in PPS of 134 (where the EU27 average is 100) and Romania at the other extreme with an index of 26 (Table 1). However, the divergence between countries has been decreasing, with the coefficient of variation of GDP *per capita* in PPS reducing from 42% in 2000 to 29.6% in 2010. The Eastern European countries show higher growth rates in this period.

Table 1: Levels and growth of GDP *per capita* (2000-2010) in EU27 (minus Luxembourg)

Country	GDP *per capita* (p.c.), EU27=100		Growth of GDP (p.c).
	2000	2010	2000-10
Belgium	126	121	0.1086
Bulgaria	28	44	0.5328
Czech Republic	68	81	0.2663
Denmark	131	128	0.1018
Germany	118	120	0.1361
Estonia	45	64	0.5031
Ireland	131	129	0.1033
Greece	84	88	0.2361
Spain	97	99	0.1895
France	115	109	0.0821
Italy	117	103	-0.0065
Cyprus	89	97	0.2519
Latvia	37	55	0.4655
Lithuania	39	62	0.4645
Hungary	55	66	0.3122
Malta	84	87	0.1244
Netherlands	134	130	0.1075
Austria	131	127	0.1071
Poland	48	63	0.4030
Portugal	81	80	0.1500
Romania	26	48	0.6901
Slovenia	80	84	0.2180
Slovakia	50	74	0.4961
Finland	117	114	0.1243
Sweden	127	124	0.0993
UK	119	108	0.0733
EU 25	105	103	
EU 15	116	110	
N	26	26	
Min.	26	44	
Max.	134	130	
Average	87.57692	92.5	
St. Dev.	36.8512	27.3528	

Coeff. Var.	0.4207	0.2957	

Source: GDP in PPS with EU27=100 is from Eurostat; growth rates are based on real GDP *per capita* at constant 2005 PPS (in mil. 2005US$) from Pen World Table 8.0.

In relation to education levels, we look at the proportion of working age population with higher education (ISCED levels 5 and 6, from Eurostat) – *Higher edu* -, or alternatively the average years of schooling of the population over 25 years (from Barro and Lee (2011), version 1.2).
Education quality is analysed on the basis of two indicators: average PISA score, i.e. the average of scores on reading, mathematics and science literacy (from PISA, OECD); and the proportion of graduates in four educational fields (humanities and arts - *humanities*; social sciences, management, and law – *social sciences*; sciences, maths and computers science - *sciences*; engineering, manufacturing industries and construction – *engineering* - from Eurostat).
In addition, we control for the investment in physical capital (investment in proportion of GDP, from Eurostat) - *Inv*, and for the importance of innovation in the economic system. Two indicators from Eurostat are used to measure innovation: gross expenditure on research and development (GERD) as a percentage of GDP, and the number of applications to the European Patent Office (EPO) per million inhabitants.

4.1. Higher education

Regarding the quantitative indicators of education, our priority goes to the proportion of the working age population with higher education rather than the average years of schooling. There are two reasons for this. Firstly, European countries are more diverse in terms of higher education; the coefficient of variation of the average years of schooling in 2000 was 12.2%, while the same indicator for the proportion of working population with higher education was 45.2%. Secondly, higher education is more relevant to assess individuals' preparation for a more complex and technologically advanced society and economy, as is the case of European countries. The correlation of the higher education indicator with GDP *per capita* in 2000 was positive (0.28) but statistically insignificant (p-value=0.17).
It is important to note that the human capital stock of the EU26 was better in 2010 than in 2000 as the average level of higher education among the active population went from 16.8% in 2000 to 22.5% in 2010 (Table 2). We can also observe convergence among countries with the coefficient of variation going from 0.45 to 0.30.

Table 2: Active population with higher education (%) in 2000 and 2010 (EU27 minus Luxembourg)

	2000	2010
N	26	26
Min.	4.93	11.93
Max.	34.74	32.74
Average	16.7528	22.5192
St. Dev.	7.5649	6.7416
Coeff. Var.	0.4515	0.2993

Source: Eurostat.

4.2. Graduates by field of higher education

In addition to analysing the population's level of schooling, our aim is also to determine whether higher qualifications in certain areas may be relevant in explaining economic performance. To this end, we examine the graduates by educational field. Indeed, we question here the importance of qualifications in science and technology due to the importance given in Europe to their acknowledged contribution to the promotion of innovation activities and the development of technology-intensive sectors, both in terms of endogenous technological production and technology imitation.
A simple correlation analysis indicates that the proportion of graduates in social sciences, business and law has a negative and statistically significant correlation with GDP *per capita* (-0.62, p-value=0.0010), whereas the proportion of graduates in science, maths and computer science has a positive and significant correlation with GDP *per capita* (0.49, p-value=0.0126). The other two

scientific areas analysed, humanities and arts and engineering, are not statistically correlated with *per capita* income. The graduates in social sciences, business and law have also a negative and significant correlation with the total proportion of higher education graduates (-0.47, p-value=0.0181). Despite its negative association with income and higher education, the area of social sciences, business and law has the most graduates, representing 33.7% of graduates in the EU27 in 2000 (Table 3). The country distribution of the graduates in this area helps explain the negative correlation with *per capita* income: Bulgaria, Latvia, Slovenia and Romania have the highest ranking in this indicator, while Germany, Finland and Sweden present the lowest figures.

Table 3: Distribution of graduates by four fields of education (%) in 2000 and 2010 (EU27 minus Luxembourg)

	2000				2010			
	Hum. and arts	Social sciences	Sciences	Eng.	Hum. and arts	Social sciences	Sciences	Eng.
N	25	25	25	25	25	25	25	25
Min.	5.8	20.6	2.3	5.1	6.16	22.45	4.67	6.41
Max.	15.6	48.2	21.6	22.6	18.93	59.98	12.87	23.98
Average	9.5633	33.7222	7.8224	14.0486	10.6548	36.7824	7.9564	13.2012
St. Dev.	3.1863	7.2463	4.4878	4.6912	3.7394	9.7910	2.4938	4.2782
Coeff. Var.	0.3332	0.2149	0.5737	0.3339	0.3510	0.2662	0.3134	0.3241

Source: Eurostat.
Notes: In 2000, data were not available for Greece; in 2010, data were not available for France.

Our preliminary analysis indicates that a higher proportion of graduates in science, maths and computer science is positively associated with economic growth. The average proportion of graduates in this area in the EU26 increased only slightly from 7.82% in 2000 to 7.96% in 2010. In addition, there is a strong convergence between countries as indicated by the reduction of the coefficient of variation from 0.57 in 2000 to 0.31 in 2010. In contrast, there was a considerable increase in social sciences, business and law, with the EU26 average proportion of graduates in this field going from 33.7% in 2000 to 36.8% in 2010.

4.3. PISA mean scores

In an attempt to measure the impact of the quality of education systems, we will also test the importance of cognitive skills generated by education: literacy in reading, maths and science assessed by PISA. We look at the average of these three literacy indicators.
As many of the EU26 countries did not participate in PISA tests in 2000, we choose to study only the EU15 countries with PISA scores available in 2000 and 2009. For this set of countries, the average PISA score was 497.3 in 2000 and 497.4 in 2009, showing that the relative position of EU15 remained basically unchanged. However, there was a reduction in the coefficient of variation from 0.045 in 2000 to 0.031 in 2009 (Table 4). Additionally, the position in relation to the OECD average improved over this period: whereas the OECD average decreased from 500 in 2000 to 496.6 in 2009, the EU15 average remained constant.

Table 4: PISA mean scores in reading, maths and science in 2000 and 2009 (EU15)

	2000	2009
N	14	15
Min.	460.67	473
Max.	540	543.67
Average	497.25	497.3542
St.Dev.	22.6335	15.4950
Coeff.Var.	0.0455	0.0312

Source: PISA database, OECD.

Notes: In 2000, data were not available for the Netherlands.

The correlation of the PISA indicators with GDP *per capita* is positive and statistically significant (0.53, p-value = 0.0330). Of course, in this case causality can run in both directions as investment in youth education is greater and better in richer countries.
There is also a positive correlation between the higher education indicator (the proportion of working age population with ISCED levels 5 and 6) and the quality of the education system (0.70, p-value=0.0026). In addition, the higher quality education systems tend to have a comparatively small proportion of graduates in social sciences, business and law, and more in science and mathematics (the correlations are significant at 10% and are -0.4835 and 0.4803, respectively).

5. Empirical results

Our goal here is to explain the growth of GDP *per capita* for the period 2000-10. We choose a ten year period to give the variables affecting economic growth a considerable span of time to produce effect. We are unable to study more decades because of the lack of data on the qualitative dimension of education.
The sample includes Norway and the EU27 countries except Luxembourg, Greece and Malta. Luxembourg was removed because it is an outlier in terms of GDP *per capita* and Greece and Malta had no data for one of the variables of the regression. Therefore, the regression includes 25 countries.
The usual equation in the study of economic growth is estimated:

$$\Delta y_t = \beta_0 + \beta_1 y_{t-1} + X_{t-1} b + \varepsilon_t$$

where Δy_t is the growth of GDP *per capita* in 2000-10, y_{t-1} is the log GDP *per capita* in 2000, and X_{t-1} is a vector of variables including human capital (both quantitative and qualitative indicators), GERD, and physical capital in 2000. The idea is that economic growth depends on the initial level of development and allocation of resources. By considering the initial values of the variables, we reduce eventual problems of endogeneity. We also consider standard deviations robust to heteroscedasticity.
The GDP *per capita* is the real GDP at constant 2005 PPPs (in 2005 thousand US$) divided by the active population, both from Penn World Tables 8.0. If the convergence hypothesis is confirmed in terms of GDP *per capita*, we should obtain β_1<1.We also introduced the squared terms of investment in physical capital and in R&D to account for possible decreasing returns on these investments.
Our first regression does not include PISA scores because they are only available in 2000 for a smaller set of countries (Table 5, model 1). This regression indicates that the variable “proportion of workforce with higher education” has a positive effect on economic growth but it is not statistically or economically significant. With the proportion of working age population with higher education constant, a rise in the proportion of graduates in the humanities and arts area tends to reduce growth, while a rise in the proportion of graduates in sciences, mathematics and computer science increases economic growth. For example, a 1 p.p. increase in the proportion of graduates in humanities and arts reduces growth by 1.58 p.p. in a ten year period. On the other hand, a 1 p.p. increase in the proportion of graduates in sciences, maths and computers increases growth by 0.69 p.p. in the same period. The result may be explained by the fact that a knowledge-based economy requires more graduates in maths, sciences, computers and engineering.

Table 5: Regression to explain growth of GDP per capita (2000-10)

	Coefficient (St. Dev.)	
	Model 1	Model 2
GDP p.c. (log)	-0.3775*** (0.0424)	-0.2351* (0.1001)
Inv	0.0597 (0.0378)	0.0592 (0.0693)
Inv^2	-0.0014 (0.0008)	-0.0013 (0.0013)
GERD	0.0569	0.0374

	(0.0504)	(0.0965)
GERD²	-0.0207 (0.0152)	-0.0150 (0.0147)
Higher Edu	0.0015 (0.0036)	0.0022 (0.0019)
Humanities	-0.0158** (0.0069)	-0.0186** (0.0186)
Social Sciences	-0.0044 (0.0028)	-0.0039 (0.0053)
Sciences	0.0069** (0.0031)	0.0040 (0.0045)
Engineering	-0.0011 (0.0038)	-0.0074 (0.0076)
Constant	3.626*** (0.4699)	1.8951** (1.7804)
PISA	-	0.00069 (0.00095)
No. Obs.	25	16
F	32.60	30.17
R^2	0.9241	0.9522

Note: All independent variables refer to 2000.

Regarding the control variables, the convergence hypothesis is confirmed because the coefficient of the initial GDP *per capita* has a negative sign and is significant at a level of 1%. Therefore, the countries with higher initial income levels (in 2000) exhibit the lowest growth rates in the 2000-10 period. Investment in physical capital has a positive and statistically significant effect on growth, but the negative coefficient of its squared term shows it has decreasing returns. In turn, investment in R&D does not have a statistically significant effect on growth. There are two possible explanations for this result. Firstly, investment in innovation has long-term effects and is associated with the country's growth model, making it difficult to capture its effect on a regression with a short period sample. Secondly, we are dealing with a set of countries in which it is precisely the countries with higher economic growth rates that invest less in R&D.

In order to assess the impact of the quality of the education system on economic growth, we introduced the PISA scores in the equation. As mentioned, the sample is reduced to Norway and the EU15 countries as several of the EU27 countries do not have these scores for 2000. Surprisingly, PISA scores for this sample of countries do not have a significant impact on growth (Table 5, model 2). Besides the small number of observations available, and the limited dispersion of values, this result might be explained by the fact that the quality of the education system has a delayed effect on economic growth. The quality of youth education today will only affect the quality of the workforce in the future. Also, the percentage change in the PISA score between 2000 and 2009 does not have a statistically significant effect on growth.[1] As a sensitivity test, we replaced the investment in R&D with an output indicator of the national system of innovation (the number of patent applications to the EPO per million inhabitants), and replaced the proportion of highly educated workforce with the average number of years of schooling, obtaining similar results to those of the first equation.

The empirical work presented has some limitations and is still exploratory. We note in particular that we cannot introduce countries' fixed effects that capture the structural characteristics of the country due to data limitations.

6. Discussion and conclusions

Given that European countries still show considerable diversity in income levels and growth performance, our point of departure was to analyse the extent to which human capital could explain this diversity. Our assumption was that the quality of human capital contributed more significantly to this than the amount of human capital. Regression models were tested to explain GDP *per capita* growth rates in EU 26 countries between 2000 and 2010, and quantity and quality measures of initial levels of education were included.

The convergence hypothesis was confirmed as countries with lower levels of initial income (in 2000) exhibit higher growth rates in this 2000-10 period but initial human capital endowments were also

[1] The remaining results in this paragraph are available upon request.

significant. As previously reviewed, several authors have stressed the importance of tertiary education for growth in developed countries (Barro and Sala-i-Martin, 1995; Gemmel, 1996). However, our results show that although higher education is positively related to GDP *per capita* growth, it was not statistically significant. Particular kinds of higher education appear to be more relevant.

In fact, when the proportion of working age population with higher education is constant, a rise in the proportion of graduates in humanities and the arts tends to reduce growth, while a rise in the proportion of graduates in sciences, mathematics and computer science increases economic growth.

We also tested for the PISA score contributions in a smaller set of European countries. Although PISA scores do not have a significant impact on growth, the correlations with GDP *per capita* and higher education are positive and statistically significant. Moreover, higher quality education systems tend to have a relatively small proportion of graduates in social sciences, business and law, and more in sciences and mathematics.

These results indicate several and interesting research findings. Firstly, a diversified pool of graduates may prove economically more rewarding. Secondly, particular kinds of human capital seem to complement innovation more than others. In particular, a larger proportion of high qualifications in science and technology may be beneficial. This interaction effect (Nelson and Phelps, 1966; Romer, 1990; Benhabib and Spiegel, 1994) may actually enable growth either through endogenous technological production or technology imitation. Finally, the quality of education systems may contribute to economic growth as Hanushek and Kim (1995, 2000), Lee and Lee (1995) and Lee and Barro (1997) have demonstrated. Although our results do not show a significant contribution from PISA scores (mean levels and variation 2000-2009), they may have a delayed and indirect effect on economic growth. Higher and continuously improved cognitive skills of youth at school, especially in mathematics and sciences literacy, will lead to further studies in higher education, notably in science and technology. In terms of policy formulation, our results suggest that both quantity and quality of education must be considered in order to promote growth in knowledge-intensive economies.

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