9. HUMAN CAPITAL, INNOVATION AND ECONOMIC GROWTH IN THE EU COUNTRIES

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Abstract

The importance of human capital for development and innovation is shown by the multitude of studies dedicated to this subject. The paper follows the methodological path from Hanushek's studies (2013) and Angel de la Fuente and Doménech (2000) adapted to the objective of an analysis at European Union level. The data was extracted form Eurostat database and the UNCTAD Human Development Report for 2019.

We apply a mixed effect model with fixed and random effects allowing highlighting the total impact of human capital, variable proxied by the average of years of education. The coefficient for the human capital was found 0.2586, in average, but different for each country. This result is closer to the estimation of Mankiew, Romer and Weil's study (1992), which found an influence of 49%, lower than the long-term effect of 66% highlighted in the studies conducted by Portela et al. (2004) and by Teulings and Van Rens (2002. Moreover, the model also showed an indirect positive effect for improving the economic growth of human capital, evidenced by its capacity for innovation. The indicators used in this case are the expenditures for research and development per capita and the number of patents applied.

Keywords: Human Capital, Innovations, Economic growth; Mixed-effect models

JEL Classification: I25, O15, O31, O12, O47

1. Introduction

Adam Smith approached human capital as the fourth element in the production function, along with the technological progress, labour and physical capital. In 'Principles of Economics', Alfred Marshall considers human capital as being the most important investment in capital. Schultz (1961) and Denison (1962) confirmed that education, regarded

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as a major factor in the accumulation of human capital, directly contributes to economic growth by improving qualification and productive capacity of the workforce. The same idea can be found in the research works of Hicks (1982) and Wheeler (1980), Psacharopoulus and Woodhall (1985, pp.15-16).

The modern concept of human capital is a result of economists' efforts to explain the size of the residue in the classical function of production, the partial explanation being linked to investment in human capital education through formal training, specializations and work experience. Other models of economic growth from Lucas (1988), Romer (1990), Barro and Sala i-Martin (1995) have considered that investment in human capital ensures both labour growth, technological progress and the innovation. All can be considered as positive factors that increase the productivity of other factors of production according to Boarini, d'Ercole, Liu, (2012, p.7).

Bas van Leuwen (2007) provides not only a summary of the literature on the relationship between human capital and economic growth, highlighting the issues raised by its measurement, but also the development of models that emphasize this relationship. The human capital in Beker (1964) and Mincer's vision (1981) refers to the skills that workers acquired through education and work experience. According to OECD (2011), the definition is much broader encompassing both competences and qualifications obtained through education and experience, as well as natural ones plus some other aspects related to motivation and behaviour, as well as physical, emotional and mental health aspects of individuals. The evolution of society after the Fourth Industrial Revolution requires that human capital be approached not only as skills and knowledge gained through education and experience by workers, but also by considering the depreciation through lack of use during life, along with the increased and in-depth knowledge, by engaging in specialized economic and social activities, therefore, considering its evolution over time. The need for sustainable development compels countries, under conditions of limited resources, to ensure that "an unchanged stock of total capital (including human capital) per capita be passed on to the next generation" (Boarini, d'Ercole and Liu, 2012, p.7).

In comparison with the existing literature on this topic this paper uses the methodological framework of mixed-effects models to estimate the country-level impact of human capital, expressed by average years of schooling, on economic growth within the European Union (EU). It is structured as follows: Section 2 is a review of the literature on human capital and its impact on development and innovation, Section 3 introduces the model along with the description of data, Section 4 present the results and finally, Section 5 presents the conclusions.

2. Literature review

There is a broad literature that seeks to highlight the relationship between economic growth and human capital and between innovation and human capital mainly due to the differences among the techniques used, starting from growth models in which human capital is approached as an endogenous or exogenous factor to panel models or models based on the production function.

By combining into one model the developments of Romer (1990), Mankiw et al. (1992) and Nelson and Phelps (1966), Jones (1996) highlighted the importance of understanding technology transfers between countries as sources of income gaps. Moreover, he points out that the model approach of the education level as an investment rate, and not as a stock of human capital as Barro Barro and Lee (1995) have considered it, seems a more accurate interpretation of human capital.

Benhabib and Spiegel (2002) analysed the relationship between human capital and technological diffusion, showing that modern theories of economic growth pay particular attention to stimulating innovation and market structure to stimulate and support the R&D activity, which requires the engagement of a much costlier human capital, able to innovate and effectively use the existing knowledge stock. Generalizing Nelson Phelps's model from the perspective of the implications regarding the exponential or logistic diffusion of technology, Benhabib and Spiegel (2002, p. 10) concluded that they may be divergent to economic growth, the logistic model implications being consistent with the theoretical predictions. As a result, human capital plays a positive role in determining the overall productivity of factors that influence the process of narrowing the gap between countries. Moreover, by resorting to the microeconomic foundations of Barro and Sala-i-Martin's diffusion model, they concluded that, under the conditions of an imperfect market in human capital accumulation, the state subsidies for education may be needed so that by technological diffusion the states will reduce the development gap as compared to developed economies.

Petrakis and Stamatakis (2002) showed that each level of education has a different impact on economic growth: for developed countries, human capital with secondary and tertiary education level has a higher impact as compared to the primary level, a fact also highlighted for Romania by Pelinescu (2015a).

Based on studies conducted on two series of data 1957- 1965 and 1966-1977 Griliches (1998, p.4) analysed the contribution of development research (CD) to increasing labour productivity and found that R&D contributes positively to productivity growth having a fairly high return on investment rate; basic research appears to be more important as a determinant of productivity than any other type of research, and finally that R&D private funding at enterprise level is much more effective than that at governmental level.

Balcerzak and Pietrzak (2016, pp.7-8), analysing the quality of human capital in the European Union countries during the period 2004-2013, considered that 'Quality of human capital is currently considered as one of the most important development factors in the case of highly developed countries that compete in the reality of global knowledge-based economy'. In terms of importance, from the perspective of influencing the quality of human capital, for the final model they took into account among others: *total intraramural R&D expenditure as a percentage of gross domestic product; material deprivation rate; people at risk of poverty or social exclusion as a percentage of total population; participation rate in education and training (the last 4 weeks) as percentage of population aged between 25-64*. The application of the model led to the conclusion that Sweden occupied the first place in terms of level of quality of human capital in E.U. countries and its changes in the years 2004-2013. Romania was situated in the 23rd place out of 24 analysed countries, the last place being occupied by Bulgaria. In terms of the biggest changes at the level of quality of human capital between 2004 and 2013, Poland ranked first with a change rate of 19.98%, followed by Slovakia with 16.63%, and Sweden ranking in 5th place. Romania ranked 10th, with a 6.68% change rate, lower than Bulgaria with 9.47%, which ranked 6th in the hierarchy. These data point out that the new members of the European Union have made much greater progress than the old ones as far as the level of quality of human capital is concerned.

De la Fuente and Doménech (2000, 2006), studying the relationship between production and human capital, both in level and in first order differences, revealed a significant, positive, statistical correlation among these two variables (also demonstrated by Temple, 1999). Mac Mahon (1998) and Psacharopoulos (1994) highlighted the fact that the importance of secondary and tertiary education increases over time, especially for developed countries involved in the implementation of knowledge-based society. Petrakis and Stamatakis (2002, 518-519) showed that each level of education has a different impact on economic growth: for developed countries, human capital with secondary and tertiary education has a higher impact as compared to primary level, as evidenced for Romania by Pelinescu (2015a).

Phillips (1993) focused his research on changes in labour productivity, in the U.S.A.'s industry, in relation to R&D expenditure and market power, focusing on Solow's residues as a measure of total factor productivity. He also highlighted a strong long-term correlation between R&D expenditure and growth of technology, emphasizing on short term, the role of companies financing R&D.

At the EU level, Diebolt and Hippe (2016) analysed the long-term impact of human capital and innovation on economic growth, highlighting the relationship between human capital and innovation (expressed by the number of patents per inhabitant), based on regressions in the fixed effects panel methodology, along with the relationship between human capital and economic growth (expressed by the Gross Domestic Product per capita at PPS), which is a positive and statistically significant one, a conclusion validated also by Pelinescu (2015a).

Altăr, Necula, Bobeică (2008), using an Uzawa-Lucas model for a two-sector economy, show that, in the long run, in Romania economic growth would be determined by the accumulation of human capital that would enhance the quality of work. Saman (2011) shows the importance of investment for

Pelinescu (2015b) highlighted the impact of human capital on economic growth, following the approach of Angel de la Fuente and Rafael Doménech (2000), applying a panel model. For the EU countries over the period 2000-2012, the model's results indicated a positive link, statistically significant, between gross domestic product per capita and the innovative capacity of human capital expressed by the number of patents applied and the qualification of the staff employed, expressed by the staff with secondary education.

In contrast to these studies, we apply a mixed effect model on the 28 EU countries and obtain a different coefficient of years of tuition for each country in order to capture the dissimilarity existing in the EU.

3. Methodology and Data

To achieve the objective of highlighting the influence of human capital on development and innovation, the methodological approach of Hanushek (2013), Angel de la Fuente and Doménech's studies (2000) is followed, adapted for the EU countries, involving the use of mixed effect models.

The model used in the paper can be presented mathematically as follows:

$$G_{\ tj} = \alpha_0 + \beta_1 H_{tj} + \sum_{k=2,\dots,K} \beta_k X_{ktj} + u_{1j} H_{tj} + v_{t1} + v_{2j} + \varepsilon_{tj} \qquad (1),$$

where G_{tj} is a measure of economic activity for country *j* in year *t* as a direct function of human capital (H_{tj}) and other K-1 factors ($X_{ktj},\ k = 2, \dots, K$) including also a stochastic element ε_{tj}.and a time and and country effects (v_{t1} and v_{2j} respectively). The model is considering random intercept that assumes different intercepts (v_{t1} and v_{2j}) and fixed (β_1) and random slopes (u_{1j}) for human capital in the country *j*.

The model is estimated on data for the EU countries between 2000 and 2017, using the following variables: as a dependent variable GDP per capita expressed in PPS (GDP_HAB), and as independent variables: (i) for human capital: the average of school years (AVG_Y_SCH), (ii) for control variables the innovation: expenditure on R&D per inhabitant (R&D_HAB_EXP), and the number of patents applied (PAT).

The data are annual for the 2000-2017 period, collected from Eurostat database in most cases, except for the average number of years of tuition that was obtained from UNCTAD Human Development Report for 2019.

All results and their statistical description were included in Table 1. The statistical analysis of the series shows large differences, with standard deviations varying in an extremely wide range, depending on the unit of measure of the used indicator. Also the variables are not stationary, so all data were stationarised by 1st order differentiation of the logarithm obtaining growth rates.

In Table 1, Panel B, we show the variability in the panel of data: (i) we have 457 observations and 28 countries with some missing data on number of patents applied (PAT); (ii) there is variability between countries; (iii) the standard deviation is larger within countries.

Table 1

Statistical description of the data

Panel A: Variables: level

	GDP_HAB	AVG_ Y_SCH	R&D_HAB_EXP	PAT
Average	24357.97	11.24888	418.58	2040.913
Std. Dev.	11293.2	1.305256	417.5134	4473.316
Maximum	5127	6.8	6.6	0.33
Minimum	78791	14.1	1615	24396.57

Panel B: Variables: growth rate (first order differentiation of the logarithm)

Variable	Average	Std. Dev.	Minimum	Maximum	Observations
GDP_HAB	0.033711	0.047959	-0.17838	0.321176	N = 457 n = 28 T-bar = 16.3214
between		0.0184741	0	0.0770695	
within		0.0443788	-0.2064726	0.3124092	
AVG_Y_SCH	0.010508	0.019618	-0.08626	0.214775	N = 457 n = 28 T-bar = 16.3214
between		0.004711	0.003447	0.02057	
within		0.01909	-0.08435	0.208361	
R&D_HAB_EXP	0.062055	0.109252	-0.49954	0.735634	N = 457 n = 28 T-bar = 16.3214
between		0.034235	0.010467	0.127668	
within		0.103905	-0.53051	0.693708	
PAT	0.044894	0.308164	-2.36143	2.813411	N = 457 n = 28 T-bar = 16.1786
between		0.056198	-0.04091	0.165241	
within		0.303166	-2.32291	2.851929	

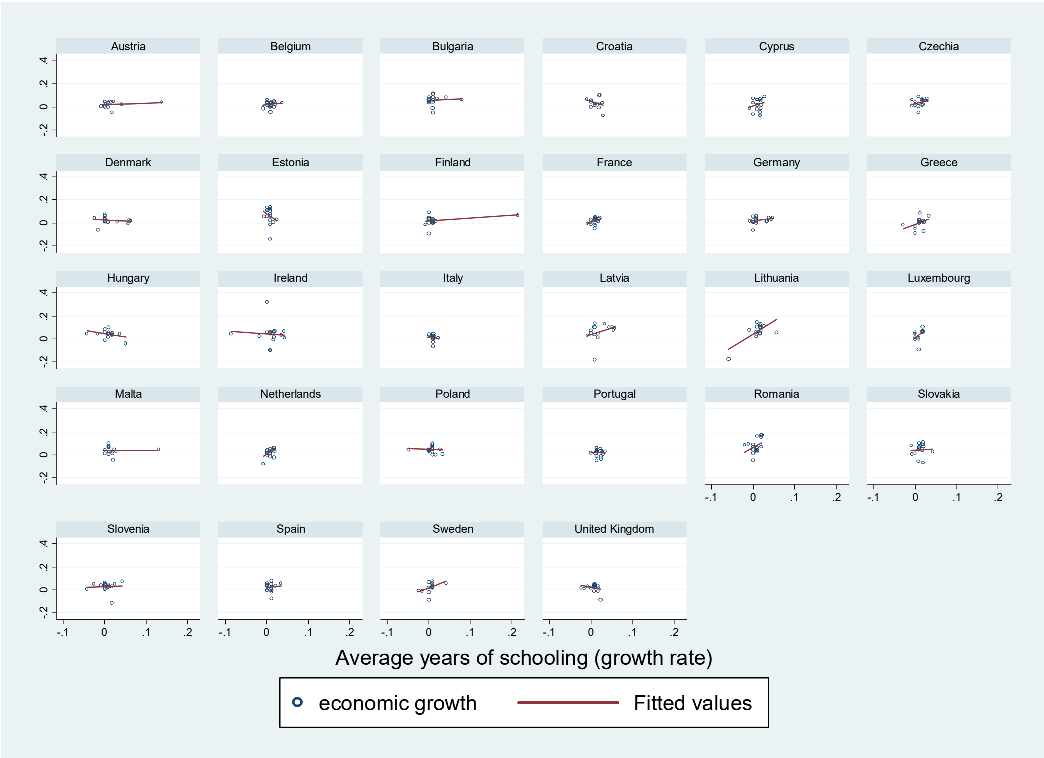
Source: Authors' calculations

The relationship between *GDP per capita* and the *Average of school years* isn't homogeneous acroos countries (Figure 1). The fact that the slope is ranging from negative to positive values is an argument for choosing the model with random slope for this variable, which assumes different slopes across countries. The model we have fitted implies that the between-country variance in dependent variable is explained by the growth rate in *Average of school years* (the coefficient u_{1j}) and the intercept that varies acroos countries (v_{2j}).

In the 17 years that are included in our data set, we see that there are still significant discrepancies between countries, either new EU members or even older members.

Figure 1

The data: Economic activity and Human capital (growth rates)



4. Results and main findings

Our chosen model has random effects for countries and for periods, considering that both the national specificity and the changes in different periods have influenced the relation between the indicators (Table 2). The model has highlighted the existence of negative coefficients in 2008, 2009 and between 2011 and 2013, which explain the impact of the economic and financial crisis which begun in the autumn of 2008 and reached the European Union with delay and also on a larger scale including the years 2011-2013. One exception was in the year 2010, which would indicate the existence of a crisis in "W" (Figure 1).

The model highlighted the existence of a positive link, statistically significant, between the growth of the gross domestic product per capita, the innovative capacity of human capital (as evidenced by the number of patents PAT) and the R&D expenditures per capita, as expected according to economic theory (table 2). The results indicate that, on average at EU level, higher spending on research and development per inhabitant (coefficient 0.2010662), as well as the increase in the number of patents applied (0.0108765), increase economic growth, the biggest influence being the research development effort. The influence of applying the patents is smaller since their effect extends over several years and their valorisation in the first year being from a low level.

Table 2

Fixed effect coefficients

Dlog(GDP_HAB)	Coefficient	Std. Error	z	P>|z|	[95% Conf. Interval]
Dlog(AVG_ Y_SCH) (β_1)	0.259719	0.136333	1.91	0.057	[0.007489, 0.526928]
Dlog(R&D_HAB_EXP) (β_2)	0.201066	0.017876	11.25	0	[0.166029, 0.236103]
Dlog(PAT) (β_3)	0.010877	0.006210	1.75	0.080	[0.001295, 0.023048]
Intercept (α_0)	0.017806	0.002908	6.12	0	[0.012105, 0.023506]

Source: own calculations.

The test results evaluate the significance of all random effects (Table 3).

Table 3

Fixed effect coefficients

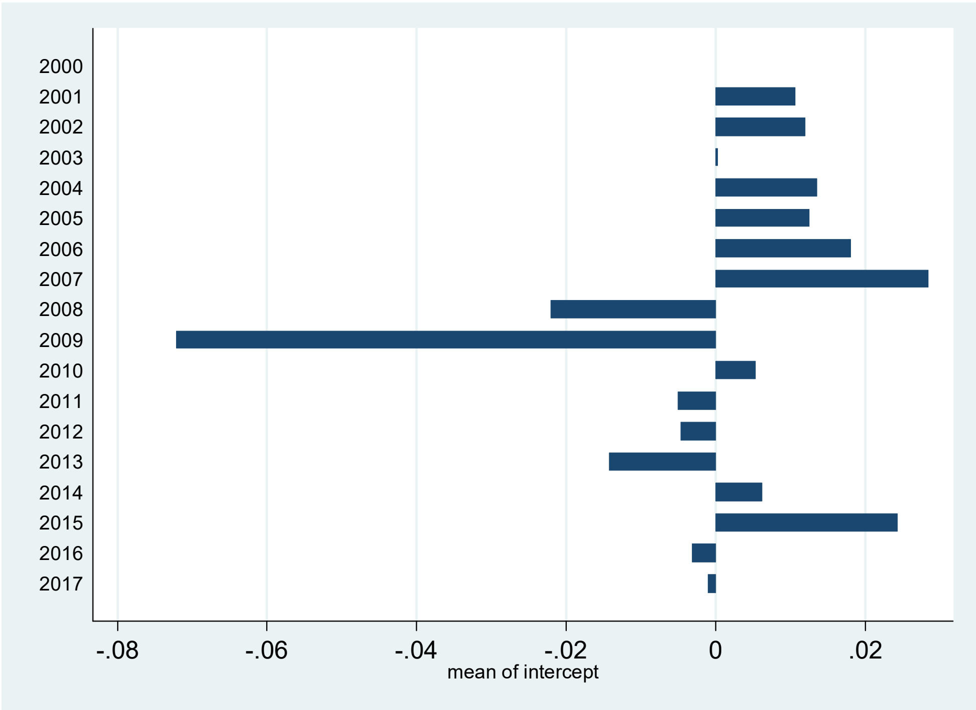
Random-effects Parameters	Estimate	Std. Error	[95% Conf. Interval]
Country: Independent			
sd(AVG_ Y_SCH)	0.371743	0.144019	[0.1739693, 0.7943498]
sd(_cons)	0.00835	0.003042	[0.0040892, 0.0170512]

Source: own calculations.

Moreover, the model showed both the negative influence of the economic crisis (large negative intercept in 2008 and 2009, Figure 2) and the existence of differences that stem from the specificities of countries (Figure 3).

Figure 2

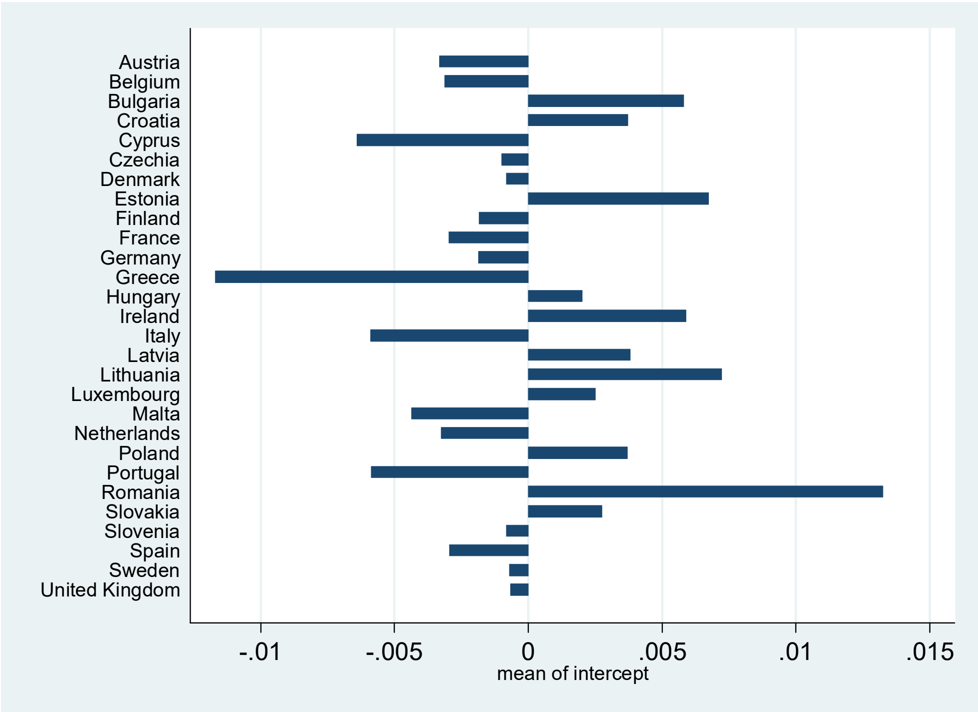
The time effect on economic growth



It is significant that the intercept sign, different from country to country, showed that the last countries who joined the European Union have had a positive influence (Figure 3) which probably indicates that the integration into the Single European Market has enabled the technological transfer which in turn has led to economic growth. This is the case for Bulgaria, Croatia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, but also for the older countries of the EU, Ireland and Luxembourg.

Figure 3

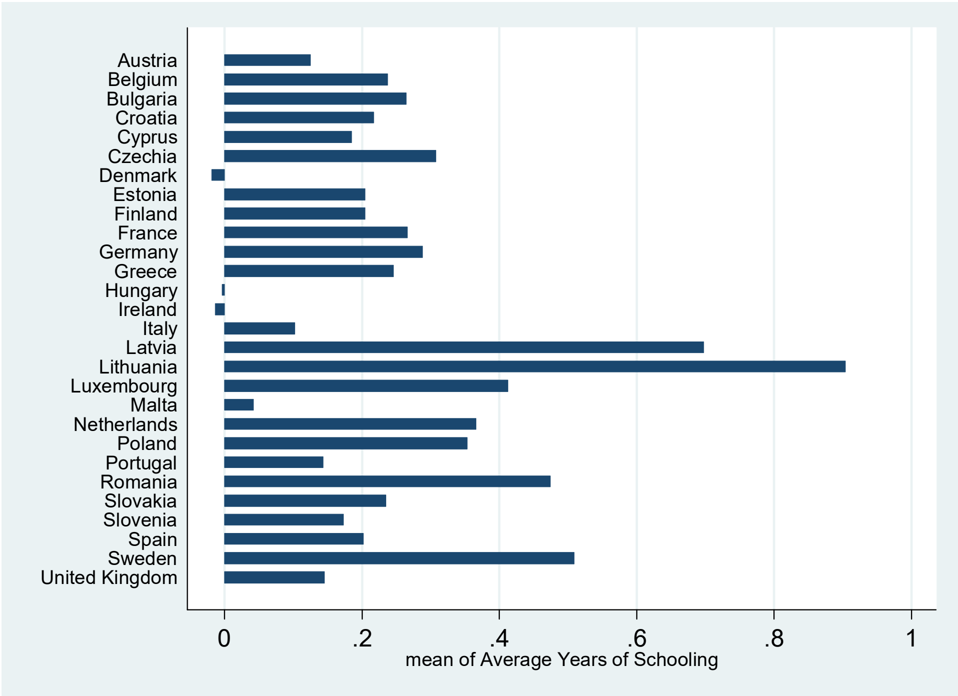
The country effect



The mixed effects model enabled highlighting the direct effect of human capital, determined as the average of years of study on sustainable development, the coefficient for proxy variable of human capital being between -0.0189 and 0.9035 with an average of 0.2586 (Figure 4). The countries with the contribution level more than 40% are Lithuania, Latvia, Luxembourg, Romania and Sweden. The result is in line with Mankiew, Romer and Weil's study (1992) that estimated an influence of 49% and with Portela et al. (2004) and Teulings and Van Rens (2002) that found a long-term effect of 66%. The negative effect for Denmark, Hungary and Ireland is unexpected, so it needs to be further investigated given the specificity of these countries, which could reveal new perspectives on analysis and could change the results.

Figure 4

The random effect of Average Years of Schooling on Economic Growth



For robustness check we estimated a model (1) with K=5 factors (X_{ktj}, $k = 2, \ldots, 5$) which included instead of the expenditure with R&D, all sectors, 3 factors for R&D expenditure that are specific to Business enterprise sector, Government sector and Higher education sector.

The results are very similar, so we only report the fixed coefficients in table 4. The random effects are similar to those of the first model, highlighting the highest total effect (fixed + random) of the human capital growth rate (over 48%) for Lithuania, Latvia, Romania and Sweden.

The greater impact on the economic growth is due to the expenses in research and development in the business enterprise sector, followed by the higher education sector.

Table 4

Fixed effect coefficients, second model

Dlog(GDP_HAB)	Coefficient	Std. Error	z	P>|z|	[95% Conf. Interval]
Dlog(AVG_ Y_SCH) (β_1)	0.25755	0.14024	1.84	0.066	[0.017320, 0.532421]
Dlog(R&D_HAB_EXP_bs) (β_2)	0.062773	0.01248	5.03	0	[0.038319, 0.087228]
Dlog(R&D_HAB_EXP_gov) (β_3)	0.024922	0.00845	2.95	0.003	[0.008369, 0.041475]
Dlog(R&D_HAB_EXP_hedu) (β_4)	0.078041	0.01234	6.32	0	[0.053853, 0.102229]
Dlog(PAT) (β_5)	0.010323	0.00638	1.62	0.105	[0.002173, 0.022819]
Intercept (α_0)	0.019319	0.00309	6.25	0	[0.013265, 0.025373]

Source: own calculations.

5. Conclusions

There are several studies that have sought to highlight the impact of human capital on development and innovation at the country level, group of countries or regions.In this paper, differently from the existing studies, we estimated the heterogeneous effect on economic growth in the EU countries of the average.years of schooling, as a representative for the development of human capital, in the contex of the growth of expenditure on development and innovation.

Applying a mixed effects panel-type model has allowed the following to be highlighted.

We show the significant positive impact of the variation of the average years of schooling on the economic growth for the countries in the European Union during 2001-2017, which is in line with the expectations, considering the prevailing role of human capital as evidenced by other studies, with the contribution level similar to that of Mankiew, Romer and Weil's study (1992), which estimated an influence from 49% to 50%. The model in this paper indicates an average effect of 0.2586 with a maximum of 0.90 for Lithuania, which is followed by Latvia, Romania and Sweden with coefficients larger than 0.4.

Furthermore, the model also showed an indirect effect of human capital in terms of its capacity to innovate. The positive and significant impact of the growth in R&D expenditure per capita on GDP growth per capita would justify the attention given by EU bodies to stimulating R&D activity, including through community funding for this activity; and stimulation of intra-community research networks.

The less significant positive impact of the number of patents applied to the variation of the gross domestic product per capita during this period is probably due to the delay with which the effects of these innovations are found in the real economy.

These results confirm that meeting the targets of the European Strategy 2020 can be delayed, unless countries start paying attention to the efforts for improving the R&D activity along with human capital growth, both quantitatively, but particularly qualitatively, by capitalizing on its innovative potential.

The conclusion is that policy measures which grow the human capital through supporting education will help economic development in the EU countries. Also encouraging innovation and increasing expenditure on R&D could accelerate economic growth in the EU countries. The main conclusion is that policy measures that increase human capital by supporting education will help economic development in EU countries. Also, encouraging innovation and increasing R&D spending could accelerate economic growth.

For future research we can consider a country-by-country in-depth specific analysis, which would put more emphasis on the extent to which human capital has contributed to development through innovation.

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