10 EXPLAINING THE EU REGIONAL ECONOMIC GROWTH THROUGH REGIONAL- AND COUNTRY-LEVEL ACHIEVEMENTS IN EDUCATION

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Abstract

This paper uses the methodological framework of multilevel mixed-effects models to shed light on the importance played by regional and country-level factors for the regional economic growth within the European Union (EU). In particular, factors in the area of education and Internet utilization are considered. Gradually, variance components models, random intercept models and random slope coefficient models are tested, and finally the random slope coefficient model is found to best fit our hierarchical dataset. The results indicate that at country level lower proportions of early school leavers, as well as higher expenditure on education and R&D, enhance regional growth. At regional level, higher achievements in education and higher rates of Internet usage are both associated with higher regional economic growth. The impact of education and Internet variables on the regional economic growth is generally found to be different across the New Member States and the Old Member States.

Keywords: regional economic growth, EU, education, ICT
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1. Introduction

Economic growth plays a crucial role in the EU Agenda for growth and jobs, being at the core of the Europe 2020 Strategy, which particularly emphasizes the smart, sustainable and inclusive growth. Recently, the European Commission has recognized that the European regions had to become more competitive by innovation, digital transformation and automation, to successfully compete with the most advanced economies and regions in the process of globalization. However, the Commission is aware of the differences among the European regions with regard to technological advance and innovation, as reflected, for instance, by the implementation of the Smart Specialization Strategies (RIS3). In the view of all EU initiatives and funds aimed to encourage broad-based innovation (*e.g.,* Lagging Regions Initiatives, RIS3, Horizon 2020, Stairway to Excellence, etc.), the regional policies must provide support for the development of innovation capacities in the less advanced EU regions, in accordance with the regional specific environment and conditions.

Education is generally acknowledged as a fundamental factor of economic growth. According to the Europe 2020 Agenda, it helps employability and it reduces poverty. In addition, R&D/innovation/technology might improve the EU competitiveness, and in the long term it can diminish the structural weaknesses in the EU economy.

Lately, providing people with ICT (Information and Communication Technologies) skills has become a new challenge for all the educational systems, because it represents the main requirement for the development of the ICT sector. Technology is the key of the global innovation-driven economic growth (Sharafat and Lehr, 2017), and at the same time the main factor of sustainable development, as stated by the 17 Sustainable Development Goals advanced by the 2030 Agenda for Sustainable Development. However, education and investment in R&D (Research & Development) can substantially enhance the impact of ICT on economic growth.

There is a substantial body of literature analyzing the dynamics, causes, implications and policies related to the regional economic growth within the EU, but most of them are either cross-country studies or country case studies. When analyzing the determinants, most papers are based on the regional drivers, and only very few ones discuss the contribution of both regional- and country-level factors to the EU regional economic growth. This paper aims to light up this issue, by considering the influence of both regional- and country-level factors in the areas of education and ICT on the EU regional growth. The empirical analysis uses hierarchical data (regions nested into countries) running from 2001 to 2017. Additionally, the paper also examines: (1) whether the impact of education and ICT on regional growth is different across the New Member States (NMS) and the Old Member States (OMS), and (2) the robustness of results under several specifications of the mixed-effects models used here.

The paper is structured into four sections. The first section is Introduction, the second section summarizes the most relevant contributions to the literature, the third section presents the methodology and data, and the last section concludes and formulates policy recommendations.

2. Literature Review

The relationship between the human capital and economic growth has been widely debated in the literature (*e.g.,* Schultz, 1961; Rosen, 1976; Romer, 1986 Lucas, 1988; Mulligan and Sala-i-Martin, 1993; Barro and Sala-i-Martin, 1995), most papers finding a positive effect of human capital on growth, especially on long term. Education has been widely acknowledged as a factor of growth, but different mechanisms have been found to explain this causality. For instance, increasing the workforce's ability to finalize the work tasks faster, facilitating the transfer of knowledge and increasing the creativity are the channels through which education may influence the productivity of any country (World Economic Forum, 2016).

Increasing the expenditure on education and the expenditure on R&D, increasing the quality of school and educational programs, and discouraging the early school leavers are only a few examples of policy measures that might lead to better educational attainments at all levels. However, the empirical results are broad and diverse. There is a mixed and inconclusive literature about the effect of education expenditure on economic growth. Barro and Sala-i-Martin (1995) and Baldacci *et al*. (2008) find a positive relationship between them, while Devarajan *et al*. (1996), Landau (1986), Levine and Renelt (1992), and Keller (2006) find no significant relationship. Hanushek (2013) underlines the importance of the cognitive skills of population and of the school quality for improvements in long term growth, especially for the developing countries. He argues that while improving in terms of school attainment the developing countries have not improved in quality terms, so that closing the gaps with the developed countries still remains an unsolved issue.

The positive impact of ICT on economic growth has been widely analyzed in the literature (Edquist & Henrekson, 2004; Hanclova *et al*., 2015; Falk & Biag, 2015), but mixed results were found when studying the differences among the countries. One body of literature argues that the less developed countries can reach higher growth rates through ICT (Steinmuller, 2001), while other papers find that investment in ICT should be undertaken by the upper middle income countries where higher marginal returns are anticipated (Dimelis and Papaioannou, 2009; Hanclova *et al*., 2015). Recent evidence indicates that the developing and the emerging countries do not benefit more from investment in ICT than the developed countries (Niebel, 2018).

In line with one of the research questions investigated in this paper, Dimelis and Papaioannou (2009) show that the higher impact of ICT on economic growth in the developed countries is due to the advantages of higher learning and experience levels. Public policies targeting higher investment in ICT should therefore increase the human capital stock by supporting higher education (King *et al*., 1994). Choi and Hoon Yi (2017) find that the effect of Internet use on economic growth is enhanced by an increase in the R&D expenditure.

A series of studies confirm the positive implications of Internet usage on economic growth. Using a time series data for South Africa running from 1991 to 2013, Salahuddina and Gow (2016) find a positive and significant long-run relationship among Internet usage, financial development, trade openness and economic growth, as well as a causal link between Internet usage and economic growth. Billon *et al.* (2017) indicate that the positive impact of Internet usage on economic growth depends on the educational inequality in both developing and developed countries, so that the public policies should consider the educational distribution in order to speed up the mechanism through which the Internet use boosts economic growth.

The ICT has allowed the development of E-commerce over time, based on real and increased productivity. This proves the worth of ICTs and unravels the "productivity paradox" (OECD, 1999). E-commerce is perceived not only as a form of trade digitalization, but also as an accelerator of progress across all the 17 Sustainable Development Goals advanced by the 2030 Agenda for Sustainable Development.

Despite all the benefits induced by the expansion of E-commerce, as often highlighted by international institutions (*e.g.,* OECD, 1999, 2017; UN, 2015; UNCTAD, 2016), the E-commerce poses a number of challenges, such as the inequitable distribution of payback. To maximize the benefits of E-commerce in the society, the governments must design policy measures to increase the number of users. This equally involves measures in the area of education and of Internet infrastructure. Engaging more people in education, including more people in lifelong learning programs, as well as discouraging early school leavers enhance the abilities and skills to purchase goods on line. Improving the Internet infrastructure, especially in the rural and disadvantaged areas, facilitates more companies and persons to engage in E-commerce. As underlined by OECD (2017), the lack of access to the Internet represents in fact the main barrier against the expansion of E-commerce.

To harness the potential of E-commerce for economic development and to stimulate governments to actively engage in enabling more people and companies to benefit from E-commerce, the international institutions publish not only regular reports on E-commerce, but also indicators of progress (*e.g.,* UNCTAD B2C E-commerce Index 2016, UNCTAD, 2016). Finally, the initiatives undertaken by governments and international institutions toward supporting the development of E-commerce were empirically found to generate a positive impact on economic development, as shown by Anvari and Norouzi (2016).

The skills development has often been claimed as a main source of digital divide, with negative consequences on E-commerce as well. A more inclusive and better education may provide more people with the necessary skills to engage in E-commerce (OECD, 2017).

To sum up, the scientific literature, as well as the international institutions, generally agrees upon the positive role of education and E-commerce in stimulating the economic growth. Moreover, the positive role played by ICT and E-commerce is found to be significantly enhanced by the education and public expenditure on R&D. However, there is modest empirical evidence on how the regional growth or regional development is enhanced by a mix of regional-national policy measures in the area of education and ICT.

Sterlacchini (2008) examines the relationship between education and economic growth at the EU regional level, and finds that the share of adult population with tertiary education and the intensity of R&D expenditures are the most effective determinants of economic growth during the period 1995–2002. Another regional approach is undertaken by Vincente and Lopez (2011), who assess the regional digital divide across and within the EU countries. Based on Eurostat cross-sectional data, they find large disparities the EU in terms of ICT adoption and use.

However, to our knowledge there is no study analyzing the impact of regional- and country-level factors of education and Internet use/ICT on the EU regional economic growth. A multilevel analysis based on a hierarchical design of data would improve the knowledge on the mechanisms that contribute to the increase in regional economic growth within the EU.

3. Methodology and Data

Data

The empirical analysis uses Eurostat panel data running from 2001 to 2017, aggregated at regional level, as well as at country level. All the 28 EU countries are included in the analysis. According to the NUTS 2016 classification, the 281 NUTS2 statistical regions of the EU group together basic regions for the application of regional policies. The selection of variables included in this study firstly depends on data availability from Eurostat and, secondly, is based on theoretical grounds.

The dependent variable is the regional economic growth (NUTS2 variable), while the explanatory variables are socio-economic and demographic variables aggregated either at regional level (NUTS2), or at country level:

- At regional level: primary educational attainments (abbr. "Education 0_2"), secondary educational attainments (abbr. "Education 0_2"), tertiary educational attainments (abbr. "Tertiary education"), E-commerce usage (abbr. "E-commerce at regional level"), proportion of population who never used the Internet (abbr. "Internet use - never"), fertility rate (abbr. "Fertility"), human resources employed in the technology sector, (abbr. "HR_tech"), Internet usage (used to create the dummy variable "Internet intensity")..
- At country level: E-commerce usage (abbr. "E-commerce at country level"), expenditure on R&D (abbr. "GERD"), early school leavers (abbr. "Early leavers"), lifelong learning, and economic growth (abbr. "GDP growth").

Method

To address the hierarchical structure of our data, in the empirical section of the paper we use multilevel mixed-effects models (also known as hierarchical models). The multilevel data structure includes time repeated observations at Level 1, nested into regions at Level 2, and regions nested into countries at Level 3. In contrast with the linear models, the multilevel models accommodate a mix of fixed effects and random effects, also being known as mixed-effects models.

The first step of our multilevel methodology consists of estimating the correlations among the observations within clusters with the interclass correlation coefficient (ICC), because this helps deciding about the appropriateness of such kind of models. The ICC is measured as the ratio of the between-cluster variance to the total variance, and it explains the proportion of the total variance that can be attributed to clustering. If the ICC is near zero, it means that there is a very low clustering of data, and in this case linear models should be used instead of multilevel ones. The ICC can be measured at each level of the clustering structure.

In our study, the country level ICC is the correlation between two years, *t* and *t'*, for the same country, *j*, but for different regions, *i* and *i'*.

$$\rho_v = \frac{\sigma_v^2}{\sigma_v^2 + \sigma_u^2 + \sigma_e^2} \tag{1}$$

The region level ICC is the correlation between two years, *t* and *t'*, for the same region and the same country.

$$\rho_u = \frac{\sigma_v^2 + \sigma_u^2}{\sigma_v^2 + \sigma_u^2 + \sigma_e^2} \tag{2}$$

where, σ_v^2 is the variance between countries and σ_u^2 the variance within countries.

In a multilevel setting, the choice of the most appropriate model is not arbitrary. In fact, the most appropriate model is not the most complex one, but the one that best describes the set of working data. In order to find it, the simplest model (also called the "null model" in the multilevel methodology) should be gradually improved with random effects and covariates. After each multilevel model, a likelihood ratio test (LR test) should be used to find out whether "the more complex" model fits the data better than the simpler one. The variance components model, the random intercept model and the random slope coefficient model are therefore tested step by step, without and with covariates, from the simplest to the most complex model. The design of empirical section, as well as the methodology, follows Răileanu Szeles (2018).

In order to examine the null hypothesis that there are no higher level effects, the three-level model is compared to the single-level model. This way, we can prove the usefulness of the hierarchical analysis.

The single-level model is presented below:

$$y_{tij} = \gamma_{000} + e_{tij} \tag{3}$$

where: e_{tij} (residual) is the time-specific deviation from region's predicted outcome and γ_{000} (fixed intercept) is the "grand" mean.

Next, the null hypothesis that there is no country effect is tested by comparing the three-level model to the two-level repeated observations-within-regions. The two-level model is presented as model (4):

$$y_{tij} = \gamma_{000} + u_{0ij} + e_{tij} \tag{4}$$

where: u_{0ij} (region-level random intercept) is the region-specific deviation from the country's predicted outcome.

In the third step, we test the null hypothesis that there are no region effects by comparing the three-level model to the two-level repeated observations-within-countries model. This specification is presented as model (5):

$$y_{tij} = \gamma_{000} + v_{00j} + e_{tij} \tag{5}$$

where: v_{00j} (country-level random intercept) is the country-specific deviation from the fixed intercept.

In the models above, the random effects and residuals are assumed to be independent one from another, and normally distributed with zero means and constant variances.

In case that the three-level model is found to best fit the data, the empirical design starts from the three-level variance-components model (also called the "empty" or "null" three-level model). By adding Level1, Level2 and/ or Level3 explanatory variables, the null model becomes a three-level random-intercept model with covariates. When relaxing the hypothesis of constant slopes across higher levels, the model becomes a three-level random slope (coefficient) model.

The three-level variance components model can be written as below:

$$y_{tij} = \gamma_{000} + v_{00j} + u_{0ij} + e_{tij} \tag{6}$$

The three-level random slope coefficient model can be further decomposed into Level 1, Level 2 and Level 3:

$$y_{tij} = (\gamma_{000} + v_{00j} + u_{0ij}) + (\gamma_{100} + v_{10j} + u_{1ij}) x_{tij} + e_{tij} \tag{7}$$

Level 1:

$$y_{tij} = \beta_{0ij} + \beta_{1ij} x_{tij} + e_{tij} \tag{8}$$

Level 2:

$$\beta_{0ij} = \delta_{00j} + u_{0ij} \tag{9}$$

$$\beta_{1ij} = \delta_{10j} + u_{1ij} \tag{10}$$

Level3: $$\delta_{00j} = \gamma_{000} + v_{00j} \quad (11)$$

$$\delta_{10j} = \gamma_{100} + v_{10j} \quad (12)$$

In all equations above, subscript *t* denotes time (at Level 1), subscript *i* denotes region (at Level 2), and subscript *j* denotes country (at Level 3).

4. Empirical Analysis

The methodological design of our study includes a descriptive analysis in the first part, based on the calculation of interclass correlation coefficients, and a set of multilevel models, running from the simplest to the most complex one, in the second part of this section.

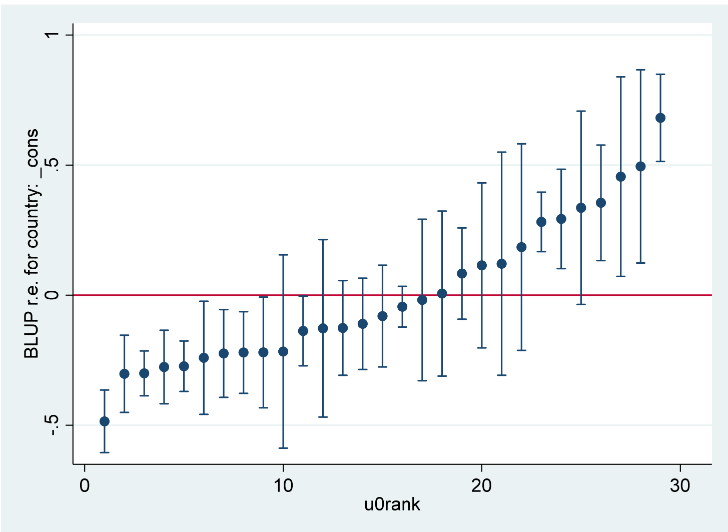
The overall mean of the economic growth rates from 2001 to 2017 across the EU regions is -3.29%, the between-country (Level 2) variance in growth rates is estimated at 9.50%, while the within-country between-regions (Level 1) variance is 57.83%. These result in a total variance of 67.33%. The variance partition coefficient is 9.50/67.33, meaning that 14.11% of the variance in the regional economic growth can be attributed to differences among countries.

In addition, when comparing the null multilevel model (the variance-component model) with a null single-level model we find that there is clear evidence of province effects on the regional economic growth within the EU, so that the multilevel models describe data better than the linear ones.

One way in which we may examine the significance of country effects is by a caterpillar plot (Figure 1), which shows the country-level residuals (empirical Bayes predictions) and the associated standard errors.

Figure 1

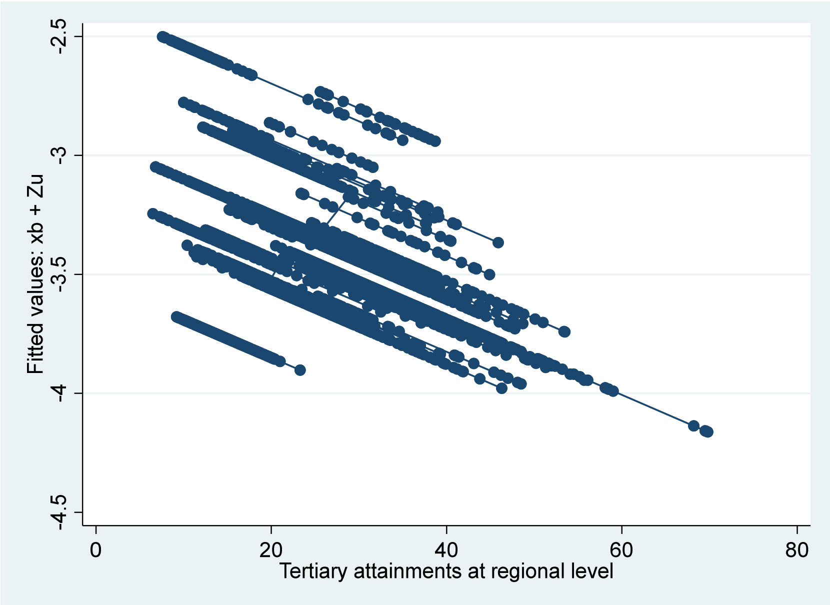
Examining the Country Effects at the EU Level by Caterpillar Plot



The first model that will be tested and analyzed is the random intercept model, which assumes different intercepts but the same slopes across countries, as shown in Figure 2. To keep the model simple at this step, the EU regional economic growth is explained as depending only on the regional tertiary attainments.

Figure 2

Random Intercept Model, Regional Growth-Tertiary Educational Attainments



In the next step, we test whether the effect of holding tertiary educational attainments varies across countries by applying the log likelihood test (LR test). The null hypothesis for this test is that the two additional parameters (intercept and slope variance) are simultaneously equal to zero. Applied to our data, the test indicates that the effect of the tertiary education attainments significantly differs among the countries, so that it is worth dropping the assumption of equal slopes, as presumed at the previous step.

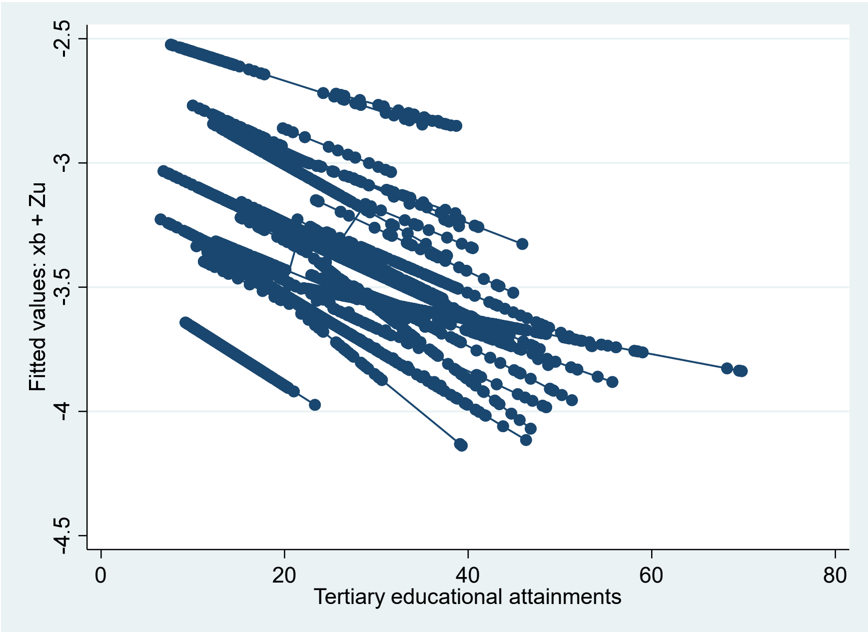
The negative covariance (-0.001) means that countries with a high intercept tend to have a flatter-than-average slope. Similarly, countries with a low slope tend to have experienced a much higher increase in the tertiary educational attainments (above-average slope).

The random slope model we have fitted implies that the between-country variance in regional economic growth is a function of tertiary educational attainments; that is, the amount of between-country variance differs along with the tertiary educational attainments.

Figure 3

Plot of the Predicted Country Lines

Between-country Variance, as a Function of Tertiary Educational Attainments



A key motivation for using multilevel modeling is, however, to assess the effects of Level2 explanatory variables on Level1 outcomes and the extent to which they can explain the Level2 variance.

The design of our empirical approach can be described as follows. First, the regional economic growth is explained through regional and country characteristics in the area of education, by random slope coefficient models (Table 1), which all consider random slopes for the tertiary educational attainments variable. In Tab. 2, different variances are assumed for the Internet intensive- and non-intensive EU regions, and in case that "Internet Intensity" is confirmed to be a significant driver of regional growth, then a set of other variables in the area of Internet usage is introduced, as to comparatively examine the impact of education- and health- related variables on EU regional growth (Tab.3). In Tab.1 and Tab.3, separate models are built for the groups of NMS and OMS.

In table 1, at the EU level (model 1.1), only education-related variables are included into the model, while for the NMS and the OMS (models 1.2 and 1.3) additional variables are also considered. The results indicate important differences especially between the NMS and the OMS with regard to the impact that both the regional- and country-level variables have on regional economic growth. Only models 1.2 and 1.3 are explained, because model 1.1 is reported only for reference.

At country level, a higher proportion of early school leavers from education is found to hamper regional economic growth in both OMS and NMS, which is in line with the literature which does not only acknowledge this relationship (e.g. Harmon et al, 2003; Sianesi and van Reenen, 2003; Krueger and Lindahl, 2001), but also places the problem of early school leaving at the core of the EU education policy (Gillies and Mifsud, 2016).. The most important determinant of regional economic growth is the country-level expenditure on education, in both NMS and OMS, while the country-level economic growth is found to be associated with an increase in the regional economic growth only in NMS.

Only in OMS, higher educational attainments in education (at all primary, secondary and tertiary levels) are found to be positively associated with regional economic growth. These findings are according to our expectations, as the effect of education on economic growth has been widely debated and acknowledged in the literature (e.g. Barro and Sala-i-Martin, 1995). The relationship between economic growth and education has also been approached from the perspective of the quality of education and the related differences in the NMS and OMS countries, (Duguleană and Duguleană, 2011).

The regional fertility rate represents a powerful and significant determinant of regional growth in both NMS and OMS in the sense that a higher feritility rate discourages regional growth. Unemployment is found to carry negative significant effects on regional growth only in OMS, because in NMS the large shadow economy swallows a significant proportion of unemployed (especially long term unemployed). A higher proportion of people employed in the technology sector encourages regional growth in OMS, while discouraging it in NMS. This is because in OMS the technology companies are largely widespread across regions, and in NMS they are rather concentrated in certain regions (Borsi and Metiu, 2015; Drumea, 2015).

Table 1

Impact of Education on Regional Growth (Random Slope Coefficient Model)

Variables	EU (Model 1.1)	NMS (Model 1.2)	OMS (Model 1.3)
Country level			
GDP growth Lag1	0.0015*** (0.0004)	0.0035*** (0.0007)	0.00036 (0.0004)
Early leavers Lag1	-	-0.0037*** (0.0010)	-0.0010* (0.0004)
Educ. Expend. Lag1	0.0261*** (0.0037)	0.016** (0.0078)	0.030*** (0.0040)
Unemployment	-	0.0087 (0.0078)	-0.0023*** (0.0009)
Region level			
HR_tech Lag1	-	-0.0045** (0.0024)	0.0016* (0.0008)
Primary education	0.0018** (0.0009)	-0.0017 (0.0019)	0.0036*** (0.0010)
Secondary education	0.0018** (0.0009)	-0.0017 (0.0016)	0.0035*** (0.0010)
Tertiary Education Lag1	0.0012 (0.0009)	-0.0010 (0.0018)	0.0028*** (0.0010)
Fertility	-0.0819*** (0.0098)	-0.07*** (0.01)	-0.07*** (0.01)

Notes. (1) Random slope coefficient models, random slope: tertiary educational attainments; (2) Level1: year; Level2: region; Level3: country; (3) Standard errors are reported in brackets; (4) *** p<0.01, ** p<0.05, * p<0.1.

In Table 2, we introduce one additional variable at the regional level, called "Internet intensity, which is created as a dummy variable. It takes the value 1 for regions with percentages of Internet usage higher than the EU average and 0 otherwise.

In contrast with the previous model specification, in Tab.2 we assume different variances for the Internet intensive regions and non-intensive regions. Given that at this step of our empirical analysis we only test the significance of Internet intensity as a driver of regional growth in the framework of multilevel analysis, only one model for the whole group of EU countries is reported.

Table 2

Impact of Education and ICT on Regional Growth (Random Slope Coefficient Model)

Variables	Random slope coefficient (Model 2)
Country level	
GDP growth Lag1	0.0013*** (0.0004)
Early leavers Lag1	-0.0006 (0.0006)
Educ. Expend. Lag1	0.0256*** (0.0037)
Unemployment	0.0011 (0.0008)
Region level	
HR_tech Lag1	0.0004 (0.0009)
Primary education	0.0020** (0.0009)
Secondary education	0.0020** (0.0009)
Tertiary education Lag1	0.0014* (0.0008)
Fertility	-0.0829*** (0.0097)
Internet intensity	0.0174*** (0.0045)

Notes. (1) Random slope coefficient model, random slope: tertiary educational attainments; (2) Level 1: year; Level2: region; Level3: country; (3) Standard errors are reported in brackets; (4) *** p<0.01, ** p<0.05, * p<0.1.

When introducing different Level 1 variance for Internet intensive and non-Internet intensive regions, most explanatory variables at country- and regional level in the area of education carry significant positive effects on regional growth. Moreover, the intensity of regions with regard to the Internet usage slightly amplifies the positive effects of all education variables. The internet intensity itself has a much important impact on regional growth compared with the education attainments in education (at all primary, secondary and tertiary levels). Overall, the results reported in Table 2 suggest that increasing the rate of Internet usage at the EU regional level results in positive direct and indirect effects on regional growth.

The regional level fertility rate, and the expenditure on education are found to be the main drivers of regional growth, which is in line with the literature (e.g. Raileanu Szeles, 2018), In addition, EU regions that are intensive in Internet usage are significantly associated with a higher regional growth.

As compared to Table 1 and Table 2, in Table 3 additional variables in the area of Internet utilization are used to explain the EU regional economic growth. The estimates are separately reported for the NMS and the OMS to unveil significant differences between the two groups of countries. This time, a random slope is assumed for the variable “Poor regions”. This variable was built as a dichotomous variable, which takes value 0 for the regions that belong to the richest 50% of regions in terms of GDP per capita and 1 otherwise. We decided to relax the assumption of constant slopes for this variable because we do not only expect, but it was also confirmed by the LR test that poorer and richer regions have different patterns with regard to the impact that variables in the area of education and Internet utilization have on the regional growth.

Table 3

Impact of Education and ICT on Regional Economic Growth

Explanatory variables	NMS (Model 3.1)	OMS (Model 3.2)
Country level		
GDP growth	-0.0004 (0.0044)	0.0025*** (0.0007)
Early leavers Lag1	-0.0025* (0.0015)	0.00005 (0.0005)
GERD country Lag1	-0.0394*** (0.0092)	-0.0030 (0.0035)
E-commerce Lag1	-0.0009 (0.0011)	-0.0006*** (0.0002)
Region level		
GDP growth Lag1	-0.2430*** (0.00847)	0.1002** (0.0552)
Primary education Lag1	0.0063*** (0.0021)	0.0012 (0.0010)
Secondary education Lag1	0.0041** (0.0019)	0.0010 (0.0010)
Tertiary education	0.0031** (0.0015)	0.0009 (0.0010)
E-commerce (regional level) Lag1	-0.0003 (0.0008)	0.0004 (0.0003)
GERD region	0.0141** (0.0073)	0.0010 (0.0014)
Internet banking Lag1	0.0014*** (0.0003)	-0.00005 (0.0002)

Notes. (1) Random slope coefficient models, random slope: Poor regions; (2) Level 1: year; Level2: region; Level3: country; (3) Standard errors are reported in brackets; (4) *** p<0.01, ** p<0.05, * p<0.1.

Most explanatory variables are introduced in models (3.1) and (3.2) by their lags, alongside with the lag value of the dependent variable. Given that the OMS are exposed to the digital divide at a lesser extent than the NMS, the usage of the Internet has not anymore in their case a significant effect on regional growth. In turn, the GDP growth at country level has a significant and positive effect on regional growth only in OMS, where regions tend to be more similar and convergent in terms of their economic growth.

In the NMS, at regional level, better achievements in education (all, primary, secondary and tertiary education), higher public expenditure on R&D, as well as a wider usage of Internet banking are found to enhance regional growth. The positive impact of the Internet banking is in line with previous findings on the benefits induced by the broader use of ICT technologies (Drumea, 2015).

At the country level, the expenditure on R&D (model 3.1) and the E-commerce (model 3.2) have a negative impact on regional growth. Even though the negative effect of E-commerce on regional growth in both NMS and OMS could be surprinsing, this finding is not new in the literature (D'Costa, 2005; Răileanu Szeles, 2018). The explanation could be that a progress in this regard at country level is too broad and often localized only in the most developed regions, so that the effect is finally negative on regional growth.

5. Discussion and Conclusions

The paper attempts to identify and analyze by a multilevel analysis the regional- and country-level determinants of regional economic growth in the EU, with a focus on education and ICT. Finding what mix of regional and national policy measures could enhance regional economic growth within the EU would be useful for the EU regional policy and for the national governments, too. Different model specifications are successively tested to reveal not only the effect of different regional and national policy measures, but to also to unveil the likely differences between the NMS and the OMS.

There is a restrained set of empirical findings that are robust to all model specifications and all country groups. A lower proportion of early leavers from education, a higher economic growth rate, as well as higher public expenditure on R&D and education are the country level policy measures that stimulate regional growth under most empirical models.

In general, the impact of regional level variables on regional growth is different across models and groups of countries. In the area of education, the tertiary educational achievements are a significant stimulus for regional growth only in the NMS, while the positive influence of the primary and secondary educational achievements is significant only in the NMS and only when determinants in the ICT area are also included in the model. These results suggest that better educational achievements matter for a higher regional growth only in the NMS, while in the OMS they carry no significant effect.

At regional level, employing more people in the technology sector stimulates regional growth, but only in the OMS. This finding should be correlated with the higher technological development of the OMS as compared to the NMS during the reference period of time (Borsi and Metiu, 2015).

In the area of education, the primary, secondary and tertiary educational achievements, when being significant, they generate positive effects for regional growth in both NMS and OMS, being therefore an important regional driver of regional growth.

As also found in other studies (Raileanu Szeles, 2018), the fertility rate is correlated with regional economic growth, in the sense that a lower fertility rate stimulate regional economic growth in both NMS and OMS.

Surprisingly, higher expenditure on R&D and higher usages of E-commerce, when both being aggregated at country level, discourage regional economic growth in NMS and OMS. However, at regional level, higher usage of Internet banking, higher Internet usages, as well as higher regional expenditure on R&D enhance regional economic growth. This finding not only underlines the positive impact of ICT on economic growth, as confirmed by other studies (Hanclova et al., 2015; Falk & Biag, 2015), but also suggests the importance of regional policy measures, compared to the national level ones, for the stimulation of regional growth.

In comparison with the existing strand of literature on this topic, the novelty of the paper consists of examining both regional and national factors of the EU regional economic growth in the areas of education and ICT, by using a hierarchical model with several specifications, and a time span of 17 years.

The conclusion is that only a mix of regional-national policy measures in education/ ICT could accelerate regional economic growth in the EU. A group of multilevel models with time occasions nested in regions and regions nested in countries revealed the impact of the two types of policy measures. When looking back over the last 17 years, we find out that important discrepancies still exist between NMS and OMS, and this also reflects in the impact of policy measures on the regional growth. Discouraging early leavers from education, increasing expenditure on R&D and enhancing the ICT development help boosting regional growth in both NMS and OMS, but increasing regional educational attainments and the Internet usage are effective only in NMS, while extending the technology sector is more effective in OMS.

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