1155 HIGER EDUCATION AND REGIONAL DEVELOPMENT

***Igor Cvecic*[1,] *Danijela Sokolic*[2], *Marija Kastelan Mrak*[3]**

[1] Faculty of Economics, University of Rijeka, Ivana Filipovica 4, 51000 Rijeka, Croatia, igor.cvecic@efri.hr
[2] Faculty of Economics, University of Rijeka, Ivana Filipovica 4, 51000 Rijeka, Croatia, dsokolic@efri.hr
[3] Faculty of Economics, University of Rijeka, Ivana Filipovica 4, 51000 Rijeka, Croatia, kastelan@efri.hr

ABSTRACT

Economic growth and employment rates depend heavily on the efficiency of the institutional and economic framework. Macroeconomic, social, political, regulatory and other factors drive different prospects of economic growth and well-being in different European regions. Higher education institutions (HEI), with their tradition, commitment, progressiveness, continuity and stability are an especially important factor for growth and development. There is empirical evidence of lower unemployment rates in countries with good communication between the educational system and the labour market that provides for employers' understanding of competencies (qualities) students have upon finishing their education. Thus, realistic expectations result in better demand and supply matching, thus contributing to regional welfare. As Europe features significant regional disparities in employment, education and economic prosperity, the support for science and technology, including HEIs and their outputs, is crucial for regional development, especially among 'peripheral' regions. Furthermore, HEIs must aim at better linking their programmes with employment and the needs for innovation and entrepreneurship. Thus, we estimate how higher education and science relate with economic growth in different European regions at NUTS-2 level, classifying them into three groups according to their level of GDP per capita. The regression estimates show different effects of specific factors of HEI influencing regional growth.

Keywords*: regional development, (un)employment, higher education, EU regions, peripheral regions*

1. INTRODUCTION

Benefits of economic development lay on economic growth and competitiveness. In order to achieve economic growth, regions need to support innovation and research and development (R&D). Thus, the key determinant of growth and development is human capital advancement since (working) people are meritorious for creation and innovation. Talents with innovative ideas are a result of hard work and passion of individuals, and expertize and enthusiasm of educators in a supporting environment. That's why new ideas and start-ups often come as outputs of quality higher education systems and tend to migrate towards competitive and benchmark enabling working environments.

European regions can be differentiated according to the value creation of industries developed in the region. A higher value-added economy region boosts industries that focus on those activities that generate a larger margin calculated as the final price of a product or service minus the cost of the inputs used to produce it, and thus create higher profits for businesses and higher wages for workers. High added-value industries (i.e. electronics, chemicals, biomedical manufacturing, professional services, etc.) depend on highly trained and well educated work force, and they are more likely to be situated in the region with the high quality higher education institutions since higher value added economies rely heavily on innovation and skills, knowledge and technology development.

The purpose of this paper is to explore how important is higher education for regional development, and how does it affect regional growth and prosperity indicators such as gross domestic product per capita. The structure of this paper stresses primarily the idea of the affirmation of specific determinants related to the 'science triangle' (education, innovations in business, R&TD) that have clear influence on development of European regions. Therefore, after the introduction section, which gives a broader perspective on the important issue of higher education and its potential effects on regional development, the second section describes the theoretical frameworks that were taken into consideration while preparing and executing the analytical research. The third section explains the methodology and the research design, while the forth section represents the main analytical part, which includes the explication of the statistical regression and its results. Finally, the conclusion section brings the major findings and interpretations of the results alongside with the main suggestions for the future.

2. THEORETICAL BACKGROUND

Heigher Education Institutions (HEI) create educated and skilled people as well as ideas. They have three important roles (Veugelers and Del Rey, 2014): teaching (dissemination of knowledge; improvement of human capital), research (extending the horizons of knowledge), transfer their knowledge to the rest of society (creation of industries and new companies). Although the higher education system and its institutions 'produce' knowledge and skills indispensable for the socio-economic development, regional effects have not been thoroughly and adequately investigated. This is mostly due to regional data not being properly collected and analysed, especially with internationally comparable methodology and harmonized data bases. However, as regional disparities become more evident, while centralization and agglomeration, as well as globalisation effects, endanger the prospects of development and wealth of 'peripheral' and/or 'vulnerable' regions, it is crucial to identify key factors which would enable regions to prosper in the future and diminish these differences. Thus, the focus should be given primarily to the regions 'in need' in order to facilitate not only their sustainable future and the process of economic and social cohesion, but especially to avoid negative outcomes of differentiated demographic and economic environment, including business prospects. Neglecting 'sensitive' regions would almost certainly mean more economic and social imbalances and tensions. As knowledge and education have clearly been at the forehead of economic and social progress, regional development strategies cannot be seriously implemented without adequate attention to HEIs, and their output.

First comprehensive research papers with estimations of HEIs economic impacts on local businesses, government and individuals can be associated with Caffrey & Isaacs (1971), Brownrigg (1973), and Booth & Jarrett (1976). Positive and negative impacts were identified primarily suggesting conditions and modes how to better manage expectations and decisions of particular HEIs and their local community. A renewed interest in the problem occurred in the late 1980ies and early 1990ies as a result of increased political interest and changes in societal and governance practices (Elliott et al., 1988; Florax, 1992; Feldman, 1994; Goldstein et al., 1995; Henderson et al., 1998.). Even though the effects of HEI on regional development have been attracting modern researchers' interests for nearly half of the century, there is little or no relevant data showing macroeconomic or economy-wide level effects of HEIs on regional development. In most cases only case-studies can be found addressing specific regions or even particular HEIs (Universities UK, 2014; Kelly et al., 2014; Boston University, 2003; Canterbury City Council, 2001). Although this approach suits investigations of specific problems and environments, it does not provide general conclusions for all (or most) HEIs and regions.

The last decade and a half actually shows a genuine interest in issues related to location effects, innovation outputs and entrepreneurship associated with HEIs and their regional development (Lawton Smith, 2007; Uyarra, 2008; Huggins and Johnston, 2009; Lawton Smith and Bagchi-Sen, 2012; Veugelers and Del Rey, 2014). Both endogenous growth theory and the 'Triple-Helix' concept of university-industry-government interactions emphasize the role of HEIs in creating ideas, as well as transferring them towards commercial uses (Gunasekara, 2006; Koschatzky and Stahlecker, 2010; Ranga and Etzkowitz, 2013), although the link between science and industry is not clearly direct nor it is always obvious (Veugelers and Del Rey, 2014). Most authors suggest the importance of a stronger involvment of HEIs in local industries and also regional policies. Tripple te al. (2012) argue that, although still much necessary and anticipated, new models of collaboration of HEIs with local actors, it is the new student populations and new university funding which acctually created new conditions for HEIs engagement at the regional level.. Lester (2005) presents a model of alternative innovation-led growth, where HEIs have specific roles in: creating new industries, industry transplantation, diversification of old industries into related new ones, upgrading of mature industries.

Kroll and Schubert (2014) used spatial panel-data models in order to identify the impact that HEIs have on value creation and unemployment in Germany. Their results suggest a strong impact of HEIs on regional GDP, but a rather flat spatial distribution due to spillovers between neighbouring regions. Interestingly, short-run effects of HEIs on unemployment rates were detrimental, which suggests a negative transitional effect. The effect is changing in medium to long term. Previously, Audretsch and Feldman (2003) presented the issue of knowledge spillovers, especially because of their influence on clusters and agglomerations. They emphasized how knowledge spillovers are in fact heterogeneous, which is also important for companies which seek better ways to arrange their strategic localization and investments.

Beside the frequently used case-study approach, the last decade and a half witnessed new concepts being presented (Segarra Blasco, 2003; Garrido-Yserte and Gallo-Rivera, 2010; Pastor et al., 2013) and more ambitious measuring methodologies being used to assess the impacts of HEIs (Goldstein and Drucker, 2006; Goldstein and Renault, 2004). For instance, Segarra Blasco (2003) estimates the impacts of private enterprises R&TD as well as universities' basic and applied R&D on innovations in a specific region, while Garrido-Yserte and Gallo-Rivera (2010) focus on the demand-side effects of a particular HEI using three different methods (a simplified version of the ACE Model, the Ryan short-cut model and the input-output technique) to estimate the induced effects. Most studies with measurable results suggested only modest positive impacts of HEIs. However, more important factors still stay outside the scope of known approaches, as well as HEIs long-term impacts on macroeconomic variables, due to time lag between academic outputs and its economic impacts. Exploring Russian regions, Egorov et al. (2017) concluded that higher education institutions, through their coverage and specific effects on their regions indeed are important economic agents which positively contribute to gross regional product growth.

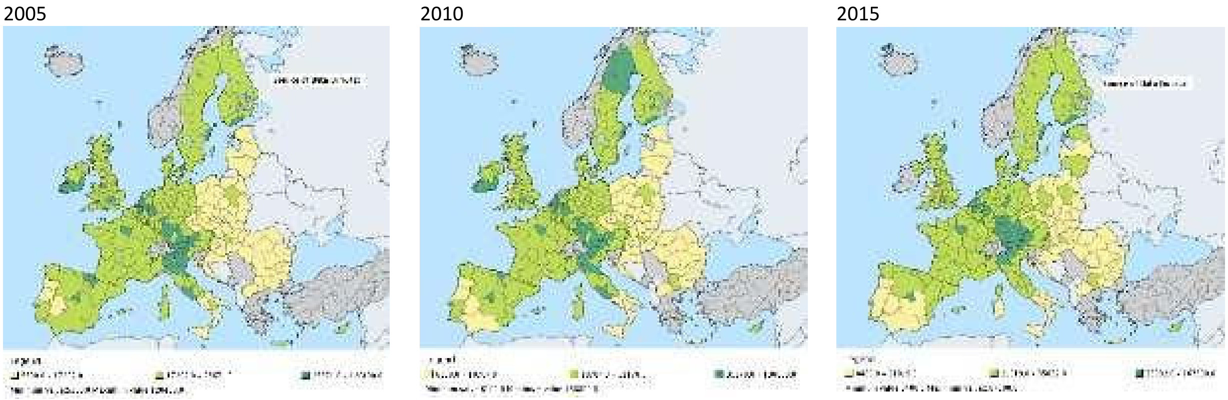
Drucker and Goldstein (2007) suggested four designs as possible estimation approaches to assess impacts of HEIs: (a) single university impact studies; (b) surveys; (c) knowledge production functions; (d) cross-sectional and quasi-experimental designs. Emphasizing a new interest in innovative potential of regions, Uyarra (2010) proposed a critique of contemporary roles of universities by testing five models, each encompassing different set of roles, mechanisms for engagement and spatial aspects of interactions. None of them gives the whole picture, while combining them can also lead to controversial assumptions. Kroll and Schubert (2014) engaged in quantitative identification of HEIs' overall macroeconomic effects while taking into account the multidimensionality of outputs, heterogeneity of regional environments and regional spillovers. Although their contribution to the field is significant, their paper deals only with regions within Germany (NUTS 3 level), which is a big and significant economy nevertheless, but less diverse than the European Union's 276 NUTS-2 regions analysed in this paper. Gennaioli et al. (2011) managed to investigate the determinants of regional development using a database of more than 1,500 sub-national entities from more than 100 countries and found that human capital (measured through education) emerges as the most consistent determinant of regional income, as well as productivity.

Multidimensionality of HEIs outputs relate to different and complex mechanisms which can be grouped into two major groups (Florax, 1992): (a) short-term, expenditure-based demand-side effects (consumption and investments) and (b) long-term, knowledge-based supply-side effects (human capital creation, knowledge production, innovation, and other less measurable socio-economic effects). These first order effects will induce second order impacts on macroeconomic outputs, such as employment and value creation. Segarra Blasco (2003) groups three categories of HEI's outputs: human capital, localization factors and knowledge. While there is strong evidence that knowledge spillovers are geographically localized and students often stay in the region of their HEI after graduation (Veugelers and Del Rey, 2014), a unique approach on investigating these effects has not been determined.

Although new graduates can temporarily unbalance the labour supply, it is their technical and managerial knowledge and skills which potentially increase regional innovativeness, creativeness and productivity. Firms increase sales, profits and wages (Florax, 1992; Goldstein et al., 1995), but they have to be in the position to use academic outputs. Effective transfer of knowledge and regional absorption of such knowledge by firms is essential for regional development (Huggins et al., 2008; Power and Malmberg, 2008). Besides forming graduates, HEI's influence the dynamics of their region (Pastor et al., 2013), generating additional benefits through the supply side (rise of productivity induced by human capital) and demand side (daily expenditures and investments made by HEIs and its multiplier effect on the economy); clearly a manifestation of regional development. Meanwhile, the extremely important data on mobility of university trained students and researchers is mostly unavailable, leaving another issue influencing regional development unexplained.

3. METHODOLOGY AND RESEARCH DESIGN

In the context of regional development, especially in Europe, it is crucial to understand the significant regional disparities because they potentiate differentiated demographic, economic and business environments and dynamics. Thus, national policies and European priorities associated with the EU Cohesion Policy are both inclined toward the idea to reduce disparities and imbalances among regions through the process of regional convergence, primarily by encouraging economic, social and territorial cohesion with the help of the European Structural and Investment Funds, as well as the improved national development instruments and policies such as education, innovation and R&D. These disparities can be displayed by several criteria, but the most common is the regional GDP per capita (Figure 1).



Source: Authors calculations based on Eurostat data

Figure 1: Regional gross domestic product (PPS per inhabitant) by NUTS 2 regions

In Figure 1, the colours represent three categories of regions: 'Lower' (up to 75% of EU average of GDP PPS pc), 'Mid' (75 - 125%) and 'Upper' developed regions (more than 125% of EU average of GDP PPS per capita) in 2005, 2010 and 2015 respectively. These three maps actually suggest two important facts: (1) the most advanced regions, often called the 'core-regions' are mostly located in the centre of the EU, especially the 'old' Member States such as Western and Southern Germany, Western Austria, Northern Italy, Benelux, Île-de-France, regions of London, Dublin, Madrid, Stockholm, Helsinki etc., while the less advanced regions are located at the 'periphery' – New Member States, plus southern Spain and Italy, most of Portugal and Greece; (2) comparing these three years, it seems that the 'core' regions are switching more toward the centre of the EU, including regions of New Member States close to Germany, Austria and the Nordic states, but at the expense of many Mediterranean regions.

One of the most discussed issues in recent decades was the increasing disparity of regions within the EU, especially after the last three Enlargements. Although all New Members States were less advanced than the previous EU15, their inclusion in the EU and the investments associated with the EU Cohesion Policy seemingly reduced the disparities, which can be observed in Table 1. Important facts can be drawn out while analysing these differences and changes: (1) 'Upper' to 'Lower' ratio suggests smaller differences among 'top' 10 and 'bottom' 10 regions; (2) least advanced regions are converging to the EU average; (3) most advanced regions are diverging from the EU average (the gap is growing). Another important detail has to be distinguished in relation to Figure 1: the total number of 'periphery' regions increased between 2005 and 2015.

Table 1. Differences in living standard in 276 EU regions (GDP pc, NUTS 2)

	Lower	Mid	Upper
GDP pc level in year:	2005	2010	2015
Average (entire group of regions)	22,936.4	24,942.5	28,025.7
Average Upper 10* (% of EU average)	49,591.3 (216.2)	54,832.4 (219.8)	62,877.8 (224.4)
Average Lower 10 (% of EU average)	2,764.9 (12.1)	4,167.6 (16.79)	5,436.6 (19.4)
Upper 10 to Lower 10 regions ratio	17.94	13.16	11.57
2nd Upper to 1st Lower region ratio*	27.44	24.71	23.59
1st Upper to 1st Lower region ratio	63.03	46.21	55.99

* Region Inner London West is excluded from calculations as outliner since its GDP per capita is 148,073, 148,786 and 215,921 in respective years, and, thus, significantly influences Upper level regions average and groups` differences.
Source: Authors calculations based on Eurostat data

A fixed effect (FE) analysis is used to estimate panel data and to assess the contribution of the economic (unemployment rate, share of employment in total population, and population ratio), educational (population with tertiary education), innovation enabling (R&D expenditure, human resources in science and technology (HRST), and employed in high-technology sector), and business materialization variables (patent application) to the economic development of the EU regions (measured in GDP per capita). We used data on 28 EU countries and 276 EU regions (NUTS 2 level) in the period of 17 years (available data includes 2000-2016 period, but not all EU NUTS 2 regions have data available for all the indicators used in the analysis through the whole period).

Due to different stage of socio-economic, integration-related, institutional, political and historic development, and other factors that caused above mentioned disparities between lower income (i.e. peripheral) and upper income (i.e. core) regions, we assume different determinants would be more relevant to their economic development at the given time. Capability to innovate and further develop human potential would probably differ in regions with cutting edge innovations and longer tradition in R&D than in new EU member states struggling yet to organize effectively their institutional frameworks. Thus it is sound to speculate that new innovations and their spill-overs in highly developed regions are leading towards even greater effects on their regional development and even greater disparities between least and most developed regions.

To address this issue, for the purposes of better assessing factors related to higher education, intellectual capital and subsequently innovations on development potential of regions, we divided EU regions in three groups based on GDP per capita: Lower, Mid and

Upper developed regions. Table 2 presents the criteria for their grouping. Tables with specific descriptive statistics on region groups are in the Appendix 1.

Table 2. Lower, Mid and Upper standard EU regions - criteria for grouping (NUTS 2)

	Lower developed	Mid developed	Upper developed
Range	GDP pc > 17,953	17,953 – 29,922	GDP pc < 29,922
Number of regions	81	127	66

Source: Authors calculations based on Eurostat data

Based on theoretical assumptions and previous research on relationship between higher education and regional development, we introduce following hypotheses:

H1: Unemployment rates are crucial for regional development, especially in lower income regions

H2: Employment and demography significantly influence regional development

H3: Higher education propensity variables influence regional development dominantly in lower income regions

H4: Innovation potential and business dynamics variables influence regional development more significantly in upper income regions.

Descriptive statistics of dependent variable (GDP per capita) and all independent variables included in empirical analyses, as well as explanations, units of measurement and sources of all data used in the regression analysis are given in Table 3. All data was collected on Eurostat.

Table 3. Descriptive statistics on main variables for 276 EU regions (NUTS 2)

Variable	Explanation	Obs	Mean	Std. Dev.	Min	Max
GDP pc	Gross domestic product (GDP) divided by total population in NUTS 2 regions in EUR	4,259	23,937.3	14,120.09	1,260.438	215,921.4
Unemployment rate	Unemployment rate by NUTS 2 regions, population aged 20 to 64 years (%)	4,414	8.749909	5.596412	1	36.1
Employment share	Share of employed in total population in NUTS 2 region aged 20 to 64 years	4,461	0.4127737	0.0512271	0.1550569	0.5919331
Population growth rate	Growth of total population of NUTS 2 region	4,291	0.2904805	0.8395236	-11.04639	5.635405
GERD in GDP	Total intramural R&D expenditure (GERD) as % of GDP of NUTS 2 regions	2,794	1.268207	1.112693	0.06	12.19
Tertiary educated population	Ratio of population with tertiary education in total population aged 25 to 64 years (%)	4,433	24.36346	9.384652	3.7	74.9
HRST in employment	Share of human resources employed in science and technology (HRST) by NUTS 2 regions in total employment	4,449	0.3084517	0.0806593	0.0895522	0.609632
High-tech in employment	Employment in high-technology sectors by NUTS 2 regions (high-technology manufacturing and knowledge-intensive high-technology services), share in total employment (%)	4,023	3.843624	1.887293	0.5	12.8
Patents	High-tech patent applications to the EPO by priority year (per million inhabitants)	2,953	20.75763	35.00501	0.052	605.773

Source: Authors calculations based on Eurostat data

We use gross domestic product (GDP) per capita as indicator of regional development, and evaluate effects of different variables on GDP per capita as the representative of regional development. Thus, we propose the following model:

$RD_{it} = ß_0 + ß_1 * ECON_{it} + ß_3 * V_{it} + \lambda_t + e_{it}$

where dependent variable RD_{it} represents regional gross domestic product per capita for European NUTS 2 region *i* at time *t*. It is calculated as the ratio of regional GDP and total population in a NUTS 2 region *i*.

Variable $ECON_{it}$ represents set of economic situation indicators. It is a control variable in a model, and consists of following variables: Unemployment rate, Share of employment in population and Population growth rate.

$ECON_{it} = UNEMP_{it} + EMPL_{it} + DEMO_{it}$

Unemployment rate ($UNEMP_{it}$) is relevant for absorbing differences in regional labour supply and demand balance. The unemployment level can also be a manifestation of macroeconomic effects of HEIs, but usually it takes much more time to reveal. Unemployment rates, however, directly influence GDP because of its influence on consumption and public spending. Moreover, we include population growth rate ($DEMO_{it}$) and share of employed people in a population ($EMPL_{it}$) as control variables in models. These variables should be solid representatives of the demographic dynamics and economic utility of capacity in a region. Additionally, net migration rate is not included in the estimations as previous studies show inconsistent conclusions, although it might reflect important trends such as brain drain or sudden influx of immigrants with lower levels of education.

V_{it} represents other explanatory variables related to employment, higher education and economic dynamics, whose effects on regional prosperity we test in this model. Explanatory variables which we refer to in our estimations can be grouped as following:

A) **Higher education (HE) propensity indicators** - ratio of population with tertiary education in total population (tertiary educated people between 25 and 64 y. o.) and share of human resources in science and technology (HRST) in total employment by NUTS 2 regions; and

B) **Innovation potential and business dynamics indicators** – ratio of intramural research and development (R&D) expenditure (GERD) in GDP in a specific NUTS 2 region in a specific year, high-tech patent applications to the EPO by priority year (per million inhabitants), and share of high-technology sectors employees in total employment.

The first group of key explanatory variables presumes greater innovative potential in regions with better managed higher education system. As far as the second group of explanatory variables, selection of these variables describes the level of technology orientation of the region (high-tech employment and the number of patents), estimates the R&D potential of a region (GERD), describes level of innovation oriented industry dynamics and predict potential for university-industry spill overs. As previously suggested in many studies, regional enterprises are expected to better link research outcomes and employed graduates with higher levels of innovativeness.

Previous studies have suggested variety of other indicators, like: the number of regional start-ups, creative contributions, number of students, investments of higher education institutions per capita, number of staff in HEI, number of publications per capita and third party funds (investments from third parties in HEIs' projects). We, however, could not include them for the lack of availability.

All non-observed shocks absorbed in the proposed model are captured by including dummy variables based on year effects (λ_t). Residuals are also included in the model and labeled as e_{it}.

Our panel data is strongly balanced. Based on Hausman test results for Lower and Mid developed group we rejected *Ha* and conducted fixed effect robust analysis. Upper developed group of regions is more dispersed, and additional testing have been made - test of over-identifying restrictions (sigmamore, sigmaless and xtoverid), the Sargan-Hansen statistic suggests that *Ha* has to be rejected (P-value < 0.05). Hence, we confirmed that the fixed effects linear panel data model (with robust standard errors) is suitable for the estimations in our model. The fixed effects model delivers consistent parameter estimates for the true causal effect in the case of a correlation between the control variables and region-specific effects.

4. ECONOMETRIC ANALYSIS AND RESULTS

We start empirical analysis by calculating the effects of individual variables on each region group – Lower, Mid and Upper developed regions (Table 4, 5 and 6), and in continuation we analyse effect of combining influencing factors in a complex model during the total analysed period (Table 7). Unemployment rate, employment and demographic factors such as population growth rate have the highest impact on regional development. They explain 63% of model variations in Upper developed regions to 78% of variations in Lower developed regions.

For the group of regions with lower GDP per capita, importance of institutional higher education for regional development reflects in positive impact of tertiary educated population and share of human resources employed in science and technology in a given region. Moreover, employed in high-tech sector significantly increase GDP per capita, while intermural research and development expenditure (GERD) has no statistically significant impact on regional development estimated through regional GDP per capita.

Table 4. Estimation of effects affecting regional development in EU regions with lower level of GDP per capita

	Lower level GDP pc					
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Unemployment rate	-64.72***	-45.90**	-61.01**	-73.72***	-88.99***	-23.90
	(23.07)	(21.91)	(23.92)	(23.13)	(23.95)	(23.88)
Employment share	23,266***	20,050***	21,608***	23,079***	21,413***	24,429***
	(5,106)	(5,196)	(4,924)	(4,958)	(5,173)	(5,664)
Population growth	148.7**	163.1**	156.8**	151.1**	131.1**	158.6**
	(59.81)	(62.76)	(62.21)	(58.70)	(53.03)	(76.52)
GERD in GDP		368.2				
		(437.8)				
Tertiary educated population			103.7**			
			(46.73)			
HRST share				8,270***		
				(3,010)		
High-tech employment					432.9***	
					(95.42)	
Patents						94.17**
						(45.72)
Constant	-746.7	-847.8	-1,553	-2,439	-2,151	-1,962
	(2,192)	(2,218)	(2,316)	(2,200)	(2,342)	(2,389)
Time dummy	yes	yes	yes	yes	yes	yes
Observations	1,167	945	1,154	1,158	974	587
R-squared	0.783	0.807	0.787	0.789	0.825	0.832
Number of regions	81	80	81	81	73	76

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Source: Authors

In the Mid developed group of regions, 25% around the EU GDP PPS per capita average, factors with the highest influence on GDP per capita are related to human potential as a generator of business growth and economic prosperity. Thus, employed in high-tech sector have positive impact on GDP per capita, while interestingly, share of HRST reduces GDP per capita. Since in HRST are calculated all employed in Science and Technology, including support staff, one can only speculate on divergence of efficiency and expenditures related with that employment segment.

Table 5. Estimations of effects affecting regional development in EU regions with mid level of GDP per capita (within +_ 25% of average)

VARIABLES	Mid level GDP pc (1)	(2)	(3)	(4)	(5)	(6)
Unemployment rate	-188.0***	-198.0***	-195.1***	-192.1***	-224.2***	-179.2***
	(47.01)	(49.81)	(48.97)	(45.58)	(52.20)	(59.19)
Employment share	22,488***	10,566	22,557***	21,186***	22,803***	21,627***
	(8,000)	(8,801)	(7,983)	(7,678)	(8,186)	(7,960)
Population growth	256.8	284.3	255.8	284.9	267.3	41.70
	(301.7)	(344.6)	(304.5)	(301.7)	(302.7)	(423.9)
GERD in GDP		364.4				
		(330.6)				
Tertiary educated population			32.18			
			(52.47)			
HRST share				-9,072***		
				(2,778)		
High-tech employment					858.0***	
					(198.0)	
Patents						2.230
						(16.44)
Constant	13,784***	16,802***	13,131***	16,793***	10,266***	14,258***
	(3,420)	(3,640)	(3,499)	(3,596)	(3,420)	(3,612)
Time dummy						
Observations	1,797	1,185	1,775	1,779	1,682	1,311
R-squared	0.655	0.603	0.652	0.656	0.688	0.573
Number of regions	127	123	127	127	125	123

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Source: Authors

On the upper developed group of regions, besides the research and development expenditure (GERD per capita) in a given region, which seems to have statistically significant, but negative effect on regional development, two positive and statistically significant impacts are to be pointed out: ratio of high-technology employment in total employment and rate of tertiary educated population. It should be noted that unemployment rate has no statistically significant impact in these regions, but mostly due to low unemployment rates that accompany highly develop regions.

Table 6. Estimations of effects affecting regional development in EU regions with upper level of GDP per capita

VARIABLES	Upper level GDP pc (1)	(2)	(3)	(4)	(5)	(6)
Unemployment rate	-18.36	-242.1	-121.4	-7.525	-64.85	-6.276
	(294.1)	(249.8)	(217.8)	(287.0)	(256.5)	(237.7)
Employment share	86,269**	85,128**	82,067***	90,575**	81,475**	82,269***
	(35,760)	(36,917)	(30,635)	(38,789)	(32,318)	(30,636)
Population growth	338.8	195.3	257.9	301.8	340.5	518.0
	(415.2)	(370.9)	(331.3)	(355.8)	(417.3)	(405.7)
GERD in GDP		-737.8*				
		(410.4)				
Tertiary educated population			356.1*			
			(181.0)			
HRST share				10,284		
				(19,243)		
High-tech employment					699.0*	
					(403.9)	
Patents						5.858
						(8.560)
Constant	-5,388	-4,959	-11,871	-10,766	-7,337	-4,549
	(17,299)	(17,354)	(17,136)	(23,196)	(17,659)	(14,688)
Time dummy	yes	yes	yes	yes	yes	yes
Observations	879	492	879	879	864	678
R-squared	0.631	0.637	0.649	0.633	0.636	0.630
Number of regions	66	65	66	66	66	66

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Source: Authors

As expected, individual factors show different impact according to the current region development stage. In the next table (Table 7), we combe variables in complex model by which we try to explain multidimensional impact of specific variables on regional prosperity. Our complex model consists unemployment rate, employment share and population growth rate, along with tertiary educated population and HRST share (as representatives of R&D potential - Higher education propensity group of variables), and relative number of people employed in high-technology sector, GERD and patents (as representatives of high-technology orientation and university-business spill over potential - Innovation potential and business dynamics group of variables).

Table 7. Comparison of effects affecting regional development in EU regions with lower, mid and upper GDP per capita

VARIABLES	Lower GDP pc	Mid GDP pc	Upper GDP pc	Lower GDP pc	Mid GDP pc	Upper GDP pc
Unemployment rate	-64.72***	-188.0***	-18.36	-63.42***	-243.2***	-479.1**
	(23.07)	(47.01)	(294.1)	(22.42)	(59.63)	(191.0)
Employment ratio	23,266***	22,488***	86,269**	19,295***	8,777	70,566***

	(5,106)	(8,000)	(35,760)	(5,921)	(6,883)	(25,319)
Population growth	148.7**	256.8	338.8	184.5**	352.4	761.6**
	(59.81)	(301.7)	(415.2)	(76.08)	(429.8)	(313.1)
GERD in GDP				10.60	214.0	-744.9**
				(386.3)	(276.9)	(296.6)
Tertiary educated population				135.3**	96.37	264.2
				(65.26)	(80.48)	(209.9)
HRST per employee				5,546	-16,090***	-14,766
				(4,314)	(3,441)	(9,786)
High-tech employment				216.1***	970.2***	498.1*
				(81.45)	(175.3)	(278.9)
Patents				87.07**	-6.479	6.079*
				(41.18)	(12.00)	(3.641)
Constant	-746.7	13,784***	-5,388	-4,454	16,717***	-2,748
	(2,192)	(3,420)	(17,299)	(2,765)	(3,238)	(16,103)
Time dummy	yes	yes	yes	yes	yes	yes
Observations	1,167	1,797	879	494	893	388
R-squared	0.783	0.655	0.631	0.856	0.638	0.658
Number of region	81	127	66	69	116	65

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Source: Authors

In the complex model, tertiary education has more influence on regional development in lower developed regions, while size of high-tech sector contribute to the development of all three groups of regions. Patents significantly affect development in lower and upper developed regions, but with large difference in their contribution to GDP per capita; it should be noted that an increase of 1 patent per million inhabitants in lower group would lead to increase in GDP pc by 87.07 EUR, while the same increase in upper group would lead to increase of 6,079 EUR. This finding is somewhat in line with research on education and innovation effect on productivity in Mexican states (German-Soto and Gutiérrez Flores, 2015), resulted in identifying innovation as an important contributor to increasing productivity of northern, central and richer states. In addition, according to their research education expenditure also seems to be more important for the poorer states.

The unemployment rate, as one of three control variables in a basic model, has significant negative influence on all three region groups, except on Upper developed regions in a basic model. Employment share, as a capacity utilization, has significant positive influence on all three region groups, except on Mid developed regions in a complex model. Population growth rate is especially important for lower developed regions, probably since they are more often hit by migrations and brain drain phenomena.

It is important to note that complex models have relatively high fit yielding R^2 values, accounting from the 78.3% (Lower), 65.5% (Mid) and 63.1% (Upper) in the basic model consisting solely of basic economic indicators; moreover, if we include tertiary educated population, HRST, ratio of employed in high-technology sector, GERD and patents, R^2 values are higher for Lower and Upper group and explain 85.6% (Lower), and 65.6% (Upper) of variations in the model, while for average developed regions (Mid) basic model better explains variation than the complex one ($R^{2=}$63.8%).

5. CONCLUSION

Disparities in living standard and wellbeing among EU regions, especially between 'core' and 'peripheral' regions, is becoming more profound, and therefore captures interest of economists and policy-makers in the EU (and elsewhere). As education, innovation and science and technology undoubtedly influence the regional issues and capacities through employment and economic growth, regional effects of higher education institutions (HEIs) have to be adequately assessed. Up to now, most studies with measurable results suggested positive impacts of HEIs, but important factors still stay outside the scope. This is probably due to different conditions and complex mechanisms associated with HEIs outputs, including multidimensionality, supply- or demand-side effects (which usually take different time spams to be clear and visible), and especially spill-over effects between neighbouring regions. 'Peripheral' and/or 'vulnerable' regions without (or without significant) HEIs can also gain through knowledge transfers from neighbouring regions and regional absorption of such knowledge by local firms.

We used panel data for the econometric analysis to evaluate the influence of specific factors directly or indirectly connected to higher education on regional development for NUTS 2 level regions in the EU (276 regions) in the period of 17 years. Our results suggest that when combined with HEI specific variables, unemployment rates are crucial for regional development (not just in lower income regions), while employment and demography significantly influence regional development in Lower and Upper income regions. Furthermore, higher education propensity variables influence regional development dominantly in Lower income regions (Tertiary educated population; positive effect) or Mid income regions (HRST per employee; negative effect). Finally, regarding innovation potential and business dynamics variables, a clear significant and positive influence can be accredited to high-tech employment, and patents per million inhabitants (although not in Mid-income regions), while GERD per GDP negatively influences regional development of Upper income regions.

The analysis emerging from the model concludes that regional differences should be seen as a potential opportunity for introducing customized policies designed to address region specific issues. Further research should be more focused on localization effects of macroeconomic, especially institutional factors and regulations enabling positive and regulatory stable environments for fragile and risky entrepreneurial endeavourments, start-ups and enterprise investments, in order to boost regional development and industry competitiveness, especially in peripheral regions. Constraints for more in depth research lie with missing and uncollected data on regional level, which could help to identify crucial effects of HEIs on regions.

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APPENDIX 1. DESCRIPTIVE STATISTICS OF LOWER, MID AND UPPER DEVELOPED EU REGIONS

Table 8. Lower GDP per capita EU regions

Variable	Obs	Mean	Std. Dev.	Min	Max
GD pc	1,286	10,053.43	4,888.121	1,260.438	21,791.93
Unemployment rate	1,322	11.84985	6.254393	1.9	35.7
Employment ratio	1,338	0.3825799	0.0533086	0.193083	0.5102708

Population growth	1,285	-0.0998477	1.008282	-11.04639	4.758798
GERD in GDP	1,006	0.6016799	0.4290951	0.06	2.91
Tertiary educated population	1,321	17.4243	6.661161	3.7	42.4
HRST in employment	1,331	0.2431212	0.0581914	0.0895522	0.4264876
High-tech in employment	1,085	2.79871	1.653125	0.5	8.8
Patents	639	1.629527	2.086649	0.052	16.37

Source: Authors calculations based on Eurostat data

Table 9. Mid level GDP per capita in EU regions

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP pc	1,963	25,028.24	4,226.42	8,993.779	3,6651.25
Unemployment rate	2,080	8.365673	5.183894	1.4	36.1
Employment ratio	2,079	0.4135611	0.0455562	0.1550569	0.5919331
Population growth	1,980	0.3935078	0.7097633	-4.773294	4.52961
GERD in GDP	1,262	1.34977	0.8715736	0.06	12.19
Tertiary educated population	2,067	25.81369	7.467232	6.7	50.6
HRST in employment	2,074	0.3147238	0.0636437	0.1127367	0.566284
High-tech in employment	1,937	3.668095	1.390283	0.9	9.7
Patents	1,493	14.21358	16.54029	0.074	139.726

Source: Authors calculations based on Eurostat data

Table 10. Upper GDP per capita EU regions

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP pc	1,010	39,494.87	16,909.69	24,476.91	215,921.4
Unemployment rate	1,012	5.490119	2.613785	1	19
Employment ratio	1,044	0.4499022	0.0298861	0.3385174	0.5229625
Population growth	1,026	0.5805172	0.6387352	-3.862195	5.635405
GERD in GDP	526	2.347281	1.541323	0.13	11.36
Tertiary educated population	1,045	30.26679	10.36643	7	74.9
HRST in employment	1,044	0.3792818	0.0694995	0.2171582	0.609632
High-tech in employment	1,001	5.315884	2.051184	1.3	12.8
Patents	821	47.54583	53.18377	0.267	605.773

Source: Authors calculations based on Eurostat data