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Research Activities and their Relation to Economic Performance of Regions in the European Union

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Abstract

Background: The intensity of innovation could often be crucial for further economic development of the regions. Science and technology are often seen as the key factor supporting innovation in the regions. Furthermore, we can assume that higher intensity of research activities could lead to better economic performance. **Objectives:** Research aims to examine the link between the economic performance of the region and the intensity of science and technology activities, proxied by the share of employees in science and technology. **Methods/Approach:** The analysis is based on panel data for NUTS2 regions of the European Union (EU) member states. We conducted correlation analysis, panel Granger causality tests and regression analysis. **Results:** Our results suggest the existence of a significant positive correlation between GDP per capita and the share of employees in science and technology. Moreover, the regions with a higher intensity of science and technology activities are mostly characterized by relatively low unemployment rates. **Conclusions:** Research activities are positive correlated with regional GDP and negatively correlated with unemployment. However, increasing the share of employment in science and technology beyond a certain turning point would not lead to any further positive effects on regional economic performance.

Keywords: science and technology, regional development, university education, innovation, economic development
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Introduction

Based on the theory of endogenous economic growth, science, research and knowledge play a key role in maintaining growth. However, the positive externalities resulting from knowledge have a geographically limited impact. Thus, they are an important source of sustainable economic growth especially at the regional level (Audretsch, 1998). The accumulation of intellectual capital is one of the main factors that create differences in the productivity of individual regions (Fischer et al., 2009). This aspect is further developed in the theory of learning regions (Lundvall et al., 1994). Despite the existence of several supranational tolls to eliminate regional disparities, there are still significant differences in regional economic development within the European Union (EU). The economic growth of the regions is often attributed to technological change and innovation intensity. The ability of poor regions to catch up with the rich ones is closely related to their ability to generate sufficient investments, but also to its innovation capacity (Fagerberg, 2010). The institutional characteristics, knowledge infrastructures and knowledge transfer systems at the regional level appear to be crucial for promoting innovations at regional level (Doloreux et al., 2005).

Innovation consists of knowledge that arises as a result of scientific, research and development activities and, consequently, the ability of workers to apply them into practice (Hudec et al., 2009). The technology sector appears to be particularly important for the knowledge based economy and this sector also undertakes a high share of all R&D expenditure. Higher R&D expenditure appears to further lead to more researchers, more patents and also higher economic growth (Hunady et al., 2014). Knowledge creation in high technology sectors depends significantly on university research and R&D performed by the high technology sectors themselves (Acs et al., 2013). Human capital is an important factor supporting the knowledge based economy. This seems to be crucial for regional economic growth. Regions with a large share of employees with a higher education experience higher economic growth (Cuaresma et al., 2014). Pylak et al. (2016) used the share of employees in science and technology as well as the share of the population with tertiary education as one of the main variables describing the characteristics of regional innovation systems. Based on logit regression they found that the chances for achieving greater economic growth by less-developed regions were better in regions with higher innovativeness. Thus, an increase in the share of people with tertiary education and employed in science and technology also appeared to have a positive effect on regional GDP per capita. In line with this statement, the intensity of science, research and development together with the proportion of tertiary educated people are those factors supporting innovation performance and thus also regional economic development (Badinger et al., 2003; Sterlacchini, 2008; Acs, 2002). R&D activities of firms seem to be the key factor leading to innovation (Hunady et al., 2014). On the other hand, there are also some different results. For example, Baesu et al. (2015) found that the number of employees in science and technology has no significant effect on the innovation performance of high-tech industry. This could be true due to so called valley of death between research and successful innovation, which could be crossed by communication and interaction between academia and business (Hudson et al., 2013).

However, in general we can say the accumulation of intellectual capital is one of the main factors that create differences in the productivity of individual regions (Fischer et al., 2009). Hence, the support of science and technology activities within the region seems to be beneficial for maintaining the economic development of the region. Furthermore, there is also some other direct positive effects of higher education institutions located in the region. However, the extent of these benefits depends on their quality and policy settings in the region (Arbo et al., 2007).

In general we can assume that higher intensity of science and technology in the region could have some positive consequences on productivity within the region. Productivity growth in the region can often be explained by research and development expenditures. There have been many studies directed at finding links between innovation, research and development (R&D) and productivity growth (for example Frenken et al., 2007; Hall et al., 2013 or Guellec et al., 2001).

Furthermore, the knowledge infrastructure of the region is a crucial stimuli for promoting innovation activities in the region (Doloreux et al., 2005). The spatial distribution of R&D expenditures among the regions has been examined in the EU countries (Martín at al., 2005) as well as in other countries, such as, for example, China (Wei et al., 2008). However, there are also significant differences in the innovation capacity of regions.

The actual acquisition of knowledge can be made either from local sources within the region or from the external environment or other regions. As stated by Pastor et al. (2013), the process of knowledge acquisition from other regions is a very important source of regional development. Perhaps, this way of acquiring knowledge is even more important for less developed regions.

According to Sandu (2012) human resources in science and technology are one of the main indicators describing the current research and innovation potential of the region together with the number of patents, publications and R&D expenditures. Moreover, the amount of innovation activities in the region could be indirectly measured by the proportion of research and development employees (Fritsch et al., 2011).

Our paper aims to examine the link between the intensity of science and technology in the regions and their economic development. There are only a few studies dealing with this issue at the regional level. In comparison to most of the other studies, we used panel data approach for all NUTS 2 regions in EU28.

We tested two main research hypotheses as follows:

- H01: We assume that human resources in science and technology in the region is positively correlated with economic growth of the region.
- H02: We assume that the share of population with tertiary education in NUTS 2 regions is positively correlated with unemployment in the region.

The intensity of science and technology is proxied by the share of human resources employed in these areas. We further describe the methodology and data used in the analysis in the next section of our paper. Key results are summarized and discussed in the third section. Finally we make some conclusions and remarks in the final section of the paper.

Methodology and data

Our main scientific aim is to identify the link between the share of employees in science and technology and the economic development of the region measured by GDP per capita. In line with this aim we stated two research hypotheses. To teste them we analysed the empirical data. In this section we describe our methodology as well as the data in more detail.

Our dataset consists of panel data for NUTS 2 regions in EU28 countries retrieved from Eurostat database (European Commission, 2017). NUTS 2 regions are basic regions for the application of regional policies from the EU perspective. Thus, this regional level is often used in this type of analysis. Furthermore, there is significant lack of data at lower levels. The data include several variables for NUTS 2 regions in the period 2003-2014. This period has been chosen based on data availability. Thus, we have more than 3471 non-missing observations. We particularly used four variables in the analysis. These are summarized in the Table 1. The two most important variables are regional GDP per capita and regional number of employees in science and technology.

Table 1
Description of variables used in the analysis

Variable	Description	Source
GDP per capita	Regional gross domestic product (GDP) by NUTS 2 regions. Purchasing power standard (PPS) per inhabitant.	European Commission (2017) - Eurostat database [nama_r_e2gdp]
Share of employees in science and technology	The share of employees in science and technology on total number employment by NUTS 2 regions. Full-time equivalent (FTE).	European Commission (2017) - Eurostat database [rd_p_persreg)]
Tertiary education	The share of population with tertiary education n NUTS 2 regions.	European Commission (2017) - Eurostat database [rd_p_persreg
Unemployment	Rate of unemployment in NUTS2 regions.	European Commission (2017) - Eurostat database [rd_p_persreg

Source: Authors' work

Basic descriptive statistics of all variables are shown in Table 2.

Table 2
Basic descriptive statistics for variables

	Mean	Median	Max	Min	Std. Dev.
GDP per capita	94.67	94.0	266.0	21.0	33.69
Share of employees in science and technology	27.01	27.00	56.1	10.5	7.09
Tertiary education	25.48	25.50	58.9	6.90	8.20
Unemployment	8.89	7.70	37.00	1.80	5.10

Source: Authors' work based on the data retrieved from European Commission (2017).

We examined the relationship between the regional share of employees in science and technology and regional GDP per capita using panel Granger causality tests and the panel fixed-effects and random effects models. The choice between random effects and fixed-effects application was based on the results of the Hausman test. Variables used in the models were tested for weak stationarity using a panel stationarity test.

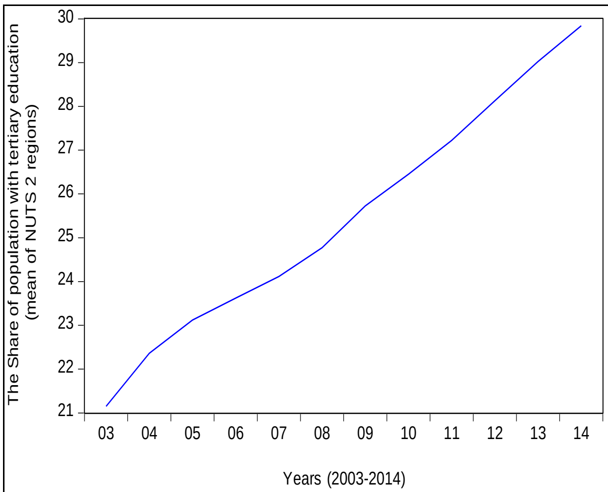
According to the results of these tests we can conclude that all selected variables are found to be non-stationary at their levels but appear to be stationary at the first differences. Thus we have to use all tested variables at their differences in order to avoid potential problem of spurious regression. Hence, we decided to use the first differences of the variables in all regression models.

Results and discussion

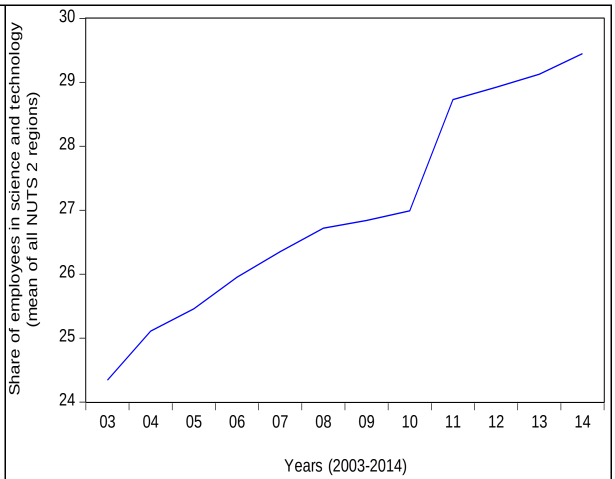
Firstly, we examine the development of the two main variables during the selected period of time. As we can see in Figure 1, average share of employees in science and technology has an increasing trend in the EU countries during the years 2003-2014. The same is true for the average share of people with tertiary education, which is rising even more quickly during this period.

Figure 1

The average share of the population with tertiary education in the active population (left) and the average share of employees in science and technology (right)



Population with tertiary education (average of NUTS2 regions in EU)



Share of employees in science and technology (average of NUTS2 regions in EU)

Source: Authors' work based on the data retrieved from European Commission (2017).

Next we analyse the correlation between all selected variables. The Pearson correlation coefficients between each pair of variables are summarized in the Table 3. As we can see, there is a strong positive correlation between regional GDP per capita and the share of employees in science and technology. There are also moderate positive correlations between the share of people with tertiary education in the region, regional GDP per capita and the share of employees in science and technology.

On the other hand, all three variables are negatively correlated with regional unemployment. Thus, the regions with more intensive science and technological activities have in general less unemployment. The negative correlation between GDP per capita and unemployment is of course in line with theoretical expectations.

In the next part of the analysis, we focus our attention on a relation between GDP per capita and the share of employees in science and education. In order to test the direction of the causality we applied Granger causality tests in order to test the direction of potential causality between the variables.

The results that can be seen in Table 4, strongly suggest that there is causality in the Granger sense arising from employment in science and technology to regional GDP per capita. On the other hand, the effect in the opposite direction is not statistically significant.

Table 3
Correlation matrix of selected variables

	GDP per capita	Number of employees in science and technology (share)	Tertiary education	Unemployment
GDP per capita	1.000	0.716***	0.435***	-0.429***
Share of employees in science and technology	0.716***	1.000	0.497***	-0.431
Tertiary education (share)	0.435***	0.497***	1.000	-0.036
Unemployment	-0.429***	-0.431***	-0.036	1.000

Note: *** denotes statistically significant at the 1 percent level.
Source: Authors' work based on the data from Eurostat database.

Table 4
The results of Granger causality test

	F-statistic	F-statistic
Number of lags:	1 lag	2 lags
ΔGDP per capita does not Granger Cause ΔShare of employees in science and technology	0.4706	0.787
ΔShare of employees in science and technology does not Granger Cause ΔGDP per capita	10.393***	27.651***
Number of observations	3154	2837

Note: *** denotes statistically significant at the 1 percent level.
Source: Authors' work based on the data from Eurostat database.

Finally, we analysed the relationship using panel data regressions. We applied several different fixed effects panel regressions. All models were tested for autocorrelation and multicollinearity. Moreover, we also used standard errors robust for heteroscedasticity.

As we can see in Table 5, we firstly applied the cross-sectional random effects model (regression 1.1), but the results of the Hausman test suggest that the fixed-effects model should be the more appropriate one. Hence, we decided to use only fixed effects models. However, the period fixed effects model (regression 1.3) shows only very small R^2 statistics, thus this model was taken into the account only as a robustness check.

The results of regressions (see Table 5) suggest that there is a significant positive effect of the share of employees in science and technology on regional GDP per capita. This effect is statistically significant at the 10% and 5% levels respectively. The change in the share of people with tertiary education in the region appears to be insignificant with respect to GDP per capita.

We also used the share of employees in science and technology lagged by one period as an independent variable. The positive effect is even more significant in this case as we can see in regression 1.5. These results are in line with the theoretical assumptions and previous empirical results such as Badinger et al. (2003) or Sterlacchini (2008). They also complement the results achieved by Pylak et al. (2016).

Table 5
Results of panel regression models with GDP growth as dependent variable

	Dependent variable: ΔGDP per capita					
Regression model:	1.1 Cross section RE	1.2 Cross section FE	1.3 Period FE	1.4 Cross-section & period FE	1.5 Cross-section FE	1.6 Cross-section FE
C	-0.12 (-1.59)	-0.116** (-2.16)	-0.124* (-2.28)	-0.112** (-2.09)	-0.204*** (-3.40)	-0.097* (-1.92)
ΔShare of employees in science and technology	0.065** (2.02)	0.006* (1.94)	0.081** (2.13)	0.078** (2.19)		0.138*** (3.58)
ΔShare of employees in science and technology2						-0.031*** (-3.682)
ΔShare of science and technology(lag=1)					0.126*** (3.61)	
ΔTertiary education	-0.03 (-0.97)	-0.033 (-0.92)	-0.038 (-1.03)	0.005 (-1.36)	-0.010 (-0.31)	
Random effect (RE) Fixed effects (FE)	Cross-section RE	Cross-section FE	Period FE	Cross-section & period FE	Cross-section FE	Cross-section FE
R2	0.002	0.20	0.005	0.20	0.21	0.20
Adjusted R2	0.001	0.12	0.002	0.12	0.12	0.12
Akaike criterion		4.93	8.475	4.94	4.97	4.93
Hausman test	1.195					
F-statistic	2.07	2.411***	1.584*	2.395***	2.383***	2.47***
Number of observations	3471	3471	3271	3271	3271	3271

Note: We used data for NUTS II regions in the EU within the period 2003-2014; symbols (.) denotes z-statistics and */**/*** denotes statistically significant at the 10/5/1 percent levels. Standard errors have been corrected for heteroscedasticity.
Source: Authors' work based on the data from Eurostat database.

Furthermore, based on the results of regression 1.6 we can say that the relationship between these two variables seems to be of a nonlinear inverse U-shape form. This means that the GDP per capita rises with the increase in the share of employees in science and technology only to a certain point. The maximum appears to be approximately at 2.23%. However, we can see that the R^2 is rather low in all models, which means that the intensity of science and technology in the region is still not the main factor affecting the regional GDP per capita.

In the next five regression models, we used unemployment share as a dependent variable instead of GDP per capita. We assume that this variable reflects in particular the intensity of R & D activities as well as the use of human resources in this area. The regression results are summarized in Table 6.

Based on our results, it is clear that the change in the share of staff in science and technology in the region negatively correlates with the change in the rate of regional unemployment. This variable is statistically significant at a 1% significance level in all models used. Again, we can say that our results are fully in line with Cuaresma et al. (2014) who stated that a large share of employees with a higher education is related to higher economic growth in the region.

Based on our results we can say that we are not able to reject both of our research hypotheses. Thus, the results suggest that human resources in science and technology as well as the share of people with tertiary education are both positively correlated with economic growth of the region.

Table 6
Results of panel regression models with unemployment as dependent variable

Dependent variable: Δ Unemployment					
	1.1	1.2	1.3	1.4	1.5
C (Fixed effects)	0.21 (0.87)	0.20 (0.82)	0.20*** (8.78)	0.19*** (9.98)	-0.17*** (8.02)
ΔShare of employees in science and technology	-0.20*** (-3.01)	-0.18*** (-2.98)	-0.19*** (-3.99)	-0.17*** (-4.15)	-0.18*** (-4.28)
ΔGDP per capita	-0.14*** (-5.31)	-0.11*** (-6.34)	-0.14*** (-5.36)	-0.11*** (-6.34)	
ΔGDP per capita (lag=1)					-0.09*** (-3.05)
ΔTertiary education	-0.033 (-0.92)	-0.038 (-1.03)	0.005 (-1.36)	-0.010 (-0.31)	
Fixed effects(FE) / Random effects(RE)	Cross-section RE	Cross-section FE	Period FE	Cross-section & period FE	Cross-section & period FE
R2	0.10	0.20	0.31	0.41	0.44
Akaike info crit		3.80	3.47	3.50	3.48
F-statistic	193.15***	2.00***	130.2***	6.55***	6.69***
Number of observations	3442	3442	3442	3442	3143

Note: We used data for NUTS II regions in the EU within the period 2003-2014; symbols (.) denotes z-statistics and */**/*** denotes statistically significant at the 10/5/1 percent level. Standard errors have been corrected for heteroscedasticity.
Source: Authors' work based on the data from Eurostat database.

Conclusion

Innovation is supposed to be the key determinant of economic growth in the long run. With respect to innovation performance, especially science and technology seems to be the most important sector. Hence, we can say that universities and other research institutions are often critical when creating innovation in the region. The intensity of science and technology has been proxied by the share of human resources employed in this sector. We can assume that a higher share of employees in science and technology will positively affect the regional economic development. We also take to the account a control variable representing the share of people with tertiary education living in the region. This has been used because the educational level is often assumed to be a very important factor with respect to knowledge creation and innovation. Of course the role of universities is again crucial in this case. Thus we can say that the public support of universities could be seen as one of the effective policies for improving innovation performance and also impact on economic growth in the region.

We found a positive correlation between the intensity of science and technology and the economic development of the region. Based on our results, we can say that an increase in the human resources in science and technology should have a positive effect on regional GDP per capita. This effect seems to be even stronger when taking to account a one year lag. However, we also found a certain turning point for this positive effect. Hence, it means that increasing the share of employment in science and technology beyond this point would not lead to any further positive effects on regional economic development. Our results also suggest a negative correlation between research activities and unemployment rate in the region.

It is also important to mention that our approach does not capture all variables that could have an effect on regional economic development. We see a potential for further research to investigate potential effects of other variables related to innovation on regional economic growth. Moreover, despite the fact that we have tested the models for reverse causality, the endogeneity could still be a problem in our case. Thus, it should be perhaps more appropriate to speak about certain correlations rather than strict causal effects.

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