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Research & development and regional smart specialisation: do they matter for productivity?

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Abstract

Research and development activities within the region are often seen as a key driving force of innovation performance. This is further important for productivity growth and economic growth of the region. These issues are part of European Union strategy for regional development called Smart Specialization. Higher education institutions play important role in the support of innovation in the region via their own research activities, knowledge creation and dissemination and improvement of the human capital in the region. The main aim of our research is to test potential link between intensity of research & development as well as specialization of the region and labour productivity in the region. In our research we compared NUTS 2 regions in the Czech Republic and Slovakia based on the selected indicators related to research and development. We used factor analysis and regression analysis based on the cross-sectional data for all NUTS 2 regions in the EU. Our results strongly suggest that focus on research & development activities is positively correlated with higher labour productivity in the region. Higher number of scientific publications and patents is also positively linked to higher productivity in the region. The same seems to be true for higher share of tertiary educated inhabitants.

Keywords: Research & Development, Labour Productivity, Smart Specialisation, Infrastructure, Higher education.

JEL classification: I23, O38, J24, E24.

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1 Introduction

Importance of research and development is becoming more prominent, especially considering globalization and the effort of individual countries and regions to increase their economic performance and competitiveness on the global scale. One of the most important determinants of innovation performance of a region or a country is the intensity of its research and development. In addition, innovation is one of the key components that lead to increase of labour productivity in business as well as public sector. It can be therefore deduced that activities related to research and development within the region can bring benefits to the citizens of the region as well as to the economy as the whole. Increase in labour productivity due to innovation was proven to cause further economic growth, which helps improve lives of the citizens. However, the R&D is not only important on national and regional level, but also on level of transnational unions. This is reflected in the policies of European Union, which are in a large part focused on increasing expenditure on R&D and on support of innovation at national and regional level. One of the EU strategies focused on support of innovation on regional level is Smart specialisation which is one of the focus points of the paper.

Our paper aims to test potential link between intensity of research & development as well as specialisation of the region and labour productivity in the region. We assume that EU regions are specialised more on services and especially those with more intensive research and technology activities have higher labour productivity. Moreover, we examine several indicators related to research & development in more detail in regions of Czech Republic and Slovakia. In the next section, we describe the concept of smart specialisation with the focus on research & development. In further sections we describe the methodology of research and present the most important results.

2 Literature review

Literature shows that there has been shift in the focus of economists in the recent decades. The higher emphasis is put on knowledge and innovation than it was in the past. This can be seen in economic theories as much as in economic and political practice of various transnational units such as European Union. Technology, knowledge and innovation are important factors influencing competitiveness and economic power of a country (Kremer, 2012). The link between competitiveness and innovation, in the form of scientific discovery has become even more important in the wake of the recent economic crisis. This can be seen in policies of more and more countries which are becoming focused on securing sustainable sources of economic growth (Krammer, 2017). Research and innovation are important for sustainable development of a country in various ways. They provide the knowledge and solutions needed to deal with short-term issues as well as long-term societal challenges. (European Commission, 2017a). The importance of research and innovation can be seen in European Commission's strategy Europe 2020 focused on smart, sustainable

and inclusive growth in EU countries. One of the five main goals of Europe 2020 is to increase expenditure on R&D. According to the European Commission, R&D is therefore one of the key elements of sustainable growth.

Various theories and projects are focused on examining the importance of innovation, research and development on national or transnational level. However, it has been proven by multiple studies that focusing on research and development on regional level is also important. One of the projects involving participation of various prestigious universities called KIT (Knowledge – Innovation – Technology) proved that "one-size-fits-all" approach is not a suitable foundation of innovation policies. KIT studies have shown that it is crucial for innovation policies to not only provide innovation support, but to look at innovation policies in wider context seeing as various regions have different innovation needs (Balog, 2015).

One of the concepts designed to support innovation, research and development in EU countries on regional level is new concept of European Commission called Smart specialization. Smart specialization can be defined as the prioritization done at regional level in a small group of sectors/technologies that could be potentially competitive on international markets and generators of new activities with competitive advantages over other locations (Jucevičius, Galkuogiene, 2014). The main aim of the smart specialisation is to increase innovation performance of EU countries. One of the goals of Smart specialisation is to promote development based on understanding of relationships between economic geography, technology and institutions (Martín, Mulas-Granados, Sant, 2005). Smart specialisation is a place-based approach characterised by the identification of strategic areas for intervention based on the analysis of the strengths and potential of the economy and on an Entrepreneurial Discovery Process (EDP). Smart specialisation strategies are based on „bottom-up" approach, seeing as they are focused on defining priorities rather than traditional industrial policies. Other elements of smart specialisation strategies are transparency (including evaluation and monitoring) and flexibility.

Five main points of focus of National/Regional Research and Innovation Strategies for Smart Specialisation (RIS 3) are:

- the focus of policy support and investment is on key national/regional priorities, challenges and needs for knowledge-based development,
- strategies are based on each country/region's strengths and competitive advantages,
- support is divided between technological and practice-based innovation and aimed at stimulation of private sector investment,
- stakeholders are fully involved and innovation and experimentation is encouraged,
- strategies are evidence-based and include sound monitoring and evaluation systems (European Commission, 2017b).

It was proved to be crucial to focus the support of public resources to R&D areas that have the largest potential or the areas that contribute to economic growth of the country, especially considering the fact that public resources are limited (Bogliacino, Pianta, 2009). The spatial distribution of R&D expenditures among the regions has so far been examined in the EU countries (Kremer, 2012) as well as in other countries such as China. Wei, Wu (2008), Zhong, Yuan, Huang (2011) and Zacharadis (2003) argue that R&D

expenditure is mostly reflected in the number of patents and that patents have a positive effect on the development of technologies, which in turn raises economic growth.

Performance of countries and regions is closely linked to labour productivity. There have been multiple studies focused on finding link between innovation, R&D and productivity. There was established correlation and plausible causality between innovation policies and labour productivity growth (Al Raee, Ritzen, Crombrugghe, 2017). Some studies were also aimed at examination of the impact of research and development and innovation policies on labour productivity on sectoral level (Bogliacino, Pianta, 2009). It was proven that R&D and ICT contribute to innovation to a different extent, with R&D being the most relevant input for innovation. Furthermore, universities appear to play very important role in creating high-tech innovation in the region (Anselin, Varga, Acs, 1997).

It has been proven that both R&D and ICT individually appear to have large impact on productivity (Hall, Lotti, Mairesse, 2013). Privately financed industrial R&D was found to have significant effects on productivity growth of manufacturing industries with industries directly conducting the privately financed R&D having larger effect than industries indirectly purchasing capital from industries conducting privately financed R&D (Kendrick, Vaccara, 1980). The study investigating long-term effects of various types of R&D on multi-factor productivity growth showed that increase of 1 per cent in business R&D generated 0.13 per cent in productivity growth with effect being larger in countries with intensive business R&D and lower share of defence-related government spending (Guellec, van Pottersberghe, de la Potterie, 2001). Research studying relationship between total factor productivity, R&D, human capital and public infrastructure showed that regional productivity is positively affected by R&D activity and public infrastructure of neighbouring regions (Bronzini, Piselli, 2009).

3. Methodology and data

In the paper, we analysed empirical data of EU NUTS 2 regions in order to fulfil our main scientific aim. As stated, the aim of the paper is to test potential link between intensity of research and development within the concept of smart specialisation of the region and labour productivity in the region. Based on the main aim we constructed four main research hypotheses as follows:

H01: There is a negative correlation between regional specialisation on agriculture and labour productivity in the region.

H02: There is a positive correlation between output of basic science measured by scientific publications and labour productivity in the region.

H03: There is a positive correlation between output of applied research measured by patent applications and labour productivity in the region.

H04: There is a positive correlation between the share of population with tertiary education and labour productivity in the region.

In order to test these hypotheses we used secondary data from Eurostat database. The dataset consists of 276 cross-sectional observations for each NUTS 2 region in the EU. Most of the observations are valid for the year 2015.

In our analysis, we chose variables closely related to research and development. Firstly, we examined selected indicators related to research and development activities in the NUTS 2 regions of the Czech Republic and Slovakia. We analysed eight following indicators:

- regional GERD used in business sector as % of GDP,
- regional GERD used in government sector as % of GDP,
- regional GERD used in higher education sector as % of GDP,
- human resources in science and technology in the region,
- share of ICT inventors in the regions,
- share of knowledge workers in the region,
- share of population with tertiary education in the region,
- number of scientific publications per inhabitant of the region,

All variables were in this section of analysis transformed to the same scale using Z-scores. We compared the regions of Slovakia and the Czech Republic separately.

Next, we focused our attention on specialisation of the regions based on the classification of employment by economic activity in EU (NUTS 2) regions. The share of employees in different sectors was used as the proxy for the specialization of regions. We decided to perform the factor analysis based on these indicators to identify potential hidden factors that could be seen as specialization of the region. We concluded there are two main factors based on this method. These factors were further used in the regression analysis as independent variables together with other variables. On the other hand, indicator capturing the labour productivity was used as dependent variable in all regression models. All variables used in regression analysis are described in more detail in Table 1.

Table 1: Description of variables used in regression analysis or comparison

Variable	Short description
Labour productivity	Wage adjusted labour productivity - defined as value added divided by personnel costs which is adjusted by the share of paid employees in the total number of persons employed, or more simply, apparent labour productivity divided by average personnel costs (the share in %).
Factor 1	Factor 1 get from the factor analysis of employment structure by type of the economic activity
Factor 2	Factor 2 get from the factor analysis of employment structure by type of the economic activity
GDP per capita	GDP per capita based on purchasing power parity (PPP). It is gross domestic product converted to international dollars using purchasing power parity rates.
Population with higher education	Population aged 25-64 with higher educational attainment (ISCED 5-8). NUTS 2 regions (%)
Scientific publications	Publications per million inhabitants. ScienceMetrix calculations, based on Scopus data
Patent applications	Number of patent applications to the EPO per million inhabitants
Motorways	Population living in surrounding regions weighted by travel time along motorways
Access to Internet	Households with access to the Internet at home (%)
Corruption	Answer on question whether corruption is a major problem in the region (% of respondents)
GERD- higher education	Gross domestic expenditure on R&D (GERD) financed by higher education (Euro per inhabitant)
GERD-total	Gross domestic expenditure on R&D (GERD) (Euro per inhabitant)
Human resources in Science and technology	Persons with tertiary education and employed in science and technology % of active population
Knowledge workers	Employment in technology and knowledge-intensive sectors (high-technology manufacturing and knowledge-intensive high-technology services) (in %)

Source: Authors based on the data from Eurostat (European Commission, 2017).

The results of regression analysis help us test correlations stated in four hypotheses as well as discuss potential causalities. Regression models have been tested for autocorrelation and data have been tested for

multicollinearity. Standard errors have been estimated with standard errors corrected for heteroscedasticity.

4. Results

Research and development activities in the regions seem to be important to acquire knowledge and technology and to develop innovation. Smart specialization of the region should be therefore aimed at increase of the intensity of research and development within the region in order to increase innovation potential. We analysed eight selected indicators related to this issue within regions in the Czech Republic and Slovakia. The performance of NUTS 2 regions of Czech Republic is shown in Figure 1. Region Prague (Praha) and region Stredni Cechy have the same values of almost all indicators. Thus, we decided to use only Prague region in this comparison. As we can see region Prague is the best performing one in five out of eight dimensions. Region Jihovýchod is the best performing region with respect to GERD used in business sector as well as in higher education sector. Region Severozápad seems to be significantly lagging behind other regions in almost every aspect except the share of ICT investors.

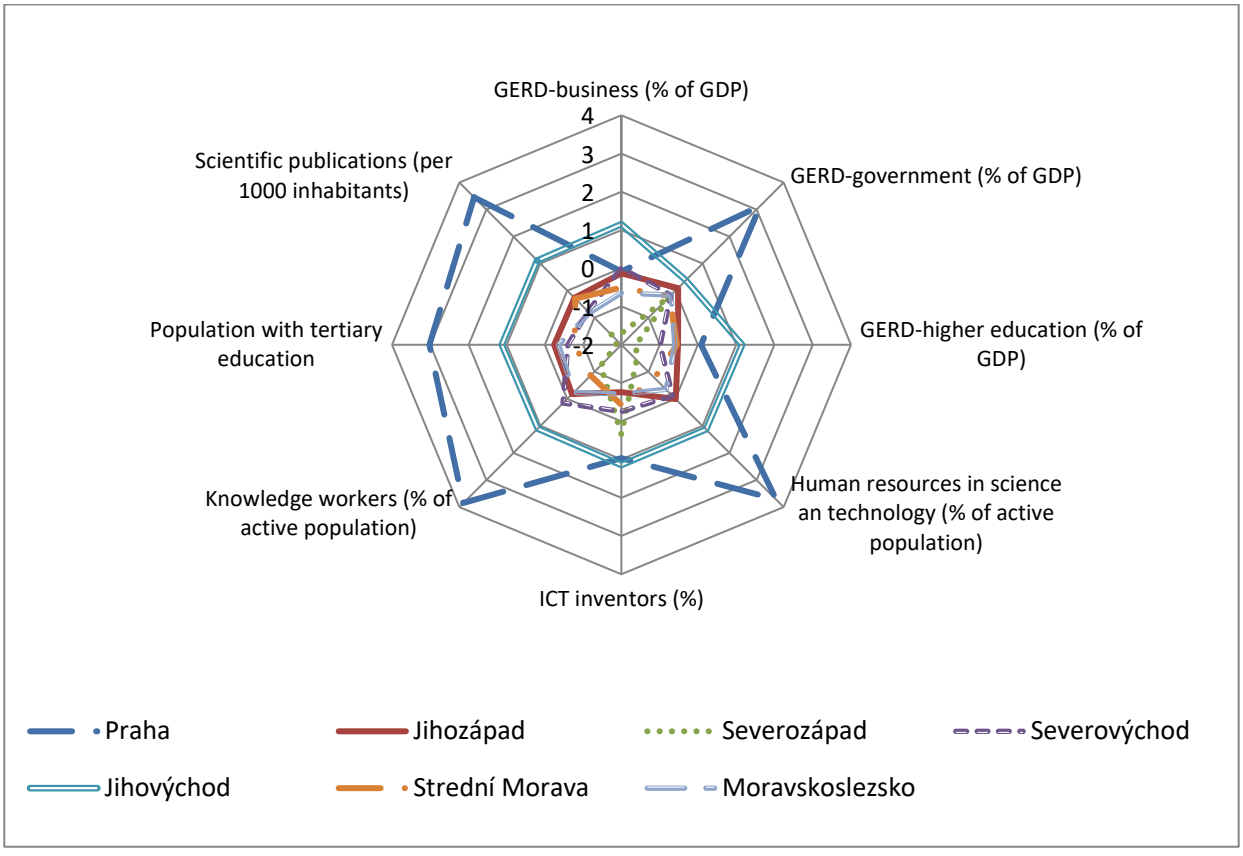

Fig. 1. Selected indicators of research and development in NUTS 2 in Czech Republic

Source: Authors based on the data from Eurostat.

Note: Values of most indicators for region Střední Čechy are the same (and are reported) as values of Prague region (Praha) in most of the indicators, thus we decided to include only Prague region in the comparison.

Next, we performed the same analysis for NUTS 2 regions in Slovakia. Results are graphically illustrated in Figure 2. Similarly as in the case of the Czech Republic, the metropolitan area of capital town is performing the best in most indicators. Bratislava region is clearly leading in six out of eight dimensions. Moreover, in this case other Slovak regions are lagging even more behind this region. The share of GERD in higher education sector as well as the share of human resources in science and technology are the only two dimensions where region Stredné Slovensko outperforms Bratislavský kraj. All three regions except Bratislavský kraj (e.g. Západné Slovensko, Stredné Slovensko and Východné Slovensko) are at very similar level in all other six dimensions. Region Západné Slovensko is relatively strong in the GERD share in the business sector and share of ICT inventors. On the other hand, region Východné Slovensko performs relatively high in the GERD share in higher education sector.

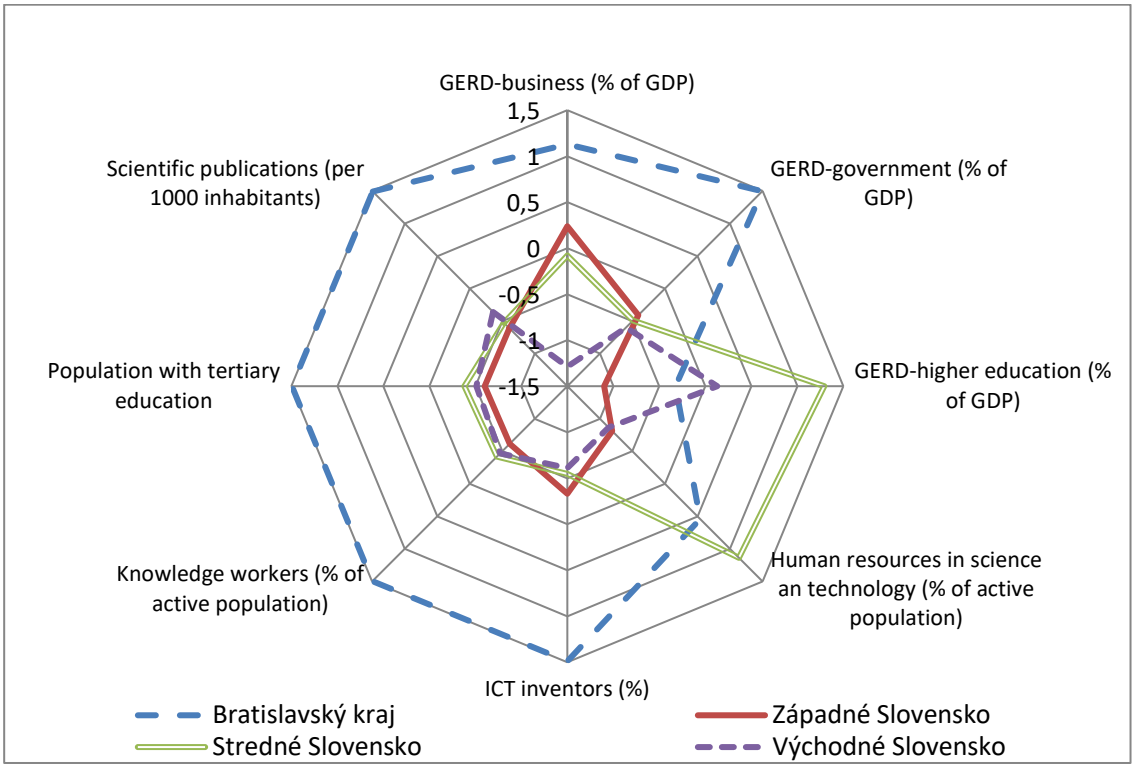

Fig. 2. Selected indicators of research and development in NUTS 2 in Slovakia

Source: Authors based on the data from Eurostat.

Expect for indicators directly related to research and development and human resources in the region there are several other indicators indirectly related to this issue. One of them is infrastructure and its quality in the region. It is factor determining the environment for R&D activities. Hence, it could be equally important for increasing labour productivity in the region. Thus, we look at this issue more closely. In our analysis we used accessibility of internet and motorways as two main proxies for quality of the infrastructure in the region. As we can see in Figure 3, the best internet infrastructure is in Prague region followed by Střední Čechy and perhaps surprisingly by Východné Slovensko.

On the other hand, Bratislavský kraj achieved the best score in the accessibility of motorways. Furthermore, the differences between regions in this indicator are much more significant than those reported in the case of internet access.

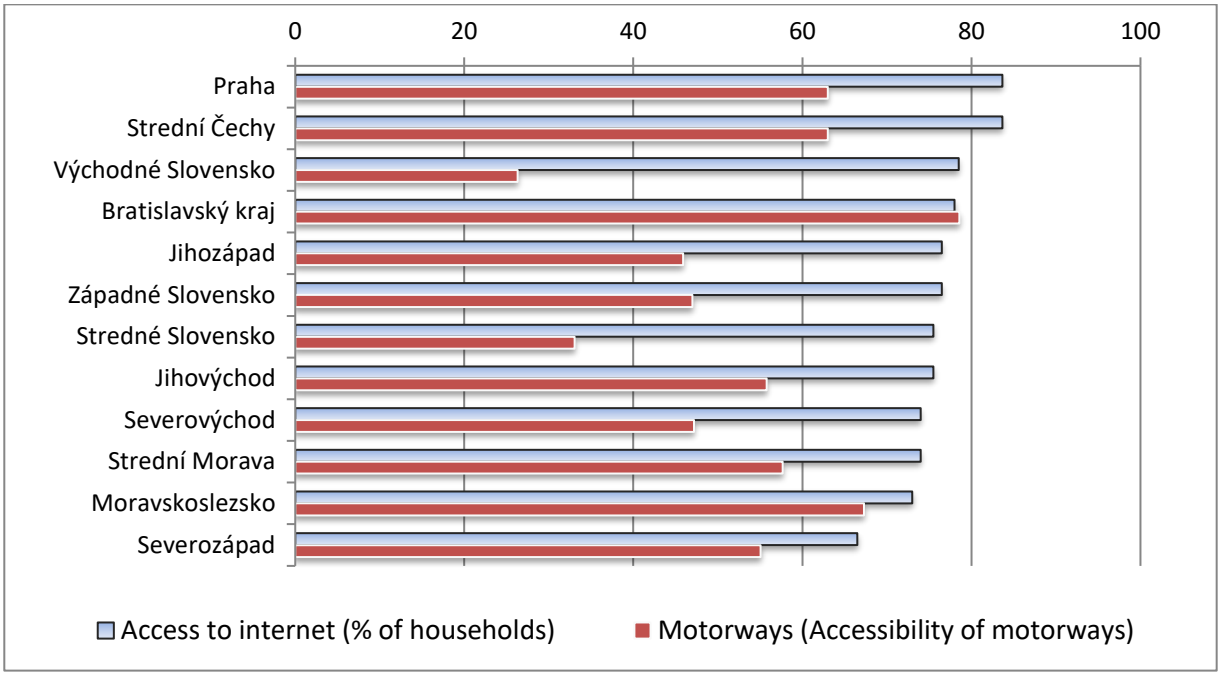

Fig 3. Proxy variables for quality of infrastructure in NUTS2 region in Czech Republic and Slovakia

Source: Authors based on the data from Eurostat.

In the next part of our analysis we focus our attention on the structure of the employment according to the different economic activities. We assume that the type of the regional specialisation could be reflected by the employment structure. We further used factor analysis, in order to reduce this information to one or two variables as well as to capture unobserved factor which in this case could mean regional specialisation.

Using the factor analysis based on the share of employment in ten different economic activities we get two main factors. These two factors have been chosen according to the eigenvalue higher than 1 as we can see in Figure 4. Both factors used together explain more than 94% of the variability of previous 10 variables as it can be seen in Table 2. First factor alone explains approximately 84% of overall variability and the second one more than 10% of overall variability.

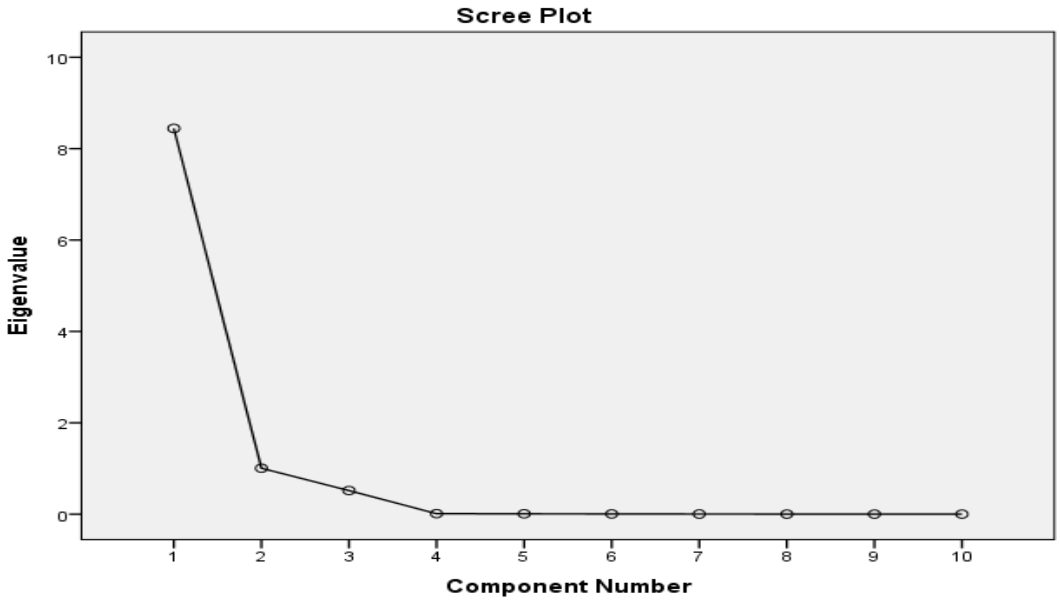

Fig. 4. Scree plot of factors from factor analysis based on eigenvalues

Source: Authors.

Table 2: Total variance explained by each factors and cumulatively

Component	**Initial Eigenvalues**		
	Total	% of Variance	Cumulative %
1	**8,443**	**84,430**	**84,430**
2	**1,006**	**10,057**	**94,487**
3	,517	5,170	99,657
4	,012	,116	99,773
5	,008	,081	99,854
6	,005	,053	99,907
7	,003	,035	99,942
8	,003	,027	99,969
9	,002	,024	99,993
10	,001	,007	100,000

Source: Authors.

Table 3 shows the results of factor analysis. We used rotated component matrix method. Factor 1 is positively correlated with employment in services and manufacturing. This could also very likely mean better

environment for further smart specialization and innovation. On the other hand, Factor 2 represents specialization of the region on agriculture. This could perhaps suggest smaller innovation potential and lower labour productivity.

Table 3: Rotated Component Matrix from factor analysis

Employment by economic activity:	**Component**	
	Factor 1	Factor 2
1. Agriculture, forestry and fishing	,001	,998
2. Mining and quarrying	,749	,087
3. Manufacturing	,991	,008
4. Wholesale and retail trade	,997	,011
5. Information and storage	,990	-,012
6. Financial and insurance activities	,991	-,030
7. Real estate activities	,988	,004
8. Professional, scientific and technical activities	,992	-,024
9. Public administration	,996	-,024
10. Art, entertainment and recreation	,994	-,024

Note: We used Factor analysis with Principal Component Analysis extraction method and Varimax rotation with Kaiser Normalization.

Both factors retrieved using the factor analysis represent the type of regional sectoral specialization. Both of them have been further used in the regression models as independent variables potentially explaining the labour productivity in the region. Hence, in general we want to examine whether regional sectoral specialization and human resources as well as research and development activities located within the region could have some positive effects on labour productivity in the region. The results of regression models are summarized in Table 4.

Table 4: Results of regression models with the labour productivity as dependent variable

	1.1	1.2	1.3	1.4	1.5
C	23.98 (0.79)				
Factor 1	4.46*** (2.93)	4.41** (2.06)			
Factor 2	-4.51** (-2.02)	-4.53** (-2.20)			
Log(GDP per capita)	4.15 (1.37)	6.50*** (14.31)	2.34 (1.2)	2.93* (1.72)	4.25*** (5.47)
Population with tertiary education	0.37** (1.99)	0.38** (2.06)	0.45*** (2.15)	0.25 (1.22)	0.73*** (3.99)
Scientific publications	0.01*** (3.69)	0.01*** (3.54)	0.01*** (3.40)	0.01** (2.44)	
Patent applications	0.03*** (3.69)	0.035*** (3.36)			
Motorways (Accessibility)	0.09*** (5.71)	0.10*** (5.76)	0.11*** (3.75)	0.10** (2.59)	0.13*** (8.60)
Access to internet			0.48* (1.80)	0.45* (1.75)	
Corruption	0.18 (0.11)	0.11 (0.07)			
GERD higher education			0.01** (2.22)		
GERD total				0.01 (1.42)	
R^2	0.53	0.53	0.44	0.47	0.44
Adjusted R^2	0.52	0.52	0.42	0.45	0.43
DW stat	1.90	1.89	2.08	1.56	1.83
Akaike crit.	8.71	8.70	8.98	9.03	8.89
Observations	261	261	173	162	265

Source: Authors.

Note: Labour productivity in the regions has been used as dependent variable in all models. Standard errors have been corrected for heteroscedasticity. (.) denotes t-statistics, */**/*** mean significance at the 10%/5%/1% levels of significance.

In regression analysis, we applied independent variables related to research and development such as Gross domestic expenditure on R&D (GERD) and the number of scientific publications and patent applications per capita. Furthermore, we used several other control variables such as GDP per capita, proxy for the quality of institutional environment (corruption) as well as proxies for quality of infrastructure. The share of tertiary educated people could be seen on one hand as the indicator related to higher education and research but on the other hand it could be also used as the proxy for human capital in the region.

Based on the results we can say that specialisation of the region on services and manufacturing is positively related to higher labour productivity. On the other hand, regions with more employees in agriculture, forestry and fishing resulted in average lower labour productivity. This result is expected and it stems from the very nature of these activities.

The results strongly suggest that especially scientific publications, patent applications and gross domestic expenditure on R&D (GERD) financed by higher education could have positive effect on labour productivity in the region. These results are complementary to findings of several previous studies (Hall et al., 2013).

With respect to our research hypothesis we can conclude that:

- We are not able to reject the null hypotheses H01 that there is a negative correlation between regional specialisation on agriculture and labour productivity in the region.
- We are not able to reject the null hypotheses H02 that there is a positive correlation between output of basic science measured by scientific publication and labour productivity in the region.
- We are not able to reject the null hypotheses H03 that there is a positive correlation between output of applied research measured by patent applications and labour productivity in the region.
- We are not able to reject the null hypotheses H04 that a positive correlation between the share of population with tertiary education and labour productivity in the region.

Inputs of research as well as outputs of the research could be seen as important part of smart specialisation. Furthermore, there is another way of how universities and higher education institutions could increase labour productivity. Higher education institutions play prominent role in increasing educational level in the region, which in turn could positively influence the labour productivity. This assumption has been supported by our results. The share of population with tertiary education seems to positively correlate with labour productivity. This variable has been significant at least at 5% level in four out of five models. Moreover, we also found relatively strong evidence that the quality of infrastructure in the region could play very important role in increasing labour productivity which is mostly in line with the results of previous studies (e.g. Bronzini, Piselli, 2009).

Conclusion

Regional specialisation on knowledge-based economy including higher share of research and development activities could be important step in order to improve regional development in the EU. Based on the theoretical background and previous research we assume that regions with more focus on research and development activities could be awarded by higher labour productivity and by higher economic growth in the long run. We have identified factors that could have positive effect on labour productivity based on the data for NUTS 2 regions in EU. We examined especially factors closely related to R&D in NUTS 2 regions of Czech Republic and Slovakia. As expected, metropolitan regions of Prague and Bratislava outperform other

regions in most indicators. However, there are still several areas where metropolitan regions lag behind some other region. In general this is especially true for the share of gross domestic expenditure on R&D used in higher education sector. Moreover, we also pointed out the differences between regions in infrastructure, which could be seen as the other important factor enabling more research activities and innovation.

Our results strongly suggest that research activities as well as appropriate infrastructure could both play important role in increasing labour productivity in the region. More scientific publications as well as more patent applications are positively correlated with higher labour productivity. The same is true for gross domestic expenditure on R&D (GERD) financed by higher education. Thus, we can say that better research performance at higher education institutions or research institutions in the region could increase labour productivity. Furthermore, higher education could have positive effect on labour productivity also by increasing the education level in the region. This assumption has been also supported by our results.

Our results could have several important implications for EU regional policy and public support of higher education and research education at national and supranational level. The support of research and development at regional level seems to be important in order to further increase labour productivity and maintain regional economic growth. Hence, universities and other higher education institutions are one of the most important subjects in these terms. The potential of these institutions for improving regional development is very high. This represents one of the main challenges for national and the EU regional development policy. However, when talking about this support it is inevitable to distinguish the regions that are performing very well in this filed, from those that are significantly lagging behind. The differences between regions seem to still be very significant.

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References

1. Al Raee, M., Ritzen, J., Crombrugghe, D de. (2017). Innovation policy & labour productivity growth: Education, research & development, government effectiveness and business policy. *MERIT Working Papers*, 019.
2. Anselin, L., Varga, A., & Acs, Z. (1997). Local geographic spillovers between university research and high technology innovations. *Journal of urban economics*, 42(3), 422-448.
3. Balog, M. et al. (2013). *Inovatívne Slovensko – východiská a výzvy*. (In Slovak) Slovenská inovačná a energetická agentúra, Bratislava.
4. Bogliacino, F., Pianta, M. (2009). The impact of innovation on labour productivity growth in European industries: Does it depend on firms’ competitiveness strategies? *Working Papers Series on Corporate R&D and Innovation*, 13.
5. Bronzini, R., Piselli, P. (2009) Determinants of long-run regional productivity with geaographic spillovers: The role of R&D, human capital and public infrastructure. *Regional Science and Urban Economics*. 2(39), 187-199.
6. European Commission,a: Research and innovation. Pushing boundaries and improving the quality of life, https://publications.europa.eu/sk/publication-detail/-/publication/ba202c94-aa5d-11e6-aab7-01aa75ed71a1/language-en, last accessed 2017/31/10.

7. European Commission,b: What is Smart Specialisation?, http://s3platform.jrc.ec.europa.eu/ what-is-smart-specialisation-, last accessed 2017/11/03.
8. Guellec, D., van Pottersberghe de la Potterie, B. (2001). R&D Productivity Growth. *OECD Economic Studies*. 2(12), 103-126,
9. Hall, B. H., Lotti, F., Mairesse, J. (2013). Evidence on the impact of R&D and ICT investments on innovation and productivity in Italian firms. *Economics of Innovation and New Technology*. 3(22), 300-328.
10. Jucevičius, R., Galkuogiene, A. (2014) Smart specialisation: towards the potential application of the concept for the local development. *Procedia – Social and Behavioral Sciences*, 156, 141-145.
11. Kendrick, J. W., Vaccara, B. N. (1980). *New Developments in Producitvity Measurement*. University of Chicago Press, Chicago.
12. Krammer, S. M. R. (2017). Science, technology, and innovation for economic competitiveness: The role of smart specialization in less-developed countries. *Technological Forecasting & Social Change*, 123, 95-107.
13. Kremer, J. F., Below, K. (2012). Innovative Capabilities and Market Performance: The European Union in International Comparison. *The Jean Monnet/Robert Schuman Paper Series*. 12 (7).
14. Martín, C., Mulas-Granados, C., Sanz, I. (2005). Spatial distribution of R&D expenditure and patent applications across EU regions and its impact on economic cohesion/Distribución espacial de los gastos en I+ D y de patentes en las regiones europeas y su impacto en la cohesión económica. *Investigaciones regionales*, 41(6), 41-61.
15. McCann, P., Ortega-Argilés, R. (2013). Transforming European regional policy: a results-driven agenda and smart specialization. *Oxford Review of Economic Policy*, 29(2), 405-431.
16. Wei, S. H., Wu, G. S. (2008). An empirical study on spatial distribution and its changing trends of regional R&D expenditure in China. *R&D Management*, 13(1).
17. Zachariadis, M. (2003). R&D Innovation and technological progress: A test of Schumpeterian framework without scale effects. *Canadian Journal of Economics* 36, 566-86.
18. Zhong, W., Yuan, W., Li, S. X., Huang, Z. (2011). The performance evaluation of regional R&D investments in China: An application of DEA based on the first official China economic census data. *Omega*, 39(4), 447-455.