ENTREPRENEURSHIP AND SUSTAINABILITY ISSUES
ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

Publisher
http://jssidoi.org/esc/home

UNIVERSITY GRADUATES, KNOWLEDGE SPILL-OVERS AND LOCALIZATION OF KNOWLEDGE INTENSIVE VENTURES - CASE OF POST-SOCIALISTIC COUNTRY *

Michal Hrivnák[1], Katarína Melichová[2], Mária Fáziková[3], Oľga Roháčiková[4]

[1,3] Slovak University of Agriculture, Faculty of European Studies and Regional Development, Department of Regional And Rural Development, Trieda Andreja Hlinku 2, 949 76 Nitra, Slovakia

[2,4] Slovak University of Agriculture, Faculty of European Studies and Regional Development, Department of Public Administration, Trieda Andreja Hlinku 2, 949 76 Nitra, Slovakia

E-mails: michal.hrivnak@hotmail.com [1], katarina.melichova@uniag.sk [2], maria.fazikova@uniag.sk [3], olga.rohacikova@uniag.sk [4]

Received 14 April 2019; accepted 20 June 2019; published 30 September 2019

Abstract. This paper investigates how universities affect formation of new knowledge intensive ventures in conditions of post-socialistic country of Eastern Europe, depending on character of university spill-overs. Using tools of spatial econometry, we investigate how graduates rollout by universities and knowledge spill-overs on basis of interpersonal relationships between entrepreneurs and senior academic researchers determines emergence of knowledge intensive ventures in Slovakia, while we distinguish between total number of knowledge intensive firms (KIF), knowledge intensive manufacturing ventures (KIM), knowledge intensive business services (KIBS) and knowledge intensive services (KIS). Our estimates of spatial Durbin models indicate that even in conditions of country that lacks universities carrying out top-excellent research, university spill-overs affects formation of knowledge intensive ventures, but only in case of services, while spill-overs in form of graduate rollout are significantly localized.

Keywords: university; graduates; knowledge spill-overs; knowledge intensive entrepreneurship

Reference to this paper should be made as follows: Hrivnak, M.; Melichova, K.; Fazikova, M.; Rohacikova, O. 2019. University graduates, knowledge spill-overs and localization of knowledge intensive ventures - case of post-socialistic country, *Entrepreneurship and Sustainability Issues* 7(1): 146-165. http://doi.org/10.9770/jesi.2019.7.1(12)

JEL Classifications: I23, M13, J24

* *This research was funded by project of Agency for the Support of Research and Development in Slovakia, APVV-14-0512 "Universities and economic development of the regions".*

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

1. Introduction

The attempts to describe the trajectories, or the spatial "range" of academic knowledge spill-overs led to a passionate scientific debate in economy, economic geography and regional science (Melichová et.al. 2017; Kowalska, 2016; Raudeliuniene et al. 2018) Universities have been first time investigated as a determinant of localization of high-tech industries using regression tools by Markusen et al. (1986). In their cross-sectional OLS regression with data for 264 metropolitan statistical areas (MSAs) in the United States, they included public research funding to universities as a control variable. However, this factor did not appear to be significant in relation to the distribution of high-tech companies in the US. Later, using panel data on county level in U.S., Woodward et al. (2006) vice versa found a significant and positive effect of university R&D expenses on localization of high-tech plants. Certain evidence of academic impacts was brought by Glasmaier (1991), which studied the spatial distribution of high-tech factories both in municipalities and their surrounding rural regions in US. He found that universities mainly attract educated labor force for high-tech firms and therefore can be considered as a significant factor for the location of high-tech plants, but only on local level. Florax and Folmer (1992) directly oriented their investigation on academic knowledge effects, as previous papers considered local or regional stock of academic knowledge only as a control variable. University knowledge effects were captured by two proxies – one measuring the contagious distribution of knowledge, second expressing hierarchical knowledge in space. Their results suggest only small positive impact of hierarchical knowledge distribution, also only for manufacturing equipment industry.

Using regional availability of researchers as an academic proxy, Audretsch and Stephan (2007) have demonstrated a strong positive relationship between localization of academic scientists and the location decisions of enterprises from biotechnology sector. They have further shown that in close spatial proximity of universities are localized mainly enterprises, in which academic scientists act as founders, co-founders, and members of various advisory committees. Likelihood that the biotechnology company locates near the university is also significantly increased, if university employs Nobel Prize winners. Audretsch and Keilbach (2007) also proxied university knowledge impact on emergence of new high-tech firms by the share of researchers on the total population in the region. Results of their empirical model based on data about emergence of new firms in 440 German LAU1 regions suggest that academic research and development intensity in a region positively influence (Zeibote et al. 2019) emergence of new high-tech ventures. They found no impact of academic research on low-tech firms and on total number of firms. The study of Hunady et al. (2018) or Mura et al. (2017) shows that universities can also support success of emerging start-ups. Acs, Arminghton and Zhang (2006) were interested whether the access to the spill-overs of university knowledge can be considered as prerequisite for the survival of new high-tech ventures. They found a positive impact of university graduates drop-out rate on survival of high-tech ventures in US 3 years after establishment. Baptista and Mendonça (2010) measured impact of university presence in a region, structure of students and graduates enrollment on emergence of new KIFs in Portugal. They found that both academic knowledge proxies explain dynamics of knowledge intensive manufacturing and also knowledge intensive services emergence. Furthermore, when shares of students and graduates in social sciences and engineering were taken into account, their results suggest that academic impact on new knowledge intensive manufacturing is to a large extent explained by students and graduates of specific technological study programs, while the effect of students and graduates in different academic fields is not significantly altered in case of knowledge intensive services.

The above-mentioned studies have focused on investigation of academic knowledge impacts on knowledge intensive entrepreneurship, either in tacit or codified form. Acosta et al. (2011) simultaneously evaluate impacts of tacit (graduates) and explicit (patents, publications) knowledge produced by universities on new business

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

formation in high-tech industries in Spain. However, only production of high-quality human capital by universities appears to be academic factor explaining emergence of high-tech start-ups in Spain. Similar approach took Bonacorsi et al. (2014) in their spatial analysis, but in addition to distinguishing the tacit and explicit knowledge of universities, they also assessed the impact of the quality of universities on the number of knowledge intensive start-ups. Using data on NUTS III regions in Italy, they proved positive impact of both tacit and codified knowledge of high-quality universities, however only knowledge protected by intellectual property rights is capable to cross regional boundaries. Authors found no effects of both tacit and codified knowledge in case of universities of lower quality. Fritsch Aamoucke (2013) worked with dataset containing information on new start-ups in Germany between 1995-2008. This data allowed them to distinguish start-ups in high-technology manufacturing industries, technologically advanced manufacturing industries and technology-oriented services. The impact of universities was measured by the number of universities, number of professors, number of students, PhD students and the volume of external funding sources. Firstly, results differ according to character of research in scientific discipline (basic vs. applied). Another finding was that the spatial proximity of new start-ups to universities appears to be more influenced by number of professors at universities in comparison with the number of students or graduates, what means that tacit knowledge of universities is also necessary to differentiate – on knowledge embodied in founder and access to expertise of research staff. The results also suggest that with increasing spending on research and development in these start-ups, impact of academic spill-overs grows. Calcagnini et al. (2014) based their quantile regression on the assumption of a decreasing distance between the newly created start-ups and the university in dependence of graduates' enrollment, the quality of universities in the region, and their "third mission" activities. Using data about 1978 knowledge-intensive start-ups in Italy between 2004-2010, they proved not only positive impact of academic knowledge on startup localization close to university, but also that localization decision of knowledge intensive firms depends on their interest in tacit or explicit knowledge and available knowledge transfer channels. The most positive academic impact was recorded in case of graduates enrollment, especially in social sciences, while from individual transfer activities of university, only production of spin-off companies explain localization pattern of new knowledge intensive start-ups.

From university impact studies on local level, it is fitting to mention contribution of Korosteleva and Belitsky (2013), even if they focused on small businesses in general. Their empirical model was based on data of 98 cities in 7 post-socialist economies in transition. They demonstrated the positive impact of localization of the university in the city, its graduate production and also production of MBA graduates on the dynamics of emergence small businesses in conditions of local economies of post-socialistic countries. We also choose to mention another contribution outside of US and Western Europe. Nagy (2016) and Fischer et al. (2018) assessed the gravitational effects of universities on knowledge intensive investments in Brazil. Author also evaluates impact of university knowledge on development of international networks in the region. Using data at 645 municipalities and 43 microregions in the state of San Paulo, Brazil, they investigated academic knowledge impact measured by the graduates' enrollment and the presence of high-quality universities in region on knowledge intensive investments, and knowledge intensive investments of multinational firms. It is also another study distinguishing knowledge-intensive production and services. However, the results of the analysis suggest that there is practically no statistically significant or positive effect of universities on the emergence of both knowledge intensive manufacturing and services in Brazil. These investments being conducted under the conditions of the surveyed country rather than traditional factors of urbanization, agglomeration effects or infrastructure. These investments appear to be influenced in conditions of Brazil only by the traditional factors of urbanization, agglomeration effects, or infrastructure.

In our paper, we will focus on university impacts on spatial patterns of knowledge intensive entrepreneurship. Instead of assessing the dynamics of KIF's formation from perspective of founder, firm or industry specific factors, our attention will be drawn to regional differences (Haviernikova, 2018; Tvaronavičienė, Razminiene, 2017; Jaskova, Haviernikova, 2016; Prakash, Garg, 2019; Pavolová et al., 2019; Girdzijauskaite et al., 2019)

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

affecting successful application of innovative ideas – especially to stock of regional academic knowledge capital. To discuss chosen approach to investigation of the issue, firstly we added relevance to our work by attempt to answer the question whether we can observe knowledge spill-overs and impact of lower-quality universities (only 2 universities ranked in SCIMAGO top 500 in 2018) on knowledge intensive businesses formation in conditions of post-socialistic country. We consider as more conductive to investigate the aforementioned university impact on knowledge intensive entrepreneurship than incumbent firms (Kowalska, 2016), as there is assumption that KIFs produce more innovative products and services (Wierzbicka, 2018; Tvaronavičienė, 2017; Zauskova, Grib, 2016; Dubravska, Sira, 2014.) and have a higher potential to generate employment growth in the medium and long term (Mura et. al, 2017; Obisi and Aliyu, 2018). Secondly, we also choose to investigate spatial patterns of emergence of knowledge intensive firms on spatial level of LAU1 regions in Slovakia, using tools of spatial econometrics to test the effects of external academic knowledge on emergence of knowledge intensive firms. We choose to measure academic impacts only trough carriers of tacit knowledge (Abramovsky et al., 2007; Audretsch and Stephan, 1996), as we cannot suggest that explicit knowledge basically measured by number of academic patents can influence formation of KIFs in Slovakia, as there is very low patenting activity of Slovak universities (Duľová et al. 2017).

2. Material and methods

According to arguments discussed in previous section, we hypothesize that formation of new knowledge intensive ventures can be affected by universities primarily through graduates rollout and knowledge spillovers. In order to investigate these relationships, we constructed dataset that contains observations on variables obtained from several sources (Tab 1) for period of 11 years between 2006-2016, on the LAU 1 spatial level. We identified new knowledge intensive ventures in Slovakia using dataset ELIS (Register of business entities in Slovak republic), by filtering the newly established KIF's according to NACE classification. Eurostat's aggregation of knowledge intensive industries (2014) based on NACE rev.2 (Appendix) allowed us to further distinguish between knowledge intensive firms, knowledge intensive manufacturing, knowledge intensive services and more specifically knowledge intensive business services and thus get more detailed information about university knowledge impacts on these knowledge intensive activities in regions. However, we can still assume that such aggregation can be "fuzzy" to some extent, as these companies cannot be automatically considered to be innovative just for its affiliation to certain knowledge intensive industry (Madrak-Grochowska, 2015). Data on academic graduates were obtained from Centre of Scientific and Technological Information of Slovak Republic (CVTI), that regularly disclose data on basic indicators of higher-education.

Academic spill-overs from universities will be measured by number of senior researchers (professors and associated professors). The main argument for this approach is that majority of Slovak universities are still only at the beginning of the process of building the institutional environment for knowledge transfer into market. Similarly as in all V4 countries (Kondratiuk-Nierodzińska, 2016; Horváth and Hollósy, 2018; Horecký, 2018), dynamics of protection of IP rights to produced technologies is in Slovak conditions very low. Thus, majority of contacts between entrepreneurs and universities are facilitated on the level of interpersonal linkages - both of formal and informal character.

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

Table 1. Variables used in empirical analysis

variable	definition	source
graduates	number of university graduates$_{it}$	CVTI SR
professors	number of professors and associated professors$_{it}$	CVTI SR
kif	number of knowledge intensive firms$_{it}$	ELIS
kim	number of knowledge intensive manufacturing firms$_{it}$	ELIS
kibs	number of knowledge intensive business services$_{it}$	ELIS
kis	number of knowledge intensive services$_{it}$	ELIS
large firms	number of firms with more than 250 employees$_{it}$	ELIS
innovations	number of patents and utility pattern in private sector$_{it}$	ÚPVSR
incubators	number of business incubators$_{it}$	SBA
population	number of residents$_{it}$	ŠÚSR
unemployment	% of unemployed population$_{it}$	ŠÚSR
avg. wage	average wage$_{it}$	ŠÚSR

Source: own processing

We decided to carry out our analysis on LAU 1 spatial level. Main argument for our choice of spatial aggregation lies in fact that there are only 8 NUTS III regions in Slovak Republic and 79 LAU1 regions, what makes LAU1 region on the first hand appropriate spatial level for statistical analysis, but on the other hand, there is also logical assumption that in country with such a small area, backwash and spreading effects can be better explained at LAU 1 spatial level. It also should be added that we integrate 5 districts of capital city Bratislava, and 4 districts of second biggest city Košice into one, as certain data are available only for these aggregated districts. We formulate following research hypothesizes:

- **(H1)** Both graduate enrollment by universities and knowledge spill-overs measured by availability of senior researchers have statistically significant and positive effect on formation of KIFs in Slovak LAU 1 regions and statistically significant and negative effect on formation of KIFs in neighboring regions (backwash effects).

- **(H2)** Both graduate enrollment by universities and knowledge spill-overs from universities expressed as availability of senior academic researchers have statically significant and positive effect on formation of the new KIM firms in LAU 1 regions of universities localization and statistically significant and negative effects on KIM firms in neighboring regions

- **(H3)** Both graduate enrollment by universities and knowledge spill-overs from universities expressed as availability of senior academic researchers have statically significant and positive effect on formation of the new KIBS in LAU 1 regions of universities localization and statistically significant and negative effects on KIM firms in neighboring regions

- **(H4)** Both graduate enrollment by universities and knowledge spill-overs from universities expressed as availability of senior academic researchers have statically significant and positive effect on formation of the new KIS in LAU 1 regions of universities localization and statistically significant and negative effects on KIM firms in neighboring regions

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

We will construct overall 8 models, which differ in two observed academic independent variables - number of graduates and number of senior academic researchers in region, and in four different dependent variables – number of newly established KIF, KIM, KIBS and KIS. We also include into our models several control variables that account for factors that affect new KIF creation, other than those related to university knowledge. Firstly, we need to note, that data for lot of indicators that are standardly used to explain localization patterns of KIF's are not collected in conditions of Slovak Republic. However, as we discussed in section 2, we want to control for number of large enterprises in regions, as there is precondition that knowledge intensive ventures locate near large firms to provide technologies and services for them. We consider to be suitable to measure knowledge spill-overs from private sector by innovations (Kendiukhov, Tvaronaviciene, 2017; Potkany et al. 2018) that were produced by private enterprises in individual regions (Prokopenko et al. 2018; Simo et al. 2016), and so we include variable "innovations" that was created using database of Industrial Property Office of Slovak Republic. This database was used to calculate sum of number of patents and utility patterns of private sector ventures for each Slovak LAU1 regions. We decided to integrate patents with utility patterns, as utility patterns protect new industrially applicable technical solutions resulting from inventive activities, thus can be also considered as innovations. Further we constructed dummy variable for presence of business incubators in region, as there are only 22 business incubators altogether in Slovak Republic, but each of them can have certain impact on formation of KIF's. We use indicator population, expressed as number of inhabitants with permanent residence in regions to control for attractiveness of regions both for living and for establishment of business. Level of unemployment in regions will serve to control for option, that unemployed people with university degree often tend to establish business, mainly in situation, when they cannot find job in their field of study on regional labor markets and also for option of proposition of labor supply by KIF's. Finally, average wage will be used to control for cost effects on the side of enterprises, as there are no other cost-related data publicly available in Slovak conditions. We also control for effect of total number of KIBS in region on emergence of new KIM ventures and vice versa, to check for colocalization of these firms.

$$y = \rho W_1 y + \beta_0 + X\beta_1 + W_1 X\beta_2 + \varepsilon \quad (1)$$

or:

$$y_i = \rho \sum_{i=1}^{n} w_{ij} y_j + \beta_0 + \sum_{k=1}^{l} \beta_{1k} x_{ki} + \sum_{k=1}^{l} \beta_{2k} \sum_{j=1}^{n} \beta_{2k} w_{ij} x_{kj} + \varepsilon_i \quad (2)$$

where:
y = vector of dependent variable (n×1)
X = matrix of independent variable (n× (k+1))
B = vector of regression coefficient parameter ((k+1) ×1)
ρ = spatial lag coefficient parameter on dependent variable
n = number of observations or locations (i= 1,2,3,...,n)
k= number of independent variables (k = 1,2,3,...,l)

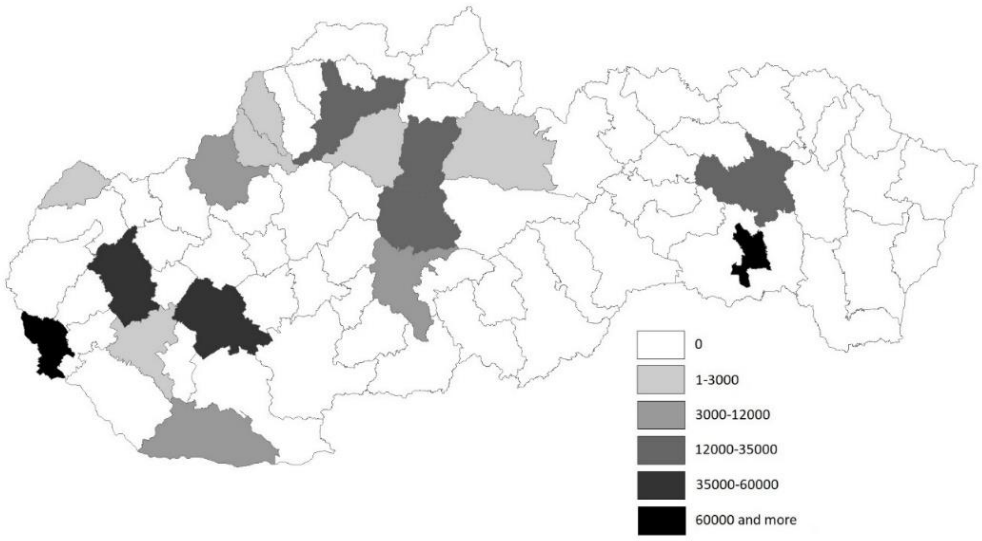
We will focus on relationship between our dependent variables in given region and our dependent variables in given region and independent variables in neighboring regions, thus we use weight matrix based on continuity approach, more exactly queen continuity of 1st order (either common border or vertex).

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

3. Results and discussion

In 2016, there were 36 universities, or high-schools in Slovak Republic, out of which 20 were public, 15 private and 3 were state universities. Nine of the Slovak universities are allocated in cities that are seats of the district, but not the NUTS III region and also many faculties of universities are also allocated in these smaller cities, what gives rationale to work on this spatial level LAU1. Saying that, it still should be noted that 14 of 36 universities are allocated in capital city Bratislava, as can be also observed on map 1, where we can see that university graduates concentrate mainly in Bratislava, second biggest Slovak city Košice that is center of eastern Slovakia and in several other cities that are centers of NUTS III regions – Trnava, Nitra, Trenčín Banská Bystrica, Žilina and Prešov.

On the national level, we can observe that number of graduates was growing between 2006 and 2010, when reached maximum and since 2011 we observe decrease of graduates rollout caused most probably by demographical changes and increased share of Slovak students that choose to rather study abroad (Table 2). Having still smaller number of students, number of professors was growing until 2015. We suppose this trend can be related mainly to the ongoing process of generation exchange and the growing need for associated professors and professors for conducting research projects, which can be considered as the most important supplement, extra-budgetary income of faculties of Slovak universities. Many professors also teach on several Slovak universities at once, thus are calculated several time in statistics. Map 1 displays concentration of graduates in 16 regions, where universities are allocated. As we can see, majority of graduates are produced mainly in regions of western and northern Slovakia.



Map 1. Spatial distribution of all graduates produced by Slovak universities between 2006 and 2016.

Source: own processing

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

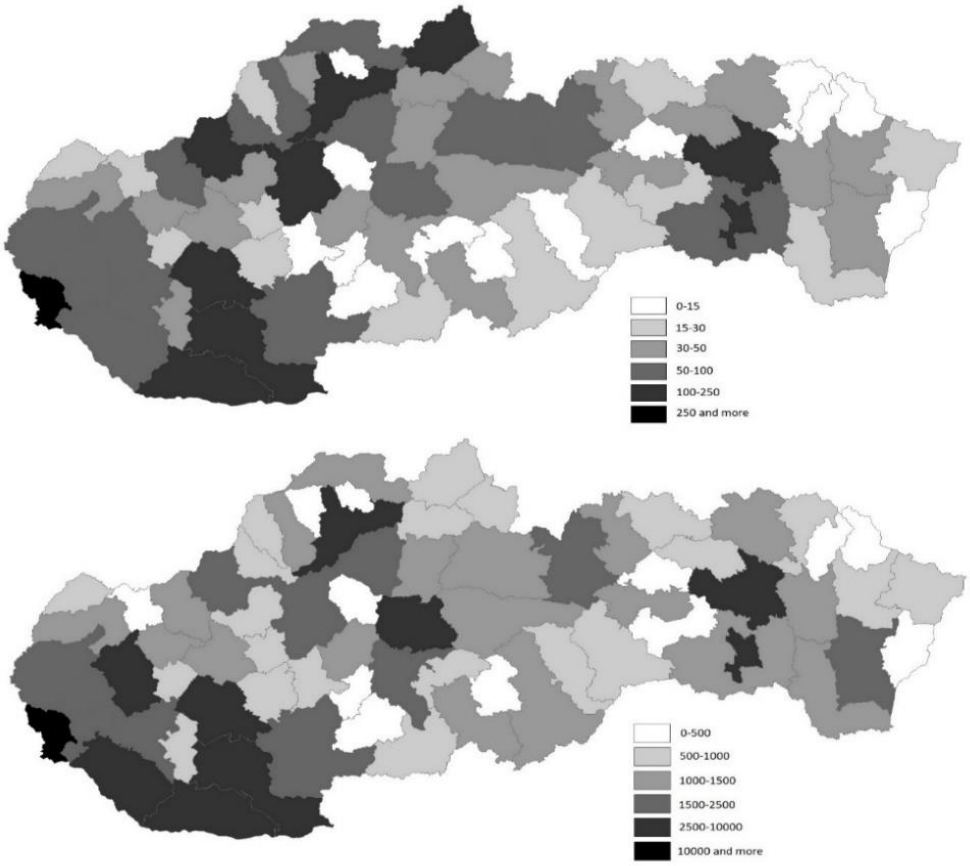
The number of newly created knowledge intensive ventures, both manufacturing companies and service ones, fluctuated significantly during 2006-2016. As shown in Table 2, significant differences in total number of created knowledge intensive firms can be observed particularly after 2011. Both new knowledge intensive manufacturing and service start-ups reached highest value in 2012. It is hard to hypothesize which factors could have affected the extreme increase of the values in this year as there has been no major legal changes affecting business environment in previous year, nor in 2011. This fact is greatly in contrast with values in 2015, as we can say that in given year Slovak Republic has already had a stable economic growth for several years.

Table 2. Total number of university graduates and senior researchers between 2006-2016, number of new knowledge intensive manufacturing firms a knowledge intensive services between 2006-2016.

year	graduates	professors	new KIM	new KIS
2006	21105	3710	390	10818
2007	24433	3497	484	10230
2008	35400	3587	473	11107
2009	42508	3905	276	9688
2010	43872	3852	338	12104
2011	42653	3915	351	12226
2012	42056	4044	828	26558
2013	40699	4061	348	11964
2014	39953	4156	234	8219
2015	38271	4240	87	3594
2016	36427	4166	224	7697

Source: own processing

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)



Map 2. and **Map 3**. Spatial distribution of new KIMs and KISs established between 2006-2016

Source: own processing

As shown on Map 2 and Map 3, we can observe spatial concentration of both knowledge intensive manufacturing ventures and services in Bratislava and Košice regions and lack of knowledge intensive activities mainly in regions that are considered to be less developed. Except for mentioned regions, where two Slovak major cities are allocated, we cannot observe significant patterns of concentration of both knowledge intensive manufacturing and services. In case of knowledge intensive manufacturing we can observe that there is more significant increase in amount of these firms in regions of western and northern Slovakia in comparison with eastern part of the country, what is connected with industrial tradition in this regions, higher share of educated human capital, availability of highways and transport connection with capital city and other factors. We can also observe on Map 2 and Map 3 certain patterns of colocalization of knowledge intensive manufacturing and services, however, it is possible to notice that emerging knowledge intensive services appears to be slightly more dispersed in space, what is consistent with the logical assumption, as that the provision of services is less capital intensive compared to manufacturing.

We will move towards interpretation of results of our analysis. First of all, we need to note that our analysis was performed in Stata software. We first run basic ordinary least squares regressions and panel regressions with fixed and random effects (Mura et al. 2018) to check for spatial dependencies, basic problems and to decide between fixed and random effects for spatial approach. Based on statistically significant Lagrange multipliers and Robust

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

Lagrange multipliers in spatial diagnostics we consider propriate to investigate spatial effects. We used Hausman test to choose between model with fixed and random effects. Results suggest using models with fixed effects.

Table 3. Results of SDM with fixed effects using start-ups of knowledge intensive firms as dependent variable

Variable	**Model I.** coefficient	spatial lag	**Model II.** coefficient	spatial lag
graduates	0,451*	-0,012**		
	(0,023)	(0,010)		
professors			-5,777***	1,529***
			(0,680)	(0,330)
kim				
kibs				
large firms	-8,306	3,884	-36,053***	10,499***
	(5,519)	(2,543)	(5,606)	(2,515)
Innovations	-12,387**	4,033*	-4,866	2,471
	(4,363)	(2,001)	(4,129)	(1,897)
Incubators	29,574	-11,678	-5,856	2,818
	(92,428)	(40,478)	(87,119)	(38,108)
Population	-0,017***	0,006**	-0,016***	0,005**
	(0,005)	(0,002)	(0,004)	(0,002)
Unemployment	-8,699	-0,286	-6,158	-0,970
	(5,129)	(1,132)	(4,838)	(1,034)
avg. Wage	-0,484**	0,119***	-0,414**	0,092**
	(0,159)	(0,033)	(0,151)	(0,032)
Number of observations	792	792	792	792
Spatial Rho	0,3035***		0,3034**	
R-sq:				
Within	0.0069		0.0443	
Between	0.6919		0,7551	
Overall	0.5045		0,5560	

** statistical significance on levels: p<0.05, ** p<0.01, *** p<0.001; standard errors in brackets.*

Source: own processing

Results of spatial Durbin models presented in Table 3 shows that graduate rollout positively affects formation of new knowledge intensive firms in Slovak Republic, while we also found no spreading, but backwash effects of graduates on new KIFs emergence in neighboring regions in line with hypothesis H1. Thus, we can suggest that university graduates tend to rather start business in regions, where their former university was allocated, even if they have not residence in that region. Considering results for knowledge spill-overs from university measured by number of professors, we find no support for H1 hypothesis, as coefficient of professors took negative value. On the other hand, there is positive spatially lagged coefficient of variable professors, what can be explained by longer spatial range of knowledge spill-overs from universities in conditions of country small as Slovak republic.
As universities are in conditions of our country localized mainly in bigger municipalities that are also centers of NUTS III regions, we can speculate that KIFs in those regions have better access to spill-overs from private sector, oftentimes own research and development capacities, or those firms can benefit from more qualified and

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

skilled human capital. It is worth noting that there is also higher share of foreign firms in regions with university cities, which are mostly subsidiaries of large foreign firms that invest to research out of Slovakia.

Among the controls, we observe that new knowledge intensive ventures tend not to locate around concentrations of large enterprises, but rather in surrounding regions. We can observe this spreading effect mainly around capital city Bratislava (there is currently noticeable process of dislocation of economic activities to surrounding districts of Senec, Pezinok and Malacky due to the high real estate costs) and another regional centers. This is also connected with results for indicator innovations, as knowledge intensive ventures locate around regions, where private research and development results concentrate, what is in contrast with development in wester European countries, where the progressing concentration of knowledge-intensive activities leads to the emergence of knowledge-hub regions (could be caused by low level of spatial aggregation of data). In Slovak conditions is this link explicable particularly due to the fact that legally protected innovations are predominantly produced by large companies. Business incubators appears to have no influence on knowledge intensive activities. This result need further investigation, but we can suggest that even in condition of country like Slovakia, current network of incubators can be considered as small (only 20 incubators, mostly in large cities) and insufficient to deliver real impact on knowledge intensive activities, or need to be more oriented on support for knowledge intensive activities, instead of less-knowledge intensive start-ups. We also get another strong evidence that the process of deconcentration of knowledge intensive activities from larger cities take place in Slovakia, as coefficient for population gained negative value, and lagged coefficient positive value.

Hence, we suppose that founders of knowledge intensive ventures tend to move to smaller cities to reduce costs of living and running business. In contrary with basic regression models, we found no support for assumption that unemployed people tend to run knowledge intensive business. We have come to this assumption, because there is relatively high level of unemployed university graduates in Slovak Republic in comparison with western countries. Finally, knowledge intensive ventures in Slovakia tend to rather choose location around regions with higher level of average wage, thus we found certain evidence that even in case of such businesses, it is still required to minimize costs in Slovak conditions. These explanations are still not enough decisive for us, as breakdown of KIF to KIM, KIBS and KIS is required due to relatively high share of knowledge intensive services on total numbers of knowledge intensive firms.

Now, we will turn our attention to the interpretation of results of models with dependent variable number of newly emerged knowledge intensive manufacturing ventures as presented in Table 4. Both coefficients for graduates in case of new KIM firms reveal that graduates practically affect only formation of knowledge intensive services. Naturally, there can be no expectation of founding manufacturing ventures by academic graduates soon after studies, but we were also interested to check whether KIM ventures do not locate close to universities to get access to potential high-quality employees. Hence, we failed to meet first part of conditions in hypothesis H2. We cannot check for effect of full regional stock of high-quality human capital, as data for total numbers, or proportion of population with tertiary degree is collected in Slovakia only for ten year census. However, we fail to find support for hypothesis H2 also as we found no evidence of impact of knowledge spill-overs from universities on emergence of new knowledge intensive manufacturing ventures in both regions where universities are allocated and neighboring regions. This means that localization of such manufacturing ventures in Slovak conditions is still led by more by traditional factors, or private knowledge spill-overs, as there is also detected the positive impact of private innovations on their location decisions, but only from surrounding regions. Thus, we proved that KIM firms tend to locate in regions that neighbor with those with high level of private research concentration. Further, we found in both models with dependent variable knowledge intensive manufacturing (Table 4) and knowledge intensive business services (Table 5) relatively strong evidence of colocalization patterns of these firms.

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

Table 4. Results of SDM with fixed effects using start-ups knowledge intensive manufacturing as dependent variable

Variable		**Model I.**		**Model II.**	
		coefficient	spatial lag	coefficient	spatial lag
graduates		-0,001*	0,001		
		(0,000)	(0,000)		
professors				-0,015	0,004
				(0,014)	(0,007)
kim					
kibs		0,023***	-0,009***	0,022	-0,009
		(0,001)	(0,000)	(0,001)	(0,000)
large firms		-0,150	-0,034	-0,155	-0,041
		(0,104)	(0,048)	(0,116)	(0,051)
innovations		0,067	-0,023	0,048	-0,021
		(0,083)	(0,038)	(0,083)	(0,038)
incubators		-3,013	0,722	-2,823	0,706
		(1,739)	(0,762)	(1,742)	(0,762)
population		0,000	0,001	0,001	0,001
		(0,000)	(0,000)	(0,000)	(0,000)
unemployment		0,009	0,011	0,028	0,012
		(0,097)	(0,022)	(0,097)	(0,021)
avg. wage		-0,018***	0,004***	-0,018	0,004
		(0,003)	(0,001)	(0,003)	(0,001)
Number of observations		792	792	792	792
Spatial Rho		0,3034**		0,3034*	
R-sq:					
	within	0,1386		0,1387	
	between	0,0020		0,0067	
	overall	0,0000		0,0011	

** statistical significance on levels: p<0.05, ** p<0.01, *** p<0.001; standard errors in brackets.*

Source: own processing

There are observable backwash effects on both kinds of enterprises on each other – manufacturing tend to locate in regions with high availability of knowledge intensive business service and vice versa. In contrary with results for KIFs in total, we find no colocalization patterns of knowledge intensive manufacturing with large enterprises in general. However, it is also desirable to note, that that on non-panel ordinary least squares regression we identified relatively higher, but still acceptable level of multicolinearity between KIMs and large enterprises, as there is logical assumption that significant share of knowledge intensive manufacturing firms employ more than 250 employees in Slovak condition. After interpretation of indicator incubators for previous models, we consider to be logical that there is no statistically significant relationship between KIM firms and availability of incubators in Slovak regions. We also find no effect of agglomeration effects measured by number of inhabitants per region in case of manufacturing, what suggest that emergence of these kind of knowledge intensive firms is less sensitive to availability of large cities in comparison with services. We would expect that certain impact of unemployment can occur in case of knowledge intensive manufacturing ventures, as we already know that significant share of these enterprises can be considered as large from employment point of view, but both coefficients are not statistically significant. Again, we find evidence that also knowledge intensive manufacturing ventures allocates

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

around regions with high level of average wage, but get statistically significant coefficients only for model controlling for number of graduates, nor knowledge spill-overs trough professors.

Table 5. Results of SDM with fixed effects using knowledge intensive business services as dependent variable

Variable	**Model I.**		**Model II.**	
	coefficient	spatial lag	coefficient	spatial lag
graduates	0,058***	-0,017***		
	(0,012)	(0,005)		
professors			-1,740***	0,312
			(0,386)	(0,187)
kim	19,679***	-5,512***	19,075***	-5,414***
	(0,843)	(0,276)	(0,867)	(0,284)
kibs				
large firms	-0,393	1,829	-12,381***	4,425**
	(2,885)	(1,324)	(3,176)	(1,403)
innovations	-7,521***	1,932	-4,015	1,367
	(2,278)	(1,049)	(2,289)	(1,056)
incubators	63,826	-21,420	41,778	-13,810
	(48,152)	(21,128)	(48,328)	(21,173)
population	-0,008**	0,002	-0,008***	0,002
	(0,002)	(0,001)	(0,002)	(0,001)
unemployment	-3,284	0,022	-3,502	-0,104
	(2,671)	(0,596)	(2,681)	(0,582)
avg. wage	0,223**	-0,055**	0,246**	-0,062***
	(0,085)	(0,012)	(0,085)	(0,018)
Number of observations	792	792	792	792
Spatial Rho	0,3041*		0,0340	
R-sq:				
within	0,4195		0,4243	
between	0,1613		0,3859	
overall	0,0637		0,2597	

** statistical significance on levels: p<0.05, ** p<0.01, *** p<0.001; standard errors in brackets.*

Source: own processing

In the following part of our interpretation of results, we will pay attention to factors affecting localization of new knowledge intensive business services in Slovak republic, as presented in Table 5. We found statistically strong, and actually most significant evidence of impact of graduates rollout on emergence of KIBS among all investigated types of knowledge intensive activities in Slovak regions. The graduates tend to support knowledge intensive business services emergence in regions, where they graduated, what is in line with hypothesis H3. We also found support for assumption in H3 hypothesis that there are expected backwash effects - the more graduates in the region, the less knowledge intensive services for entrepreneurs in the surrounding regions. Similarly, as in case of basic ordinary least squares estimates and panels with fixed and random effects, we got negative coefficient for knowledge spillovers trough professors, but positive for spatial lag of this variable, what is in contrary with H3. From these results, we can only suppose that know-how and knowledge of senior academic researchers is more required in regions with smaller cities, with not so significant concentration of private research and higher share of domestic firms.

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

Knowledge intensive business services locate more in neighboring regions to those, where large enterprises concentrate, according to negative value of coefficient and positive of spatially lagged coefficient. In case of innovation production in private sector impact, we can only state that concentration of private research negatively impacts formation of new knowledge intensive business services, but we recorded statistically significant evidence only in case of model with graduates as university control. Than we also recorded the negative effect of agglomeration effects on KIBS measured by total number of inhabitants of region. We did not get significant estimations for spatially lagged variable, thus we cannot say, whether this information support results for KIM firms that deconcentrate from larger cities and are colocalized with KIBS. We again found no statistically significant effect of unemployment, but reversed effect of average wage as in case of knowledge KIM firms. In comparison with KIM firms, KIBS rather locate in regions with higher average wage, while those regions drain KIBS from those, where costs of employment are lower. Hence, we can accept logical assumption that business services are more dependent on concentration of entrepreneurship.

Table 6. Results of SDM with fixed effects using knowledge intensive services as dependent variable

Variable	**Model I.** coefficient	spatial lag	**Model II.** coefficient	spatial lag
graduates	0,019	-0,003		
	(0,016)	(0,007)		
professors			-3,488***	0,658**
			(0,488)	(0,237)
kim	26,928***	-7,871***	25,157***	-7,556***
	(1,112)	(0,365)	(1,096)	(0,360)
kibs				
large firms	-0,097	2,766	-16,594***	5,786***
	(224,129)	(1,747)	(4,016)	(1,774)
innovations	-7,562*	1,443	-3,688	0,762
	(3,004)	(1,384)	(2,895)	(1,336)
incubators	98,002	-23,606	76,537	-14,646
	(63,523)	(27,872)	(61,117)	(26,776)
population	-0,007*	0,002	-0,008*	0,002
	(0,003)	(0,001)	(0,003)	(0,001)
unemployment	-4,480	-0,143	-3,167	-0,391
	(3,524)	(0,787)	(3,391)	(0,736)
avg. wage	0,168	-0,038	0,173	-0,040
	(0,112)	(0,024)	(0,108)	(0,023)
Number of observations	792	792	792	792
Spatial Rho	0,3040*		,3040*	
R-sq:				
within	0,3883		0,4401	
between	0,0228		0,3712	
overall	0,0053		0,2525	

** statistical significance on levels: p<0.05, ** p<0.01, *** p<0.001; standard errors in brackets.*

Source: own processing

While interpreting the last models with dependent variable knowledge intensive services (aggregated), we will pay more attention to the relationship between results for KIBS and KIS, as data for KIBS are built as

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

subcategory of aggregated knowledge intensive industries in KIS data. Firstly, as shown in Table 6, we found interesting relationship for observed independent variable graduates, as in case when we aggregate knowledge intensive business services with another knowledge intensive services that are not oriented on the services provision to enterprises (this may be a question of the extent to which some of these non-business services can be truly considered to be knowledge intensive, and to what extent), we found no statistical significance of this control, what is in contrary to the hypothesis H4.

But we still found statistically significant effect of knowledge spill-overs from professors. This way measured knowledge spill-overs of universities again positively influence only emergence of new knowledge intensive services in more peripheral regions, thus we also again failed to meet conditions of H4 hypothesis. The colocalization patterns was found also in this case, as coefficient for control KIM was negative, while spatially lagged coefficient took positive value. In case of model that controls for knowledge spill-overs in form of links to professors, we found support for previous results that knowledge activities locate in neighboring regions to those, where large enterprises are concentrated. Quite similar results in comparison with KIBS were recorded also for controls innovations, incubators, population and unemployment, but we found no significant effect of average wage on aggregated KIS. Hence, cost effects probably affect more knowledge intensive activities oriented on provision of services to the businesses.

Conclusions

The vaste majority of authors agree that universities affect economic activities in various geographic areas (Woodwart et al., 2006; Bonnacorsi et al. 2014, Fischer et al. 2018). This article is an attempt to deliver empirical evidence that even in case of small, post-socialistic state of Eastern Europe that lacks research excellent universities, academic sector influence development of knowledge intensive entrepreneurship. In order to do so, we decided not to measure academic impacts on knowledge intensive entrepreneurship by mix of basic university knowledge-based outputs (patents, publications and graduate, as is currently preferred in scientific literature (Caree et. al. 2013), as Slovak Universities have quite low patent activity (e.g. there was only 25 patent application filled altogether by 38 Slovak universities and high schools in 2016). We rather considered to be more appropriate in Slovak conditions to follow approach of Fritsch and Aamoucke (2013) and base our research focus on two basic assumptions. Firstly, graduates may establish new businesses mainly in knowledge-intensive industries, based on their research for final thesis, or simply knowledge and skills acquired during studies. Due to this argument, we can consider graduates to be also academic knowledge spill-over as university knowledge relevant for running business in knowledge intensive industries is directly embodied in them (Lorincová, 2018; Kucharcikova, et al. 2018). Furthermore, rather the knowledge spill-overs from senior academic researchers, potentially transferable on the basis of inter-personal relationships can be considered as determinant of knowledge intensive ventures localization.

By this empirical study, we have helped to fill the gap in the research of university impacts on formation of regional environment, specifically on development of knowledge intensive entrepreneurship in several ways. First, we have carried precise analysis of academic impacts on knowledge intensive entrepreneurship in conditions of Slovakia. Than, we used the classification of Eurostat to calculate values for newly emerged knowledge intensive firms disaggregated to several categories – total number of knowledge intensive firms, knowledge intensive manufacturing firms, knowledge intensive business services, and all knowledge intensive services. We also consider as an added value that we adopted spatial approach to check for backwash and spreading effects.

While controlling for several non-academic factors, we found empirical evidence for assumption that knowledge spill-overs embodied in academic graduates are highly localized in line with results of other authors (Acosta et al. 2011; Baptista and Mendonça, 2010; Bonnacorsi et al. 2014). We found that also in conditions of small, post-

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2019 Volume 7 Number 1 (September)
http://doi.org/10.9770/jesi.2019.7.1(12)

socialistic country, graduates tend to stay and run business in region of their university allocation, but is important to state that this only applies to knowledge intensive business services. We found only weak and minimal negative effect of graduates on knowledge intensive manufacturing and no effects of graduates from surrounding regions, what is relatively conformable with the results of Fritsch and Aamoucke (2013). In contrary with most of the research results of other authors, we failed to find support for assumption that spill-overs from senior academic researchers are also localized. We assume that this is caused by the level of spatial aggregation of data that finally appears to be suitably chosen. As Slovak LAU1 regions are relatively small (79 districts), we actually get strong evidence that there is certain impact of knowledge spill-overs measured by availability of senior researchers, but these spill-overs are considered as location factor again just by knowledge intensive services (both business and non-business) and only in peripheral regions, which centers are smaller cities (as Slovak universities are allocated mostly in districts with city that is always center of NUTS III region). Thus, it is important result that localization of knowledge intensive manufacturing ventures is in conditions of Slovak Republic (from observed factors) determined only by lower cost of labor and private research spill-overs, while we proved that universities play role in emergence of knowledge intensive business services by graduates in region of universities allocation, and also affects both business and non-business knowledge intensive services in more peripheral regions.

Further, we found strong evidence for localization patterns of knowledge intensive manufacturing in regions that neighbor with those, in which significant concentrations of large enterprises and private research and development activities are observable – thus, again around regions with large central cities. This refers to progressing process of deconcentration of economic activities in Slovakia. It is also connected with strong colocalization pattern between knowledge intensive manufacturing and services that we found. Thus, we can see that knowledge intensive services are pushed on the first hand to regions with larger regional centers, as there have more opportunities (as suggested by results for average wage), an on the other hand to surrounding regions, where knowledge intensive manufacturing ventures emerge. The presumption of this trend is supported also by results for impact of agglomeration effects, as they also refer to traced deconcentration process. In contrary to assumption of Caree et al. (2012) we found no connection between emergence of knowledge intensive firms and unemployment. Also, business incubators, as their networks is in Slovakia still considerably small and less oriented on knowledge intensive activities, do not appear to affect emergence of knowledge intensive activities.

References

Abramovsky, L.; Harrison, R.; Simpson, H. 2007. University research and the location of business R&D. *Economic Journal*, 117(519): 114-141. http://dx.doi.org/10.1111/j.1468-0297.2007.02038.x

Acosta, M.; Coronado, D.; Flores, E. 2011. University spillovers and new business location in high-technology sectors: Spanish evidence. *Small Business Economics* 3: 365 -376. http://dx.doi.org/10.1007/s11187-009-9224-4

Acs, Z.; Armington, C.; Zhang, T. 2006. The Determinants of New-firm Survival across Regional Economies. *Papers in Regional Science* 86(3): 367–391. http://dx.doi.org/10.1111/j.1435-5957.2007.00129.x

Audretsch, D.; Stephan, P. 1996. Company-scientist locational links: the case of biotechnology. *American Economic Review* 86(3): 641-652.

Audretsch, D.B.; Keilbach, M. 2007. The localization of entrepreneurship capital: Evidence from Germany. *Papers in Regional Science* 86(3): 351–365. https://doi.org/10.1111/j.1435-5957.2007.00131.x

Baptista, M.; Mendonça, J. 1010. Proximity to knowledge sources and the location of knowledge-based start-ups. *The Annals of Regional Science*, 45(1): 5–29. https://doi.org/10.1007/s00168-009-0289-4

Bekkers, R.; Bodas Freitas, I.M. 2008. Analyzing knowledge transfer channels between universities and industry: To what degree do sectors also matter? *Research Policy* 37(10): 1837-1853. https://doi.org/10.1016/j.respol.2008.07.007

Belitski, M.; Korosteleva, J. 2012. Entrepreneurial Dynamics and Higher Education Institutions: Evidence from the Post-Communist World. *Regional Studies* 51(3): 439-453. https://doi.org/10.1080/00343404.2015.1103370

Bonaccorsi, A.; Colombo, M. G.; Guerini, M.; Rossi-Lamastra, C. 2014. The impact of local and external university knowledge on the creation of knowledge-intensive firms: evidence from the Italian case. *Small Business Economics* 2(1): 261–287. https://doi.org/10.1007/s11187-013-9536-2

Calcagnini, G.; Favaretto, I.; Giombini, G.; Perugini, F.; Rombaldoni, R. 2014. The role of universities in the location of innovative start-ups. *The Journal of Technology Transfer* 41(4): 670–693. https://doi.org/10.1007/s10961-015-9396-9

Carree, M.; Malva, A. D.; Santarelli, E. 2012. The contribution of universities to growth: empirical evidence for Italy. *The Journal of Technology Transfer* 2012, 39(3): 393–414. https://doi.org/10.1007/s10961-012-9282-7

Dubravska, M.; Sira, E. 2014. The analysis of the chosen indicators of the innovatiove environment development in the Slovak republic and in the Czech Republic. *17th International colloquium on regional sciences*: 194-200. https://doi.org/ 10.5817/CZ.MUNI.P210-6840-2014-23

Duľová Spišáková, E.; Mura, L.; Gontkovičová, B.; Hajduová, Z. 2017. R&D in the context of Europe 2020 in selected countries. *Economic Computation and Economic Cybernetics Studies and Research* 51(4): 243 – 261.

EUROSTAT. 2014. Eurostat indicators on High-tech industry and knowledge intensive services. European Commission – Eurostat: Luxembourg. Available online: https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an3.pdf (accessed on 11 December 2018).

Fischer, B.B.; Queiroz, S.; Vonortas, N.S. 2018. On the location of knowledge-intensive entrepreneurship in developing countries: lessons from São Paulo, *Brazil. Entrepreneurship & Regional Development* 30(6): 612–638. https://doi.org/10.1080/08985626.2018.1438523

Florax, R. The university: a regional booster? 1992. Avebury, United Kingdom: Beatty.

Fritsch, M.; Aamoucke, R. 2013. Regional public research, higher education, and innovative start-ups: an empirical investigation. *Small Business Economics* 41(4): 865–885. https://doi.org/10.1007/s11187-013-9510-z

Ghio, N.; Guerini, M.; Rossi-Lamastra, C. 2016. University knowledge and the creation of innovative start-ups: an analysis of the Italian case. *Small Business Economics* 47(2): https://doi.org/293- 311. 10.1007/s11187-016-9720-2

Girdzijauskaite, E.; Radzeviciene, A.; Jakubavicius, A. 2019. Impact of international branch campus KPIs on the university competitiveness: FARE method. *Insights into Regional Development* 1(2): 171-180. https://doi.org/10.9770/ird.2019.1.2(7)

Glasmeier, A. 1991. *The high-tech potential. Economic development in rural America*. New Brunswick, New Jersey: Center for Urban Policy.

Haviernikova, K. 2018. Regional Dimension of Cluster Policy: Case Study Slovakia. *Proceedings of the 4th International conference on European integration 2018 (ICEI 2018), PTS 1-3. International Conference on European Integration*: 422-429

Horecký, J. 2018. Operation and action of a trade union (in terms of Czech Republic labour law). *Central European Journal of Labour Law and Personnel Management*, 1(1): 17 – 27. http://doi.org/10.33382/cejllpm.2018.01.02

Horváth, Z.; Hollósy, G. 2018. Vadász testing the public service motivation and calling in Hungary. *Acta Oeconomica Universitatis Selye* 7(2): 47 – 58.

Hunady, J.; Orviska, M.; Pisar, P. The effects of higher education on entrepreneurial activities and starting up successful business. *Inzinerine Ekonomika-Engineering Economics* 29(2): 226-235. http://dx.doi.org/10.5755/j01.ee.29.2.19069

Jaskova, D.; Haviernikova, K. 2016. The assesment of Slovak regions' competitiveness. *SGEM 2016, BK 2: political sciences, law, finance, economics and tourism conference proceedings, Vol III. International Multidisciplinary Scientific Conferences on Social Sciences and Arts*: 1077-1084

Kendiukhov, I.; Tvaronaviciene, M. 2017. Managing innovations in sustainable economic growth. *Marketing and management of innovations* 3: 33-42. http://dx.doi.org/10.21272/mmi.2017.3-03

Kondratiuk-Nierodzińska, M. 2016. New knowledge generation capabilities and economic performance of Polish regions. *Equilibrium. Quarterly Journal of Economics and Economic Policy* 11(3): 451-471. https://doi.org/10.12775/EQUIL.2016.021

Kowalska, I. 2016. Sources of financing knowledge-based economy: the case of formal, non-formal and informal education in Poland. *Oeconomia Copernicana*, 7(1): 75-90. https://doi.org/10.12775/OeC.2016.006

Kucharcikova, A.; Miciak, M.; Hitka, M. 2018. Evaluating the Effectiveness of Investment in Human Capital in E-Business Enterprise in the Context of Sustainability. *Sustainability* 10(9): 3211. https://doi.org/10.3390/su10093211

Lorincová, S. 2018. Human resource and corporate culture: Gender-based differences in the assessment. *Central European Journal of Labour Law and Personnel Management*, 1(1): 28 – 45. http://doi.org/10.33382/cejllpm.2018.01.03

Madrak-Grochowska, M. 2015. The knowledge-based economy as a stage in the development of the economy. *Oeconomia Copernicana* 6(2): 7-21. https://doi.org/10.12775/OeC.2015.009

Markusen, A.; Hall, P.; Glasmeier, A. 1986. *High tech America: the what, how, where, and why of the sunrise industries*. Boston, United States of America: Allen & Unwin.

Melichová, K.; Hrivnák, M.; Roháčiková, O. 2017. Multiplier effects and economic impact of university spending - case study of sectoral and spatial aspects of expenditures of Slovak University of Agriculture in Nitra. *Acta Oeconomica Universitatis Selye* 6(2): 119 – 137.

Mura, L., Daňová, M., Vavrek, R., Dúbravská, M. 2017. Economic freedom – classification of its level and impact on the economic security. *AD ALTA-Journal of Interdisciplinary Research* 7(2): 154 – 157.

Mura, L.; Marchevska, M.; Dubravska, M. 2018. Slovak Retail Business across Panel Regression Model. *Marketing and Management of Innovations* 4(1): 203-211. http://doi.org/10.21272/mmi.2018.4-18

Mura, L.; Haviernikova, K.; Machova, R. 2017. Empirical results of entrepreneurs' network: case study of Slovakia. *Serbian Journal of Management* 12(1): 121-131. https://doi.org/10.5937/sjm12-10418

Nagy, B. Z. 2016. Regional inequalities in the European Union. *Acta Oeconomica Universitatis Selye* 5 (1) : 109 – 118

Obisi, C.; Aliyu, M. O. 2018. Learning and development in Nigerian higher institutions: a study of employee attitude. *Acta Oeconomica Universitatis Selye* 7(2): 91 – 108

Pavolová, H.; Bakalár, T.; Emhemed, E. M.; Hajduová, Z.; Pafčo, M. 2019. Model of sustainable regional development with implementation of brownfield areas. *Entrepreneurship and Sustainability Issues* 6(3): 1088-1100. https://doi.org/10.9770/jesi.2019.6.3(2)

Potkany, M.; Gejdos, M.; Debnar, M. 2018. Sustainable Innovation Approach for Wood Quality Evaluation in Green Business. *Sustainability* 10 (9): 2984. https://doi.org/10.3390/su10092984

Prakash, R.; Garg, P. 2019. Comparative assessment of HDI with Composite Development Index (CDI). *Insights into Regional Development* 1(1): 58-76. https://doi.org/10.9770/ird.2019.1.1(5)

Prokopenko O.; Holmberg R.; Omelyanenko V. 2018. Information and communication technologies support for the participation of universities in innovation networks. *Innovative Marketing* 14(3): 17-29. https://doi.org/10.21511/im.14(3).2018.03

Raudeliuniene, J.; Tvaronaviciene, M.; Radeckyte, V. 2018. Regional Development via Entrepreneurship: Women Leadership in Lithuanian E-Commerce. *Innovation management and education excellence through VISION 2020*, Vols I -XI: 1151-1162

Simo, D.; Mura, L.; Buleca, J. 2016. Assessment of milk production competitiveness of the Slovak Republic within the EU-27 countries. *Agricultural Economics-Zemedelska Ekonomika* 62(10): 482-492. https://doi.org/10.17221/270/2015-AGRICECON

Tvaronavičienė, M.; Razminiene, K. 2017. Towards competitive regional development through clusters: approaches to their performance evaluation. *Journal of Competitiveness* 9(4): 133-147. https://doi.org/10.7441/joc.2017.04.09

Tvaronavičienė, M. 2017. Clusters, innovations and energy efficiency: if relantionship could be traced. *Marketing and Management of Innovations* 2: 382 - 391 http://doi.org/10.21272/mmi.2017.2-35

Wierzbicka, W. (2018). Information infrastructure as a pillar of the knowledge-based economy - an analysis of regional differentiation in Poland. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 13(1), 123-139. https://doi.org/10.24136/eq.2018.007

Woodward, D.; Figueiredo, O.; Guimarães, P. Beyond the Silicon Valley: University R&D and high-technology location. *Journal of Urban Economics* 60(1): 15–32. http://dx.doi.org/10.1016/j.jue.2006.01.002

Zauskova, A.; Grib, L. 2016. Marketing communication of eco-innovations and their impact on regional development. *Marketing identity: brands we love, PT II. Marketing Identity*: 494-503

Zeibote, Z.; Volkova, T.; Todorov, K. 2019. The impact of globalization on regional development and competitiveness: cases of selected regions. *Insights into Regional Development* 1(1): 33-47. https://doi.org/10.9770/ird.2019.1.1(3)

Appendix

Aggregation of KIF	**NACE Rev. 2 codes – 2-digit level**	**Description of codes**
KIM	20, 21, 26, 27 – 30	manufacture of chemicals and chemical products; manufacture of basic pharmaceutical products and pharmaceutical preparations; manufacture of computer, electronic and optical products; manufacture of electrical equipment; manufacture of machinery and equipment n.e.c.; manufacture of motor vehicles, trailers and semi-trailers; manufacture of other transport equipment
KIBS	62, 63, 69, 70, 71, 72, 73,	computer programming, consultancy and related activities; information service activities; legal and accounting activities; activities of head offices, management consultancy activities; architectural and engineering activities, technical testing and analysis; scientific research and development; advertising and market research

KIS	50, 51, 58, 59, 60, 61, 62, 63, 64, 65, 66, 69, 70, 71, 72, 73, 74, 75, 78, 80, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93	water transport; air transport; publishing activities; motion picture, video and television program production, sound recording and music publish activities; programming and broadcasting activities; telecommunications; computer programming, consultancy and related activities; information service activities; financial and insurance activities; legal and accounting activities; activities of head offices, management consultancy activities; architectural and engineering activities, technical testing and analysis; scientific research and development; advertising and market research; other professional, scientific and technical activities; veterinary activities ; employment activities; security and investigation activities; public administration and defense, compulsory social security; education, human health and social work activities; arts, entertainment and recreation

Aknowledgements

This research was funded by project of Agency for the Support of Research and Development in Slovakia, APVV-14-0512 "Universities and economic development of the regions".

Michal HRIVNÁK is PhD Candidate on Faculty of European studies and regional development. His PhD thesis concern problems of difusion of academic knowledge, and university impacts on local and regional economy.
OCRID ID: https://orcid.org/0000-0003-2816-7825

Katarína MELICHOVÁ is an young expert in problematics of regional and local economic development, while focusing on statistical modeling. She participated in several domestic and international projects.
OCRID ID: https://orcid.org/0000-0003-0010-7476

Mária FÁZIKOVÁ is associate professor and senior researcher of Slovak University of Agriculture, focusing mainly on problems of rural areas, rural economy and management of agriculture development in rural areas. She participated on many national and international research projects and projects for policy makers on national, regional and local levels in Slovakia. She is a member of many research organisations.
OCRID ID: https://orcid.org/0000-0002-8526-8510

Oľga ROHÁČIKOVÁ is associate professor and dean of Faculty of European studies and regional development on Slovak University of Agriculture. In her research, she focus mainly on problems of public administration and governance.
OCRID ID: https://orcid.org/0000-0002-0534-0368