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Subregional Economic and Innovation Contribution of Hungarian Universities

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Several success stories prove that universities are able to significantly influence regional development. Partially due to this fact a number of regions have created development strategies to strengthen the regional effects of universities and to motivate the academic sphere for a more intense involvement in regional economic development also in the post-socialist transition economies. In spite of this, it is not obvious whether the significant regional contribution of universities is a rule or rather an exception. On the top of this the validity of the relevant results of the literature can not be unambiguously extended to transition economies.

Present paper aims to measure the contribution of Hungarian higher education institutions to regional economic and innovation performance. On the one hand, it attempts to adapt the methodology of a former US study of Goldstein and Renault to a transition economy, and instead of regional to sub-regional (LAU-1) level. One the other hand it expands the focus of their method, and connects the role of universities to complex territorial innovation performance, and especially to knowledge exploitation ability. It concludes that universities have significant contribution to overall local innovation performance, but very limited contribution to the knowledge exploitation ability. This contribution is too forceless to result in the dynamic improvement of the local economic performance or in the rise of the local incomes.

Keywords: universities' regional contribution, innovation performance, transition economy, Hungary.

1. Introduction

The role of universities in systems of innovation and their contribution to economic development are widely approached research issues. The increasing importance of the academic sphere in the innovation systems is usually explained by the growing importance of knowledge compared to the conventional factors of production (Etzkowitz et al 2000).

Nowadays "the growth in technological knowledge relies increasingly on science" (Rosenberg 1994, p. 9.). This "ties industries to universities, which provide both people trained in the relevant fields, and research findings which enable the technology to advance further" (Nelson 1995, p. 77.). On the top of this, it is often argued that nowadays the conventional teaching and research functions of the universities are able to evolve and generate economic effects only in synergy with the new function of the "economic utilization" (Etzkowitz et al 2000).

The contribution of universities to innovation performance and economic growth *may significantly differ* regarding the peculiarities of the given region or university. In certain cases the contribution of the academic sphere is apparent and vital. These success stories (Silicon valley, Route 128, Cambridge) served as a basis for numerous economic development actions all over the world (technology-transfer programmes, science parks, technology business incubators, etc.), but the success of these programmes are in may cases questioned (Cooke, 2001, Asheim–Coenen 2005, Löfsten–Lindelöf 2005).

Therefore, it remains a basic question whether universities' economic contribution is *a rule or rather an exception*. This seems to be particularly important in the post-socialist transition economies, where the success stories are absent, but still a number of central and local development strategies are based on the hoped economic development effects of universities.

In present paper we focus on the question whether universities' contribution to regional innovation and economic performance can be proved in a transition economy, namely in Hungary. In chapter 2 we synthesize the main finding of the literature dealing with the (regional) economic contribution of universities. We outline the importance of the regional-level analysis, and touch upon the peculiarities of transition economies in this respect. In chapter 3 we present the hypotheses to be tested. Chapter 4 provides an overview on the methodology of our analysis, which is based on Hungarian sub-regional (LAU-1) data. In chapter 5 we show the results of the analysis and we draw our conclusions in chapter 6.

2. Regional economic contribution of universities

In today's knowledge- or learning-based economy the innovation potential depends to a great extent on extra-organizational factors and relations, in other words the innovation system (Lundval 1992, Nelson 1993). In almost all innovation systems have higher education institutions (HEIs) a significant role, especially research universities as essential knowledge-producers (Inzelt 2004, Tödtling–Trippl 2005).

The literature of *innovation systems* has uncovered that not solely the presence of the universities are important, but the character and intensity of the relations between universities and other participants of the system. A large body of literature deals with the mechanisms through which the academic knowledge production affects the corporate innovation performance (Etzkowitz–Leydesdorff 2000, Inzelt 2004, Bercovitz–Feldman 2006), with the spatiality of these mechanisms (Feldman 1994, Morgan 2002, Goldstein–Renault 2004, Varga 2009) and with the transformation within the academic sphere that enables the operation of these mechanisms (Etzkowitz et al 2000, Goldfarb–Henrekson 2003, Clarysse et al 2005, Antonelli 2008).

As we can see only a part of the studies dealing with the economic role of universities puts the problem of spatiality into the focus. One could easily argue that universities are rather national and not regional "resources". Students do not gain scholarships solely from the host region of the university, nor do they remain there necessarily after graduation. Furthermore research ties make universities become parts of global networks.

Nevertheless certain universities contribute significantly to their *local (regional)* environment and catalyze local economic processes. As a consequence regions are increasingly looking at universities as exploitable local "resources". This raises the need for analyzing the spatial characteristics of the university-business relations.

Although the external relations of the universities are to a great extent globally tied, a certain part of university-industry relations have local characteristics. This is due to the fact that the technology-transfer process is embedded into the contexts of local routines and local / regional systems of innovation (Bercovitz–Feldman 2006). Hence personal relations and local embeddedness gains and important role, which sheds light on the importance of the analysis of the local and regional innovation systems (Asheim–Coenen 2005). On the top of this, externalities (spillovers) that play a vital role in the innovation process have spatial characteristics, they are mostly local, thus the spatial distribution of the participants matters (whether they are spatially concentrated or evenly distributed) (Varga 2009). A number of innovation models emphasize that innovation is a spatial phenomenon, depending to a great extent on resources that are region-specific and can not be reproduced elsewhere (Ács et al 2000, Asheim–Gertler 2005, Storper 1997). Although the literature of territorial innovation models is heterogeneous (Moulaert–Sekia 2003, Lagendijk 2006), the given approaches usually emphasize the importance of the local scpecifities (participants and relations), the learning ability, which naturally sheds light on the essential role of knowledge-producing organizations.

Therefore the *spatiality of the effects of universities* has an abundant literature. The (spatially restricted) economic effects of the academic sphere are manifold: they range from the increase of local demand through the direct technological effects to the contribution of regional "milieu" (Goldstein–Renault 2004).

These potential effects can be divided into two main groups: the input-side or income effects, and the output-side or knowledge-effects, which latter covers the scientific, technical and economic knowledge streaming from the academic to the business sphere (Armstrong–Taylor 2000, Morgan 2002, Varga 2004). Income effects basically derive from the local spending of the university, its students and staff. Although they may have a significant role in certain areas, they are not able to catalyze the local economy[1], they are static in nature. Conversely, knowledge-effects are able to induce dynamic local development: they can serve as a basis of the local innovation potential, and thus eventually the improvement of economic performance and the rise of local incomes.

In connection with the *knowledge-effects* the most intensely researched issue is probably the analysis of the local spillovers deriving from the spatial concentration of R&D activities. A number of empirical studies proved a significant and positive relation between university R&D and the number of company-owned patents[2] in case of spatial proximity (Audretsch–Feldman 1996, Anselin et al 1997, Varga 1998, Autant-Bernard 2001). With the increase of the distance the relation becomes insignificant. These econometric analyses, which are based on the knowledge-production function, provided important proofs of the existence of the academic knowledge spillovers and their local nature.

However, beside the knowledge externalities connected to the formalized R&D results, there are numerous other channels of universities' potential regional effects. Therefore it is still a pivotal question that, to what extent are the effects of universities general. Do they also affect (beside the patent or product-innovation effectiveness of the business sphere), the overall local economic performance or the rise of local incomes. In this respect the analysis of Goldstein and Renault (2004) based on American time series provides essential results. They generally proved that in the USA the presence of research universities significantly affects the rise of regional incomes, but only after 1986[3], when – as a consequence of the Bayh-Dole Act – universities started to make serious efforts to strengthen their industrial relations. They proved furthermore, that the channels of the R&D related effects are way broader than the transfer of formalized achievements (patents); overall university R&D expenditures are more significant indicators than the number of university patents.

While the econometric analyses based on the knowledge production function suggest that the critical concentration of R&D capacity and local industrial activities is required for the spillovers to become significant factors, Goldstein and Renault (2004) found that the general economic effects of universities are more intense in the smaller regions. It seems that universities are able to serve as a substitute for agglomeration economies to a certain extent.

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[1] The ways of strengthening the income effects are on the one hand the increase of the number of students and the staff, on the other hand the rise of the proportion of local spending. These face objective hinders (e.g. public procurement rules do not allow the university to prioritize local buying). Therefore the strengthening of the income effects is not an objective of local economic development.

[2] These studies usually use the number of patents as a measure of innovation performance, which can be seriously criticized. Nevertheless Ács et al (2002) proved that using the number of newly introduced high-tech products leads to the same results as using the number of patents.

[3] Although the Bay-Dole Act was adopted in 1980, its effects became measurable only a few years later.

However, the above *results can not be unambiguously exteriorized to transition economies*, it is not at all obvious, that these effects could be proved there as well. In the transition countries the performance of the regional innovation systems is weak (Hollanders 2006), so are the university-industry relations (Inzelt 2004, Papanek 2006), and the political actions aiming at the encouragement of university-related technology-transfer have just begun being amplified. Furthermore, the effectiveness of university-related local economic development programmes can be questioned in many cases (Barta 2002, Buzás 2003, Bajmócy 2006).

The literature of *Hungarian universities' economic contribution* is quite scarce. Inzelt (2004) provides a general overview on the transformation of university-industry relations, but spatiality is not in the focus of her inquiry. Varga (2009) verifies empirically that localized knowledge spillovers of university and private R&D are more intense in case of the spatial concentration of the system's participants. Several authors analyse the opportunities and effectiveness of university-related development-programmes (Barta 2002, Lengyel 2004, Pálmai 2004, Bajmócy 2006, Papanek–Perényi 2006), and the opportunities of university-based local economic development strategies (Lengyel 2009).

3. Hypotheses

The literature of universities' regional effects puts the knowledge-effects into the focus of the interest. In present paper we also carry on with this tradition, since we attempt to analyse the ability of Hungarian HEIs to boost the economy of their host region.

Studies that link the presence of universities to regional innovation performance use the number of patents or incidentally the number of newly introduced high-tech products as a measure of innovation. The general understanding of innovation (OECD 2005) is however much broader, and does not seem to be reducible to one given dimension.

On the basis of the Oslo Manual's recommendations a number of attempts have been made to measure the innovation performance of territorial units in its complexity – ultimately to map the performance of the innovation system (Arundel–Hollanders 2005, Hollanders 2006, Kanerva et al 2006, EIS 2007). Such a complex approach seems to be especially important in transition countries like Hungary, since in Hungary for example less than half of the innovative companies carry out any R&D activity (EIS 2007).

Therefore in present paper we attempt to link the presence of HEIs to the complex innovation performance of the territorial unit. Within this, the correspondence between HEIs and the region's knowledge-exploitation ability is especially important. On this basis we conceptualized our first hypothesis:

- *Hypothesis 1*: Higher education institutions contribute significantly and positively to sub-regional overall innovation performance, but they do not contribute to a substantive element of the innovation performance, namely the knowledge-exploitation capacity.

The literature surveyed in the previous chapter suggests that in the developed countries universities' economic contribution is more general than just affecting the innovation performance of the business sector. They contribute to the overall regional economic performance and the rise of local incomes as well. At the same time, the validity of such an effect in a transition country is not at all obvious:

- *Hypothesis 2*: Higher education institutions contribute significantly and positively to the growth of sub-regional economic performance and the income of the residents.

4. Methodology

For the purpose of our study we took the analysis of Goldstein and Renault (2004) as a starting point, but we carried out certain modifications on it. These modifications basically derive from three factors. First, we widened the focus of analysis; beside the change in average wages we also examined the effects of HEIs on the complex innovation performance with a special emphasis on the knowledge-exploitation capacity, and the change in the sub-regional economic performance. Second, we carried out our analysis on local (LAU-1) level, which significantly influenced data availability. Therefore we had to make certain changed on the set of indicators used. Third, we carried out our examinations in such a country, where the sub-region of the capital (Budapest) concentrates a significant proportion of the population, gross value added (GVA), and research capacities, and excels from the country also in a relative way. This inevitably had to be considered in the statistical analysis.

The units of our analysis were the 168 Hungarian (LAU-1) sub-regions, the examined period was 1998-2004. The system of statistical sub-regions undergone slight changes between the two dates, therefore we converted all the data to be in line with the 2004 system[4]. For the computations we used MS Excel and SPSS 15.0.

4.1. Indicators used

For analyzing the regional effects of HEIs, we used three set of indicators: the dependent variables (which indicate the potential forms of contribution), HEI-related

[4] The data therefore refer to the 168 sub-regions defined by the Government Regulation 244/2003.

indicators, and control variables. During the selection of the variables we carried out certain modifications on the set of indicators used by Goldstein and Renault (2004). These changes were partially due to the differences in the focus of examination, and partially due to the restricted sub-regional data availability (Table 1).

Table 1. Indicators of the analysis

Dependent	Change in the gross personal tax base per tax payer compared to national average (in % points)
	Change in the gross value added per capita compared to national average (in % points)
	Sub-regional Summary Innovation Index (SRSI)
	Knowledge Exploitation Index (KEI)
HEI-related	Is there a HEI in the sub-region
	Is there a state HEI in the sub-region
	Is there a university in the sub-region
	Is there a college in the sub-region
	Number of teaching staff in HEIs per 1000 inhabitants
	Number of scientists with PhD per 10000 inhabitants
	Number of full-time students in HEIs per 1000 inhabitants
	Numbers of degrees awarded in the fields of science, engineering and informatics
Control	Number of employees
	Population of the centre of the sub-region
	Per cent employment in manufacturing and construction
	Per cent employment in services
	Complex accessibility indicator
	Per cent of incomes generated by proprietorships
	Number of patents per 10000 inhabitants
	Per cent of incomes generated by proprietorships
	Number of patents per 10000 inhabitants
	Base-year level of gross personal tax-base per tax payer
	Base-year level of gross value added per capita
	Trade integration (Export sales per gross value added)

Source: own construction

Two of the *dependent variables* are related to the innovation performance: the sub-regional summary innovation index (SRSI), and the knowledge-exploitation index (KEI)[5]. These measures of innovation potential refer to adaptability and the speed of technical change. These capabilities can eventually lead to the change in the other two dependent variables.

The latter two dependent variables refer to the change in the sub-regional economic performance and in the incomes of the inhabitants: the per capita gross value added (GVA) and the gross tax base per tax payer. Per capita GVA is analogous to per capita GDP in its content[6], while the gross tax base per tax payer

[5] The computing method of the two indexes is outlined later in the chapter.
[6] GDP is not available for LAU-1 sub-regions, thus GVA is used as a substitute.

captures the disposable incomes of the residents[7]. The computation of the variables is analogous to the method of Goldstein and Renault (2004). We first calculated the values of the variables as a percentage of the national average for each sub-region for 1998 and 2004. The dependent variable is then calculated as a difference in the indexes for the gives sub-region between the two years. The positive value of the variable therefore refers to a growth rate exceeding the national average (catching-up, or increasing the advantage).

Thus two of our dependent variables are based on the change of the indicator values, while two are cross-section data. But innovation performance refers to the speed of change in itself, so the introduction of the growth rate of the innovation indexes is unneeded.

The presence and the performance of HEIs is measured by eight indicators. Four of them are dummy variables (present or not in the sub-region), while for are measured on scale. These latter are indicators related to the basic functions of the universities: the number of teaching staff, the number of full-time students, the number of scientists with PhD, and the number of degrees awarded in the fields of science, engineering and informatics. These variables – where available – refer to the base year (1998).

To capture the potential effects of universities the use of university-related indicators is not sufficient, since the difference between sub-regions with and without HEIs may be caused by many other influencing factors. Therefore in our analysis we applied control variables which are potentially able to explain a significant proportion of the dependent variable's variation.

The first group of the *control variables* tries to capture the agglomeration economies, they refer to the size of the sub-region. Instead of using the overall population of the sub-region, we decided to introduce the population of the centre of the sub-region, which better indicates the size of the local concentration.

In order to map the economic structure of the sub-regions we used two variables: the relative weight of manufacturing and services in the employment. We indicated the accessibility of the sub-region by the complex accessibility index[8] of the Hungarian Central Statistics Office (KSH 2004). Several empirical results prove the link between entrepreneurship and economic performance (Bosma–Harding 2006). We used two variables in this category: the per cent of incomes generated by sole proprietors and the number of patents per 10000 inhabitants.

[7] Goldstein and Renault (2004) used the wages as dependent variable, but in this case we also had to face the unavailability of the data in sub-regional level.

[8] The index considers the time distance from the nearest county-centre (40%), from the nearest sub-region-centre (40%), and the state of supply (20%), which latter indicates the extent to which the residents are dependent on the services of the centres. Accessibility is calculated for all the municipalities and then, weighted by the population of the municipalities, the sub-regional index is calculated.

We considered furthermore the base-year performance of the sub-region to control the endowment effect. On the top of these we introduced a variable reflecting the peculiarities of the transition countries: the indicator of trade integration (export sales per GVA). A number of empirical results indicate that in Hungary foreign direct investments, and in association with this export orientation basically influences territorial disparities (Lengyel–Lukovics 2006, Kovács–Lukovics 2006).

4.2. The steps of the analysis

We carried out the analysis of HEIs' potential contribution in two basic steps. The differences regarding the innovation and economic performance of subregions with and without HEIs may derive from many factors. In the *first step* of our analysis we attempted to explain these potential differences by using our control variables.

We fitted linear regression models to all of the four dependent variables in order to test the explanatory power of the control variables. We used the "backward" method of the SPSS so we gained such "base-models" where a relevant set of the control variables are included with the maximum possible overall explanatory power. Therefore the "base-models" indicate the explanatory power of the relevant control variables in case of all the dependent variables.

In the second step we attempted to unfold the extent of university contribution. We used here two methods. First, we analysed whether there is a correspondence between the dependent variables and the HEI-related indicators when controlling for the effects of the relevant set of control variables. We calculated here partial correlations controlled for the independent variables of the base models.

Second, if we found significant correlation between a HEI-related indicator and a dependent variable, than we attempted to supplement our base-model with that given variable. Actually, we analyzed whether the HEI-related indicators provide extra explanatory power to our models.

We must mention here that both the HEI-related indicators and the control variables are strongly correlated to each-other, thus our regression models are characterized by strong multicollinearity. Hence we only analyzed the overall explanatory power of the models (where the lack of multicollinearity is not a precondition), we could not and did not draw any conclusions on the partial effects of the given variables.

4.3. The distorting effects of the Budapest sub-region

We inevitably had to consider during the analysis that a significant proportion of Hungary's population, economic performance and research capacity is concentrated in the sub-region of the capital (Budapest). The values of the Budapest sub-regions significantly influence the average values of the dependent variables and thus distort the results of our examinations.

Therefore we removed the values of the Budapest sub-region from the database in order to gain a more realistic picture on the remaining part of the country. Thus all our results refer to Hungary's extra-Budapest parts. We certainly removed the values of Budapest also when calculating the average values of the given indicators.

4.4. Measuring the complex innovation performance of the sub-regions[9]

One of the main focuses of our study is to unfold the correspondence between the presence of HEIs and the innovation performance of the host sub-region. Innovation performance data on the Hungarian sub-regions were not available, thus we had to carry out our own analysis to construct these data.

The first step of the innovation analysis was the selection and classification of the indicator set. In connection with the construction of the groups we built on Tödtling and Trippl's (2005) approach on the structure of regional innovation systems, the smart infrastructure concept of Smilor and Wakelin (quoted by Stimson et al 2006), which has became widely known through the interpretation of Malecki (1997), and the arguments of Florida (2002) on the economic geography of talent. We attempted to define our sub-indexes in such a way that they should reflect to the elements of a "typical" regional innovation system.

In purpose of the index selection the indicators of the Summary Innovation Index of the European Innovation Scoreboard (EIS 2007), the Service Sector Innovation Index of the European Trend Chart on Innovation (Kanerva et al 2006), the EXIS Summary Index (Arundel–Hollanders 2005), the National Innovative Capacity Index of Porter and Stern (2003), the Europe Creativity Index of Florida and Tingali (2004), the RRSI Index of the European Regional Innovation Scoreboard (Hollanders 2006), the indicators of the analysis of Csizmadia and Rechnitzer (2005) on the innovation potential of Hungarian cities and of Kocziszky (2004) on the innovation potential of the sub-regions of the North-Hungarian Region served as a basis.

We tried to avoid to reduce the innovation output to one certain (and perhaps ill-defined) indicator. However this approach would provide the advantage of an objective selection criteria[10], the choosing of the dependent variable is problematic, and it would not provide a detailed picture about the innovation system's performance. Besides, the sub-regional availability of data influenced the construction of the indicator-set.

[9] A more detailed description of the innovation performance measuring method, and the results of an analysis that also includes data on the Budapest subregion can be read at Bajmócy–Szakálné (2009).

[10] Like in the analysis of Porter and Stern (2003), where the relevance of the indicators were defined by their explanatory power in a regression model where the number of USPTO applications served as the dependent variable.

Eventually we carried out the innovation performance analysis with 28 indicators (Table 2), which were classed into three groups: knowledge production (10 indicators), knowledge exploitation (9 indicators), and smart infrastructure (9 indicators). Three sub-indexes measure the performance in these three categories, while the sub-indexes serve as the basis of the Sub-regional Summary Innovation Index (SRSI) with an equal weight. The indicators of the Knowledge Production Index measure the ability to create new scientific and technological knowledge. The indicators of the Knowledge Exploitation Index (KEI) attempt to measure the characteristics of the innovative business sectors, while the Smart Infrastructure Index systematizes the factors that provide a background for sustaining knowledge production and exploitation.

Table 2. The indicator set of the innovation performance analysis

Knowledge creation	1	Number of R&D performing units per 100000 inhabitants
	2	Total staff of R&D units per 1000 inhabitants
	3	Calculated staff number (FTE) of R&D units
	4	Calculated staff number of R&D units per 1000 inhabitants
	5	Number of scientists with PhD per 10000 inhabitants
	6	Investments of R&D units per 1000 inhabitants
	7	R&D costs per 1000 inhabitants
	8	Expenditures of R&D places
	9	Expenditures of R&D places per 1000 inhabitants
	10	Number of patents per 10000 inhabitants
Knowledge exploitation	1	Export sales as a percent of total sales
	2	Export sales per inhabitant
	3	Number of foreign owned companies per 1000 inhabitants
	4	Share capital of foreign owned companies as a % of total share capital
	5	Incomes from intellectual properties per inhabitant
	6	Percent of companies in NACE 24 and 29-34 divisions within all companies (high and medium tech manufacturing)
	7	Percent of companies in NACE 64 and 72-73 divisions within all companies (high-tech services)
	8	Percent of companies in NACE 74 division within all companies (business services)
	9	Number of knowledge-intensive firms with more than 50 employees
“Smart” infrastructure	1	Per cent of employees with university or college degree
	2	Percent of white collar workers in leading positions within all employees
	3	Number of full-time students in higher education institutions per 1000 inhabitants
	4	Number of teaching staff of higher education institutions per 1000 inhabitants
	5	Number of ISDN lines per 1000 inhabitants
	6	Registered members of public libraries per 1000 inhabitants
	7	Cinema visits per 1000 inhabitants
	8	Museum visitors per 1000 inhabitants
	9	Tourist arrivals in public accommodation establishments per 1000 inhabitants

Source: own construction

In the second step of the innovation performance analysis we compared the innovation performance of the sub-regions with respect to the SRSI and the KEI. For the calculation of the index values we built on the methodology of the European Innovation Scoreboard's Summary Innovation Index and Service Sector Innovation Index. On this basis the construction of our Sub-regional Summary Innovation Index is as follows:

1. *Calculating the minimum and maximum values for each indicator*. Regarding almost all of the 28 indicators, the values of some sub-regions significantly excelled the national average (usually positively). We considered a value to be an outlier if its distance from the national average exceeded the standard deviation more than four times. In most of the cases 1-3 values had to be considered as outliers. We removed the outliers when calculated the minimum and maximum values in order to avoid the extreme concentration of the index values. We also removed the values of the Budapest sub-region.
2. *Rescaling of the values*. We subtracted the indicator's minimum from each subregional value and divided by the difference of the maximum and minimum value. In this way all the rescaled values are between 0 and 1. Outlier received 0 or 1 depending on the direction of deviation.
3. *Calculating the sub-indexes*. The sub-indexes are calculated as the arithmetical mean of the rescaled values of the indicators in their group. We faced a dilemma about the occasional weighting of the indicators, but – just like in the case of the EIS – we rather put emphasis on the transparency of the method. In addition the development of an objective weighting system would have raised further questions.
4. *Calculating the SRSI*. The SRSI is calculated as the unweighted arithmetical mean of the three sub-indexes. The SRSI and the sub-index values are measured on scale therefore they are capable of being used for the comparison of the sub-regions. The distance of sub-regional innovation performance from the national average can also be interpreted in this way.

Out of the results of our innovation performance analysis *we utilized the SRSI and the KEI values*. The other two sub-index values are heavily influenced by indicators that can directly or indirectly be linked to the presence of HEIs, therefore we could not use them in our study. SRSI is also influenced by these indicators, even though we decided to use this index as a dependent variable. In this case the overall influence of HEI-related indicators are presumably much more modest, the effects of other indicators may overcompensate it. Nevertheless these results have restricted power.

For the calculation of the KEI we did not use any HEI-related indicators, so in this case we do not have to face such problem. The analysis of knowledge exploitation ability has basic importance in our examinations, since it may be able to transform the university outputs into increased economic performance.

5. Results

While presenting the results we follow the steps of analysis outlined in the methodological chapter 4.2. During the given steps we first show the results regarding the dependent variables SRSI and KEI, and than regarding the further two dependent variables. This is in line with the logic of universities' knowledge-effects, since innovation capacity (and especially the knowledge exploitation ability) can lead to the increased economic performance and incomes.

By comparing the performance of subregions with HEI (let us call them *study population*), and subregions without HEI (*control group*) we gained an overview on HEIs' effects on the dependent variables. The differences between the two groups are spectacular.

The SRSI and the KEI value of the study population (0,36 and 0,35) is significantly higher than in the case of the control group (0,13 and 0,18). With respect to the other two dependent variables the case seems to be more complex. Regarding the per capita GVA the study population departs from a significantly better position (well above the national average), which may be due to the size or partially the static income effects of HEIs. But the advantageous initial position did not infer a more intense growth rate. In fact the differences between the two groups decreased[11].

The case is quite similar regarding the change in "tax base per tax payer", however the differences are not too sharp this time[12]. The apparently higher base-year performance may partially explain the lower growth rates in itself, but only partially, since in Hungary the territorial disparities measured at both regional and subregional level widen (Lukovics 2008). Therefore the higher base-year values do not necessarily infer the lower growth rates.

Therefore spectacular differences appeared between the study population and the control group. However the direction of the deviation was surprisingly opposite regarding the innovation and the economic performance. Still, these differences cannot be unambiguously accredited to the presence of HEIs at this level of analysis, since they may derive from many other factors.

5.1. Explanatory power of the control variables

We attempted to reveal the causes of the differences between the study population and the control group by introducing control variables. First, we had to test the explanatory power of the used control variables. We fitted linear regression models

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[11] Change in per capita GVA compared to the national average in percentage points is -7,68 in case of the study population and 3,81 in case of the control group.

[12] Change in gross tax base per tax payer compared to the national average in percentage point is -0,39 in case of the study population and 0,33 in case of the control group.

on all our dependent variables, where a relevant set of the control variables were used as independent variables[13] (Table 3).

Table 3. The explanatory power of the control variables

			SRSI	KEI	GVA	Tax base
Control variables		Number of employees		x	x	x
		Population of the centre of the sub-region	x	x	x	x
		Per cent employment in manufacturing and construction				x
		Per cent employment in services	x			x
		Trade integration	x	x	x	
		Complex accessibility indicator		x		x
		Per cent of incomes generated by proprietorships	x			x
		Number of patents per 10000 inhabitants	x	x	x	x
		Base-year level of Gross personal tax-base per tax payer	x	x		x
		Base-year level of Gross Value Added per capita			x	
Model	**Summary**	R	0,916	0,916	0,551	0,611
		R Square	0,839	0,840	0,304	0,373
		Adjusted R Square	0,832	0,834	0,282	0,342
		Std. Error of the Estimate	0,051	0,053	48,935	3,720
		Durbin-Watson	2,156	2,041	2,009	2,253
	ANOVA	Sum of Squares	2,159	2,388	168066,069	1302,942
		df	6	6	5	8
		Mean Square	0,360	0,398	33613,214	162,868
		F	138,462	139,885	14,037	11,766
		Sig.	0,000	0,000	0,000	0,000

Note: “x” means that the given control variable has been put into the “base model”. We did not mark the Beta and t values of the given indicators, nor did we analyse their partial effects due to the strong multicollinearity of the models.
Source: own calculations

The explanatory power of the control variables are high regarding SRSI and KEI, while relatively low in case of per capita GVA and gross tax base per tax payer. This step of the analysis revealed which group of the control variables explains the variance of the given dependent variables the best, and how strong this

[13] The provided the detailed description of the method in *chapter 4.2.*

explanatory power is. We did not analyse the partial effects of the given indicators due to the strong multicollinearity of the models, but for the purpose of our study is was not necessary anyway. In the next step we attempt to control for the effects of these relevant control variables, and try to increase the explanatory power of these “base-models” by introducing the HEI-related variables.

5.2. Regional economic effects of the Hungarian HEIs

On the basis of the results of the previous step we here attempted to reveal the real effects of the HEIs. First, we analyzed the correspondence between our eight HEI-related variables and the dependent variables while we controlled for the effects of the relevant control variables. We calculated partial correlations while controlling for the effects of the independent variables of the “base-models” (presented in Table 3) – in other words the relevant set of control variables. These partial correlation results showed great differences with respect to the different dependent variables (Table 4).

Regarding the SRSI all the HEI-related variables proved to be significantly correlated while filtering the effects of the control variables. The partial correlation values are relatively strong and in all cases positive. Regarding the KEI only one partial correlation result proved to be significant (the number of degrees awarded in the fields of science, engineering and informatics), but the strength of the correlation is weak in this case. Regarding per capita GVA and gross tax base per tax payers non of the HEI-related indicators correlated.

Table 4. Partial correlation results

	SRSI		**KEI**		**GVA**		**Tax base**	
	Pear-son's	Sig	Pear-son's	Sig	Pear-son's	Sig	Pear-son's	Sig
Number of teaching staff in HEIs per 1000 inhabitants	**0,714**	0,000	0,101	0,202	0,680	0,389	0,100	0,210
Number of full-time students in HEIs per 1000 inhabitants	**0,678**	0,000	0,057	0,476	0,114	0,149	0,054	0,501
Number of scientists with PhD per 10000 inhabitants	**0,663**	0,000	0,068	0,390	-0,170	0,830	0,080	0,315
Is there a HEI in the sub-region	**0,391**	0,000	0,056	0,484	0,340	0,664	0,134	0,092
Is there a state HEI in the sub-region	**0,455**	0,000	-0,044	0,580	0,820	0,298	-0,040	0,618
Is there a university in the sub-region	**0,528**	0,000	0,034	0,672	-0,300	0,707	0,045	0,570
Is there a college in the sub-region	**0,363**	0,000	0,095	0,230	0,610	0,442	0,158	0,046
Number of degrees awarded in the fields of science, engineering and informatics	**0,606**	0,000	**0,133**	0,092	0,100	0,899	0,132	0,097

Source: own calculations

On the basis of these results we attempted to increase the explanatory power of the base-models by entering the relevant HEI-related indicators. In case of the KEI the only HEI-related indicator that showed significant partial correlation did not increase the explanatory power of the model. In connection with the SRSI we managed to further increase the high explanatory power of the base model (Table 5). We constructed here two models. In model 1 we used the backward method of the SPSS, and in this way four HEI-related indicators remained in the model. In model 2 we entered all the eight HEI related indicators and the control variables of the base-model. The explanatory power of both two models is very strong.

Table 5. The explanatory power of HEI-related indicators regarding SRSI

		Base model	Model 1*	Model 2*
Model summary	R	0,916	0,961	0,969
	R Square	0,839	0,924	0,939
	Adjusted R Square	0,832	0,920	0,934
	Std. Error of the Estimate	0,051	0,035	0,032
	Durbin-Watson	2,156	1,821	1,905
ANOVA	Sum of Squares	2,159	2,380	2,418
	df	6	9	14
	Mean Square	0,360	0,264	0,173
	F	138,462	212,4	167,8
	Sig.	0,000	0,000	0,000

Note: * Backward method. Dependent variable: SRSI. Independent variables: (1) Population of the centre of the sub-region (2) Per cent employment in services (3) Trade integration (4) Number of patents per 10000 inhabitants (5) Base-year level of GVA per capita (6) Is there a HEI in the sub-region (7) Number of teaching staff in HEIs per 1000 inhabitants (8) Number of full-time students in HEIs per 1000 inhabitants (9) Number of scientists with PhD per 10000 inhabitants. ** Enter method. Dependent variable: SRSI. Independent variables: the control variables of the "base model" and all the HEI-related indicators.
Source: own calculations

The results of our analysis indicate the very restricted economic effects of HEIs in the Hungarian sub-regions (not counting with the Budapest sub-region). Although the presence of HEIs influences the overall innovation performance of the host sub-region (which result has a limited power due to the set of indicators used[14]), the contribution to the knowledge exploitation ability can not be proved. Differences between the study population and the control group in this field can be well explained by the control variables. The introduction of HEI-related indicators does not provide extra explanatory power. Therefore *we accept our first hypothesis*.

Our results unambiguously show that the presence of HEIs does not affect the growth rate of per capita GVA (economic performance) and gross tax base per tax payer (incomes of the inhabitants). However these results leave the opportunity for the presence of income-effects open. Since the absolute values of the study population are significantly higher with respect to both two variables, the presence of income-effects is quite probable. At the same time these effects are static, do not influence the growth rates. Therefore we *do not accept our second hypothesis*, the presence of HEIs does not affect the growth of sub-regional economic performance and incomes in Hungary.

[14] We mentioned this in chapter 4.4.

6. Conclusions

In present paper we studied the link between the presence of higher education institutions and the innovation and economic performance of their host region in a transition country, Hungary. On contrary to developed countries, the local knowledge-effects of universities are not significant in Hungary (outside of Budapest), nor are the effects on the economic performance of the host region, and on the rise of local incomes.

By linking the presence of universities to the complex sub-regional innovation performance we found that the knowledge-producing ability did not result in increased knowledge-exploitation ability. In Hungary the university-based local economic development programmes are therefore carried out in such an environment, where the knowledge-producing and knowledge-exploiting abilities are spatially departed. Hence the success of these programmes depends to a great extent on the endogenous development of industries that build on the local knowledge-producing capacity. Such a process is inevitably slow and ambiguous.

We showed that the differences between sub-regions with and without HEIs do not derive from the presence of universities, they can be well explained by other factors. HEIs contribution is restricted to the optional presence of the income-effects, they are not able to boost the local economic performance or the disposable incomes of the residents.

In Hungary, in the studied period HEIs can not be considered as real „resources" of local development. Regional innovation systems are not able to link the knowledge-producing ability to knowledge-exploitation, thus the effects of universities may make themselves felt only in the national innovation system. But this inevitably infers the lower intensity of the effects, since several channels of university-industry relations require spatial proximity.

Our results suggest that the nature and intensity of higher education institutions' regional economic and innovation contribution differ in developed and transition economies. This infers a strong need for further empirical evidences from transition countries, and calls for a cautious adaptation of university-based development tool that proved to be successful in highly developed regions.

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