Universities' Impact on Regional Economic and Innovation Performance. A Hungariran Subregional Analysis.

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Abstract

Several success stories prove that universities are able to significantly influence regional economic and innovation performance. Partially due to this fact a number of regions 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. In spite of this, it is not at all obvious whether universities' significant regional contribution is a rule or rather an exception. On the top of this the validity of the relevant results of the literature cannot be unambiguously extended to transition economies.
Present paper aims to measure the contribution of Hungarian higher education institutions (HEIs) to regional economic and innovation performance. On the one hand, we attempt to adapt the methodology of a former US study of Goldstein and Renault to a transition economy, and instead of regional to subregional (LAU-1) level. One the other hand, we expand the focus of their method and connect the role of universities to complex territorial innovation performance, especially to knowledge exploitation ability. We conclude that HEIs have significant contribution to overall local innovation performance, but very limited contribution to the knowledge exploitation ability. This contribution is way 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
JEL classification: O18, O30, O43, R11

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 [1].

Nowadays "the growth in technological knowledge relies increasingly on science" [1, 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" [1, p. 77.]. The interdependencies and "co-evolutionary" knowledge production between the academic and business sphere is widely recognized in the literature of innovation systems [4, 5] and especially in the triple helix concepts [1, 6].

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 [6, 7, 8] the spatiality of these mechanisms [9, 10, 11, 12] and the transformation within the academic sphere that enables the operation of these mechanisms [1, 13, 14, 15].

Regional science has made a very important contribution to this issue. They have shown that the flow of knowledge from universities to industries is spatially bounded [16, 17, 10, 18]. Since economic actors cannot equally benefit from university "spillovers" in different places, the spatial distribution of academic knowledge production becomes a significant factor of economic development [19]. However we still have a lot of questions unresolved regarding the contribution of the academic sphere to the economic and innovation performance of regions. We have well documented cases, where the contribution of the academic sphere was 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 many cases questioned [20, 21, 22]. There are also cases in the literature where the effects of large research universities are more or less absent [9].

Although several attempts – that will be surveyed in the next chapter – have been made to uncover, whether *universities' economic contribution is a rule or rather an exception*, certain issues still generate lively debates. *First*, the empirical evidences are constrained to a few countries. The evidences hardly regard less developed and transition economies, however in many of these countries a number of central and local development strategies are based on the hoped economic development effects of universities. *Second*, the way of capturing innovation in the econometric models of university knowledge spillovers is often criticized. *Third*, it is very difficult to carry out nationwide (or an even broader) analyses on a low level of territorial aggregation, therefore subregional analysis are almost totally absent in the literature.

In present paper we attempt to focus on these three crucial fields. We analyze whether universities' contribution to territorial innovation and economic performance can be proved in a transition economy, namely in Hungary. We use an innovation system based approach to capture territorial innovation performance, to measure universities' contribution and to carry out a countrywide analysis on a subregional level. In chapter 2 we provide a brief review of the literature of universities' regional contribution and draw attention the certain problematic fields. 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 subregional (LAU-1) database. In chapter 5 we show the results of the analysis and we draw our conclusions in chapter 6.

2 Regional economic contribution of universities

While the role of the academic sphere is widely recognized in the systems of innovation and therefore in (regional) economic development, only a smaller part of this literature 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.

Although the external relations of the universities are to a great extent globally tied, a certain part of university-industry relations have strong spatial characteristics. This is due to the fact that the technology transfer process is embedded into the contexts of local routines and in many cases requires regular personal interactions [8]. Hence local embeddedness gains an important role, which sheds light on the importance of the analysis of the local and regional innovation systems [21]. Also policy competences and institutions that influence university-industry relations are in many cases bound to subnational territories [20]. On the top of this, knowledge 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) [23]. A number of innovation models emphasize that innovation is a spatial phenomenon, depending to a great extent on resources that are region-specific and cannot be reproduced elsewhere [24, 25, 26] and influenced by institutions and organizations that are region-specific [27, 28]. Although the literature of territorial innovation models is heterogeneous [29, 30], the given approaches usually emphasize the importance of the local specifities (participants and relations), the learning ability, which naturally sheds light on the essential role of knowledge-producing organizations.

Therefore the spatial characteristics of universities' effects have 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" [12]. 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 [31, 11, 23]. 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 unable to catalyze the local economy, and static in nature. 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.
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 efficiency of private innovation activities in case of spatial proximity [16, 17, 10, 18]. 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 these studies are often criticized for the way they capture innovation capacity. They either use number of patents or a literature based innovation measure that basically captures R&D-based high-tech product innovation activity. So they exclude a whole range of potential innovations that have vital importance especially in transition countries. The European Innovation Scoreboard [32] shows for example that in Hungary 55% of innovative firms do not conduct any R&D. This proportion is also reinforced by Csizmadia [33] and Inzelt – Szerb (2003).

Beside the knowledge externalities connected to the formalized R&D results, there may be numerous other channels of universities' potential regional economic effects. Therefore it is still a pivotal question that, to what extent are universities' effects 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 [12] 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 compared to national average, but only after 1986, when – as a consequence of the Bayh-Dole Act – universities started to make serious efforts to strengthen their industrial relations. (Although the Bay-Dole Act was adopted in 1980, its effects became measurable only a few years later.) 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 above results provide strong supporting evidence about universities regional economic and innovation effects, they still leave a lot of questions open, and cannot be unambiguously exteriorized to transition economies.

First, in the transition countries the performance of the regional innovation systems is characteristically weak [35] and in many cases heavily influenced by foreign affiliates [36]. University-industry relations are far from being a real triple helix [7, 37], 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 [38, 39, 40, 41].

Second, the literature of university knowledge spillovers indirectly interprets territorial innovation capacity as the R&D based product (and possibly process) innovation performance of the private sector. However, the literature of innovation systems stresses that there is a whole range of factors influencing territorial innovation capacity. Measurement approaches rooted in this tradition use a complex set of indicators that are able to reflect the operation of the innovation system [32, 42, 35, 43]. The main advocates of the innovation system literature agree that the innovation potential (capacity) of a territorial unit (country or region) must be considered as a large set of influencing factors and their relation [3, 4, 44].

Third, a large part of universities' expected effects are markedly local. This infers that even the regional level may be too wide to capture certain processes or differences. At the same time the difficulties of data access usually prevents scholars from going beyond the level of regions. While methods remaining at a higher level of territorial aggregation provide greater opportunities for nationwide and international comparison and the use of more sophisticated data sets, they are unable to reflect to the subregional (local) characters of the examined phenomenon.

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 Hungarian higher education institutions' (HEIs) ability to boost their host region's economy.

First, we attempt to link the presence of HEIs to the complex innovation performance of the subregions. Since we are engaged in capturing territorial innovation capacity in a complex way on the basis of the innovation system literature we have to face a vital methodological problem. An important aspect of the complexly measured territorial innovation performance is the knowledge creating ability of a region, which is to a great extent, depends on the presence of HEIs. This infers that contribution of HEIs to overall performance is strongly expected. Therefore, in line with the literature of regional innovation systems [27, 28, 45], we distinguish three main components of the subregional innovation capacity: the knowledge-creating ability, the knowledge exploitation capacity and the innovation or "smart" infrastructure of the region. On this basis we conceptualized our first hypothesis:

> *Hypothesis 1*: Higher education institutions contribute significantly and positively to subregional 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 obvious at all:

> *Hypothesis 2*: Higher education institutions do not contribute significantly to the growth of subregional economic performance and the income of the residents.

The literature that deals with the economic contribution of the academic sphere links the studied effects basically to research universities. At the same time the knowledge-effects may occur in connection with colleges as well [46, 47]. In this case, though, fewer channels are available for the transmission of the effects. Nevertheless, the importance of non-R&D innovations in transition countries suggests that universities may not be the only significant players in this respect.

> *Hypothesis 3*: The subregional innovation and economic effects of higher education institutions cannot be solely linked to universities.

4 Methodology

For the purpose of our study we took the analysis of Goldstein and Renault [12] 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 subregional economic performance. *Second*, we carried out our analysis on local (LAU-1) level, which significantly influenced data availability. Therefore we had to make certain changes on the set of indicators used. *Third*, we carried out our examinations in such a country, where the subregion of the capital (Budapest) concentrates a significant proportion (one fifth) of the population, gross value added (GVA) and research capacities. This inevitably had to be considered in the statistical analysis.

The examined period was 1998-2007, while the units of our analysis were the 168 Hungarian (LAU-1) subregions (defined by the Government Regulation 244/2003). Although the presently valid classification defines 174 subregions, the statistical data used by us could not be aggregated according to the new territorial classification in all cases. For the computations we used MS Excel and SPSS 15.0.

4.1 Used indicators

For analyzing the HEIs' regional effects, we used three set of indicators: the dependent variables (which indicate the potential forms of contribution), HEI-related 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 [12]. These changes were partially due to the differences in the focus of examination and partially due to the restricted subregional data availability (*Table 1.*).

Two of the *dependent variables* are related to the innovation performance: the subregional summary innovation index (SRSI) and the knowledge-exploitation index (KEI). 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 subregional 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, while the gross tax base per tax payer captures the disposable incomes of the residents. Goldstein and Renault [12] used the wages as dependent variable, but in this case we also had to face the unavailability of the data in subregional level.

The computation of the variables is analogous to the method of Goldstein and Renault [12]. We first calculated the values of the variables as a percentage of the national average for each subregion for 1998 and for 2007. The dependent variable is then calculated as a difference in the indexes for the given subregion 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.

Table 1. Indicators of the analysis

	Economic Effects	Innovation Effects
DEPENDENT	Change in the gross personal tax base per tax payer compared to national average (in % points)	Subregional Summary Innovation Index (SRSI)
	Change in the gross value added per capita compared to national average (in % points)	Knowledge Exploitation Index (KEI)
HEI-RELATED	Is there a HEI in the subregion	Is there a HEI in the subregion
	Is there a university in the subregion	Is there a university in the subregion
	Number of scientists with PhD per 10000 inhabitants	Number of scientists with PhD per 10000 inhabitants
	Number of full-time students in HEIs per 1000 inhabitants	Number of full-time students in HEIs per 1000 inhabitants
	High education in the fields of science, engineering and informatics	High education in the fields of science, engineering and informatics
CONTROL	Number of employees	Number of employees
	Population of the centre of the subregion	Population of the centre of the subregion
	Percent employment in manufacturing and construction	
	Percent employment in services	
	Complex accessibility indicator	Complex accessibility indicator
	Percent 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	

Note: The source of data is TEIR (Hungarian Spatial Development Information System), Higher Education Statistical Database of the Ministry of Education and Culture and own computation in case of the SRSI and KEI. Indicators refer to 1998 and 2007 respectively, except for the complex accessibility indicator that was calculated only once in 2004.

The *presence of HEIs* is measured by five indicators. Two of them are dummy variables (present or not in the subregion), while three are measured on scale. These latter are indicators related to the basic functions of the universities: the number of scientists with PhD, the number of full-time students 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 HEIs the use of HEI-related indicators is not sufficient, since the difference between subregions 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 subregion. Instead of using the overall population of the subregion, we decided to introduce the population of the centre of the subregion, which better indicates the size of the local concentration. In order to map the economic structure of the subregions we used two variables: the relative weight of manufacturing and services in the employment. We indicated the accessibility of the subregion by the complex accessibility index of the Hungarian Central Statistics Office [48]. The index considers the time distance from the nearest county-centre (40%), from the nearest subregion-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 subregional index is calculated.

Several empirical results prove the link between entrepreneurship and economic performance [49]. We used two variables in this category: the percent of incomes generated by proprietorship and the number of patents per 10000 inhabitants. In Hungary the number of private sector patents is not available for subregions, but in the examined period (basically due to regulatory causes) the patent activity of the academic sector is very low. We considered furthermore the base-year performance of the subregion to control the endowment effect. In case of the analysis of the innovation effects we decreased the number of control variables, since part of them are taken into account as components of the subregional innovation performance.

4.2 The steps of the analysis

We carried out the analysis of HEIs' potential contribution in three steps. *The first step* is similar to a quasi-experimental research design, where we divided the Hungarian subregions into "study population" and "control group" on the basis of two HEI-related criteria:

- is there a university or a college (a HEI) in the subregion,
- is there a university in the subregion,

Actually, we compared certain indicator values of the "study population" (consisting of subregions with HEI) to the "control group" (consisting of subregions without HEI). Since the gained differences may derive from many influencing factors, we had to carry out further steps to capture the real effects of the HEIs.

In the *second step* 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 *third step* we attempted to unfold the extent of university contribution. We used here two methods. Fist, 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 correlation results 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 the 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 subregion

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 subregion of the capital (Budapest). The values of the Budapest subregions significantly influence the average values of the dependent variables and thus distort the results of our examinations. This effect is so significant that we had to remove the values of the Budapest subregion 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 subregions

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 subregion. Innovation performance data on the Hungarian subregions were not available thus we had to carry out our own analysis to construct these data. The detailed results of this subregional innovation measurement exercise is available at [50].

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 [27] approach on the structure of regional innovation systems, the smart infrastructure concept of Smilor and Wakelin (quoted by [51]), which has became widely known through the interpretation of [45], and the arguments of Florida [52] on the economic geography of talent. We attempted to define our subindexes in such a way that they should reflect to the elements of a "typical" regional innovation system.

In purpose of the index selection several measurement attempts served as a basis, such as: Summary Innovation Index of the European Innovation Scoreboard [32], the Service Sector Innovation Index of the European Trend Chart on Innovation [43], the EXIS Summary Index [42], the National Innovative Capacity Index of Porter and Stern [53] ,the Europe Creativity Index of Florida and Tingali [54] ,the RRSI Index of the European Regional Innovation Scoreboard [35], the analysis of Csizmadia and Rechnitzer [33] regarding the innovation potential of Hungarian cities and Kocziszky's survey [55] on the innovation potential of the North-Hungarian subregions. Besides, *the subregional availability of data* influenced the construction of the indicator-set.

Based on all this, *the survey was started with 26 indicators*, eight of which were classified in the subindex of knowledge creation, nine fell in the subindex of knowledge exploitation and another nine were included in the "smart" infrastructure. The subindexes measure the performance in these three categories and they serve as the basis of the *Subregional 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. Indicator set for measuring subregional innovation capacity

Category		Indicator	
Knowledge creation	1	Number of R&D performing units per 100000 inhabitants	1
	2	Total staff of R&D units per 1000 inhabitants	2
	3	Number of scientists with PhD per 10000 inhabitants	3
	4	Number of teaching staff of higher education institutions per 1000 inhabitants	4
	5	Investments of R&D units per 1000 inhabitants	5
	6	R&D costs per 1000 inhabitants	6
	7	Expenditures of R&D places per 1000 inhabitants	7
	8	Number of patents in a 5 year period per 10000 inhabitants	8
Knowledge exploitation	1	Export sales as a percent of total sales	9
	2	Export sales per inhabitant	10
	3	Number of foreign owned companies per 1000 inhabitants	11
	4	Share capital of foreign owned companies as a % of total share capital	12
	5	Incomes from intellectual properties per inhabitant	13
	6	Percent of companies in NACE 24 and 29-34 divisions within all companies (high and medium tech manufacturing)	14
	7	Percent of companies in NACE 64 and 72-73 divisions within all companies (high-tech services)	15
	8	Percent of companies in NACE 74 division within all companies (business services)	16
	9	Number of knowledge-intensive firms with more than 50 employees per 100000 inhabitants	17
Smart-infrastucture	1	Percent of employees with university or college degree	18
	2	Percent of white collar workers in leading positions within all employees	19
	3	Number of full-time students in higher education institutions per 1000 inhabitants	20
	4	Number of ISDN lines per 1000 inhabitants	21
	5	Broad band internet access per 1000 inhabitants	22
	6	Registered members of public libraries per 1000 inhabitants	23
	7	Cinema visits per 1000 inhabitants	24
	8	Museum visitors per 1000 inhabitants	25
	9	Tourist arrivals in public accommodation establishments per 1000 inhabitants	26

Note: The innovation performance refers to year 2007, however in case of certain indicators we had to consider the last available data (indicators 14-17 refer to 2005, 3 and 8 refer to 2004, and 18-19 refer to 2001). At indicators 14-16 the sector codes refer to TEÁOR'03 (NACE 3.1). The source of data: TEIR – Hungarian Spatial Development Information System, Hungarian Central Statistics Office (HCSO) Central and Territorial Database, HCSO R&D Database, HCSO Census Database, Hungarian Patent Office Pipacsweb Database and Hungarian Academy of Sciences General Assembly Database.

In the *second step of the innovation performance analysis we compared the innovation performance of the subregions* 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 Subregional Summary Innovation Index is as follows:

1. *Calculating the minimum and maximum values for each indicator*. Regarding almost all of the 26 indicators, the values of some subregions 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 subregion.
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 subindexes*. The subindexes 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 subindexes. The SRSI and the subindex values are measured on scale therefore they are capable of being used for the comparison of the subregions. The distance of subregional 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 subindex 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 is 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. The measurement of the subregional innovation performance is certainly characterized by huge weaknesses, such as its limited ability to capture the relations among the elements of the system, or the lack of innovation survey data. We still believe that at this very low level of aggregation our indexes might be able to provide a more complex picture of territorial innovation capacity than methods that equal innovation performance with one highlighted indicator.

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 then 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.

5.1 Comparing subregions with and without HEIs

On the basis of the presence of HEIs we classified the Hungarian subregions into a study population and a control group. By comparing the performance of the two groups we gained an overview on HEIs' effects on the dependent variables. Since a relative small proportion of Hungarian subregions host a HEI, we could not create a more sophisticated classification (combined with the control variables).

Table 3. The innovation performance of subregions with and without HEIs

	Yes					No				
	N	SRSI mean	Percent of subregions above the national average	KEI mean	Percent of subregions above the national average	N	SRSI mean	Percent of subregions above the national average	KEI mean	Percent of subregions above the national average
Is there a HEI in the subregion	25	0,32	84,00	0,30	80,00	142	0,13	27,46	0,18	35,92
Is there a university in the subregion	9	0,45	100,00	0,36	100,00	158	0,14	32,28	0,19	39,24

There is significant difference between the innovation performance of the study population and the control group both regarding SRSI and KEI (*Table 3.*). Both the means and the proportion of subregions above the national average are higher in the study population. We must note however, that these differences may derive from many factors beside the presence of HEIs (or universities), such as the size of the subregion, or its position in the city hierarchy. The effects of such variables will be controlled in the forthcoming steps of the analysis.

Table 4. The economic performance of subregions with and without HEIs

	Yes				**No**			
	N	GVA per capita compared to the national average (1998)	Change in GVA per capita compared to the national average in %-points (1998-2007)	Percent of subregions with positive value	N	GVA per capita compared to the national average (1998)	Change in GVA per capita compared to the national average in %-points (1998-2007)	Percent of subregions with positive value
Is there a HEI in the subregion	25	148,96	-14,68	52,00	142	76,39	7,15	40,84
Is there a university in the subregion	9	151,39	-16,37	22,22	158	89,58	3,12	43,67

The results are much more blurred in case of the change in the GVA per capita (*Table 4.*). 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.

The case is quite similar regarding the change in "tax base per tax payer", however the differences are not too sharp this time (*Table 5.*). 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 [56]. Therefore the higher base-year values do not necessarily infer the lower growth rates.

Table 5. The incomes of subregions with and without HEIs

	Yes				No			
	N	Gross tax base per tax payer compared to the national average (1998)	Change in gross tax base per tax payer compared to the national average in %-points (1998-2007)	Percent of subregions with positive value	N	Gross tax base per tax payer compared to the national average (1998)	Change in gross tax base per tax payer compared to the national average in %-points (1998-2007)	Percent of subregions with positive value
Is there a HEI in the subregion	25	109,56	-0,73	44,00	142	94,81	0,56	54,23
Is there a university in the subregion	9	111,96	-1,00	22,22	158	97,28	0,31	54,43

On the basis of the first step of our analysis 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.

5.2 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 on all our dependent variables, where a relevant set of the control variables were used as independent variables (*Table 6.*).

Table 6. The explanatory power of the control variables

			SRSI	KEI	GVA	Tax base
Control variables		Number of employees	x	x	x	x
		Population of the centre of the subregion	x	x	x	x
		Percent employment in manufacturing and construction				
		Percent employment in services				x
		Complex accessibility indicator	x	x	x	x
		Percent of incomes generated by proprietorships				x
		Number of patents per 10000 inhabitants				x
		Base-year level of Gross personal tax-base per tax payer				x
		Base-year level of Gross Value Added per capita			x	
Model	**Summary**	R	0,835	0,735	0,514	0,654
		R Square	0,697	0,541	0,264	0,428
		Adjusted R Square	0,693	0,532	0,246	0,402
		Std. Error of the Estimate	0,059	0,078	63,647	3,620
		Durbin-Watson	2,112	2,102	1,950	2,053
	ANOVA	Sum of Squares	1,297	1,161	235192,990	1556,537
		df	2	3	4	7
		Mean Square	0,649	0,387	58798,247	222,362
		F	188,574	64,013	14,515	16,966
		Sig.	0,000	0,000	0,000	0,000

"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.

The explanatory power of the control variables are high regarding SRSI and KEI, while moderate in case of gross tax base per tax payer and rather low in case of the per capita GVA. 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 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 it 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.

5.3 Regional effects of the Hungarian HEIs

On the basis of the results of the previous steps 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 6.*) – in other words the relevant set of control variables. These partial correlation results showed great differences with respect to the different dependent variables (*Table 7.*).

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 modest (rather strong in one case) and positive. *Regarding the three other variables* none of the HEI-related indicators correlated significantly, when controlling for the variables of the base models.

Table 7. Partial correlation results

	SRSI		KEI		GVA		Tax base	
	Pearson's	Sig	Pearson's	Sig	Pearson's	Sig	Pearson's	Sig
Is there a HEI in the subregion	**0,302**	0,000	0,098	0,214	0,062	0,432	0,159	0,045
Is there a university in the subregion	**0,340**	0,000	0,021	0,788	-0,027	0,731	-0,045	0,575
Number of scientists with PhD per 10000 inhabitants	**0,657**	0,000	0,094	0,232	0,012	0,880	0,029	0,717
Number of full-time students in HEIs per 1000 inhabitants	**0,578**	0,000	0,054	0,489	0,069	0,384	0,029	0,716
Number of degrees awarded in the fields of science, engineering and informatics	**0,322**	0,000	0,049	0,530	0,034	0,669	0,008	0,919

On the basis of these results we attempted to increase the explanatory power of only one base model, the one that regards SRSI (*Table 8.*). We used two methods to try to complement the base model with the HEI-related indicators. In *model 1* we used the backward method of the SPSS, and thus 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, however it was already the case at the base model.

Table 8. The explanatory power of HEI-related indicators regarding SRSI

		Base model	Model 1*	Model 2**
Model summary	R	0,835	0,920	0,921
	R Square	0,697	0,847	0,849
	Adjusted R Square	0,693	0,841	0,842
	Std. Error of the Estimate	0,059	0,042	0,042
	Durbin-Watson	2,112	1,965	1,970
ANOVA	Sum of Squares	1,297	1,576	1,580
	df	2	6	8
	Mean Square	0,649	0,263	0,198
	F	188,574	147,102	111,167
	Sig.	0,000	0,000	0,000

* Backward method. Dependent variable: SRSI. Independent variables: (1) Number of employees (2) Population of the centre of the subregion (3) Complex accessibility indicator (4) *Is there a HEI in the subregion (5) Number of scientists with PhD per 10000 inhabitants (6) Number of full-time students in HEIs per 1000 inhabitants.*
** Enter method. Dependent variable: SRSI. Independent variables: the control variables of the "base model" and all the HEI-related indicators.

We must also consider an important limitation of the used methodology that we have earlier outlined in the methodological chapter. In the course of analysing the overall subregional innovation performance one of our subindexes measured the knowledge creating ability that was heavily influenced by indicators that can directly or indirectly be linked to the presence of HEIs. Therefore the correspondence between the SRSI and the presence of HEIs was strongly expected.

The results of our three-step analysis indicate the very restricted effects of HEIs in the Hungarian subregions (not counting with the Budapest subregion). Although the presence of HEIs influences the overall innovation performance of the host subregion (which result has a limited power due to the set of indicators used), the contribution to the knowledge exploitation ability cannot 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 did not provide extra explanatory power. Therefore *we accept our first hypothesis.*

Neither did the HEI related indicators influence the growth rate in GVA and tax base, when we considered the effects of the control variables. 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 result in dynamic growth, or in other words HEIs are unable to be the catalysts of regional development in Hungary. This does not infer the lack of HEIs contribution in all the subregions, but this potential catalytic role is far from being general. Therefore *we accept our second hypothesis*.

In the light of the above results, deciding on the third hypothesis is fairly dubious. We could not find significant differences depending on which criteria we used to define the study and the control population. Furthermore we could not prove the significant contribution of nor the whole set of HEIs, neither for the universities. Therefore *we cannot decide on the third hypothesis*, but it might serve as a basis for further research efforts.

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 innovation effects of universities are not significant in Hungary (outside of Budapest), nor are the effects on the productivity of the host region's enterprises, neither on the rise of local incomes.

By linking the presence of universities to the complex subregional 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 subregions 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 cannot be considered as real „resources" of local development. Regional (local) 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.

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