Higher Education Institutions Performance in Convergence Regions after the EU Enlargement – Case of Slovakia[1]

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Abstract

The membership expansion of EU in 2004 brought some challenges for post--communist countries which were expected to approach the EU average. Regional policy of EU provided new member states with significant support in order to catch up. Although cross-country convergence appeared, convergence within the countries is still not clear. Institutions can play a crucial role in economic development, especially universities. During 2007 – 2015 were Slovak higher education institutions supported mostly in convergence regions and the support should be seen in their better performance. A main goal of this paper is to find out whether the efficiency of Slovak public higher education institutions in convergence regions changed comparing to Bratislava region after the first entire programming period 2007 – 2013. A Data Envelopment Analysis is applied to compare years 2007 and 2015. The results show that public higher education institutions in less-developed regions in Slovakia indeed experienced a convergence comparing to Bratislava region, especially in the area of research that was mostly supported from Structural Funds.

Keywords*: higher education institutions, regional policy, cohesion policy, data envelopment analysis, institutional convergence*

JEL Classification: I23, R58

Introduction

The EU enlargement of ten new member states in 2004 represented the most significant membership expansion of the European Union. In order to ensure the convergence of EU regions, Regional Policy (Cohesion Policy) of the EU thus

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had to put even more emphasis on improving the regions that are less developed with lower economic and social performance. Countries of Central and Eastern Europe or so-called post-communist countries faced a difficult situation in political, economic and social area and they were expected to converge to EU average. Therefore, Regional Policy of EU provided them with funding in order to catch up. The sources represented significant support for further development (Dabrowski, 2008; Abrahám, 2011) and most post-communist regions were included among the areas with the highest rates of entitlement to aid.

With no doubts then arises a question how EU funds affected these regions. Several studies used macro models to empirically estimate influence of EU funding (Gillespie et al., 2001; Bradley, 2006). EU regions have according to the official macroeconomic indicators like GDP per head, employment or share of higher education institutions indeed shown a path of convergence since 2000, but there are still huge differences among them (Goecke and Huther, 2016). Studies often find convergence in countries of Central and Eastern Europe (Paas et al., 2007; Niebuhr and Schlitte, 2009) including V4 countries (Nežinský and Fifeková, 2014; Deichman et al., 2017), however, mostly on cross-country level. Focusing on convergence within the post-communist countries, the results are not clear (Paas et al., 2007; Abrahám, 2011) and show that regional disparities have strong pattern of polarisation (Monastiriotis, 2014). For more precise assessment, there are also studies that measure efficiency of concrete actions (Cerqua and Pellegrini, 2014). However, Rodriguez-Pose (2013) points out that for every development intervention, the quality of institutions is important and enables the interventions to be more successful. Thus, studies also measure the quality of institutions as a factor related to regional disparities and effectiveness of Structural Funds (Kyriacou and Roca-Sagalés, 2012). Institutional development in post-communist countries including Slovakia is considered to be backward (NBS, 2017).

Institutions are indeed crucial for economic development (Rodriguez-Pose, 2013), especially specific local institutions are believed to have an influence (Streeck, 1991). Because education is often assumed to be a factor of development (Mankiw, Romer and Weil, 1992), there is a broad literature discussing the role of educational institutions in regional development. Higher education institutions (HEIs) are employers, payers of wages and salaries, buyers of products and services and attractors of students spending money in the region (Etzkowitz et al., 2000; Rehák et al., 2015). They also bring economic contributions in commodification of knowledge produced through intellectual property right, science parks, technology transfer or spin-off firms (Goldstein, 2010). Additionally, over the years appeared new contributions of higher education institutions to region that have moved away from economic to a non-economic area, where

they shape the quality of graduates or are even considered as regional stakeholders and active local and regional promoters in area they are located (Boucher, Conway and van der Meer, 2003; Uyarra, 2010).

In this article we investigate changes in performance of public HEIs in Slovakia as one of post-communist countries, where these institutions can be important player in regional development as well, especially may be helpful in convergence regions. Since 2007, HEIs have received significant amount of EU funds as additional source to national funding and most support was allocated within the public HEIs in convergence regions. We expect that it should be seen in their better performance. This approach differs from previously mentioned, mainly macroeconomic studies and may provide additional findings on convergence of institutions crucial for regional development. Especially, in countries of Central and Eastern Europe where convergence within countries is not clear.

We apply Data Envelopment Analysis, a non-parametric method that is commonly used in studies (Athanassopoulos and Shale, 1997; Johnes, 2006; Kuah and Wong, 2011; Korónyand Hronec, 2012; Kosor, 2013) to measure relative efficiency of higher education institutions. Because we compare efficiency of DMUs over time, we apply Malmquist productivity index (MPI) along with DEA method. Our aim is to explore whether the relative efficiency of public HEIs in convergence regions changed comparing to Bratislava region after the first entire programing period 2007 – 2013. Because Slovak universities could benefit from EU funding from 2007 until 2015, we compare efficiency scores of public HEIs in years 2007 and 2015. DEA handles a multiple inputs and multiple outputs which makes it an appealing choice for measuring the efficiency of higher education institutions, where the usual market indicators of performance cannot be used accurately (Abott and Doucouliagos, 2003; Johnes, 2006; Kuah and Wong, 2011).

1. Support of Higher Education Institutions in Slovakia

The national funding model of HEIs in Slovakia is as in many EU countries (Pruvot, Claeys-Kulik and Estermann, 2013) based on performance indicators. To stimulate their effort, higher education institutions have also a possibility to receive financial sources trough a competitive project mechanism established in the country. This includes three research agencies – the Scientific Grant Agency, the Cultural and Education Grant Agency and the Slovak Research and Development Agency. All three reallocate the funds given by the Ministry of Education, Science, Research and Sport (Ministry of Education). The entire national funding system should lead to greater support for better and more efficient higher education institutions.

The enlargement of Slovakia into the European Union in 2004 brought additional resources for the country as well as for the institutions including HEIs. On the contrary, these funds were more oriented on less developed regions and institutions within them. The aid during the first programming period (2004 – 2006) focused more on general issues and areas, though. Finally, the programming period 2007 – 2013 set Operational Programs (OP) suitable also for HEIs. During 2007 – 2015 were HEIs able to use EU financial support for the first time within the entire programming period. Two OP were determined: OP Research and Development funded from the European Regional Development Fund and OP Education funded from the European Social Fund (Government Office of the Slovak Republic, 2013).

Activities funded from EU funds were supposed to adapt higher education to the needs of knowledge based on society and the labour market e.g. in support of bachelor studies as full-fledged higher education studies in the economic practice and society. OPs also provided the HEIs with an opportunity to modernize their research and laboratory infrastructure and equipment or build and modernize a local supporting IT infrastructure for R&D. Additionally, HEIs could purchase machines, devices and laboratory instrumentation or intangible assets like software or licenses, build computer networks, purchase ICT technologies or rent all that equipment during the project. Slovak HEIs could also participate on joint research projects in cooperation with foreign R&D organizations or projects in areas of strategic importance for the further development of the economy and the society. EU also funded transfer of knowledge and technology from R&D into practice by raising innovation culture by incubators or by supporting applied R&D (Ministry of Education, 2007a; 2007b). Nowadays we can conclude that the programming period 2007 – 2013 has mainly brought restoring the infrastructure to HEIs and the creation of various types of research centres such as centres of excellence, industrial research and development centres, centres of competence, university science parks and research centres of national importance (Ministry of Education, 2014).

During 2007 – 2015, funds from EU represented a significant source of income for higher education institutions. On average, these resources counted for slightly more than 12% of all national funds but they differed each year. While at the beginning of the programming period they accounted for just over 1%, reaching a peak in aid spending in 2013 accounted for 23.78% of the resources that have been allocated under the Chapter Higher Education Institutions of the Ministry of Education (Šipikal and Némethová, 2017). In terms of use of resources from the Structural Funds, dominant was support of research against support of education. The total contracted volume of resources in the programming period

2007 – 2015 for higher education institutions was more than 860 million euros compared to the total volume of resources they contracted within the OP Education, which reached just over 92 million euros (Šipikal and Némethová, 2017). Most of the funds (63.43%) was spent on HEIs in convergence regions (Šipikal and Némethová, 2017).

2. Methodology

The aim of this paper is to find out whether the efficiency of Slovak public HEIs in convergence regions changed comparing to Bratislava region after the first entire programming period 2007 – 2013. We apply NUTS II classification of regions which divides Slovakia into four regions – SK 01 Bratislava Region, SK 02 Western Slovakia, SK 03 Central Slovakia and SK 04 Eastern Slovakia. Only Bratislava Region is considered to be a developed one having a GDP per capita over 75% of EU average. Analysis is run on all public HEIs in Slovakia (20) and this number has not changed over the period. We include into analysis only public HEIs as they awarded 96% of all grants allocated to HEIs by national research agencies and Research agency in 2007 – 2015 (Lešková and Šipikal, 2017).

An efficiency by itself is in our analysis a performance indicator which is usually measured in studies by Data Envelopment Analysis (DEA), Stochastic Frontier Estimation or Regression analysis (Kosor, 2013). Stochastic Frontier Estimation and Regression analysis require a set of explanatory variables and the dependent variable. DEA proposed by Charnes, Cooper and Rhodes (1978) is a non-parametric frontier analysis that provides efficiency estimates which are not conditional on the specific functional form. Moreover, DEA handles a multiple inputs and multiple outputs which makes it an appealing choice for measuring the efficiency of HEIs, where the usual market indicators of performance cannot be used accurately (Belfield, 2000; Cohn and Cooper, 2004). By using the linear programming methods, DEA constructs a piecewise linear surface over the data. The best identified performers are then on the frontier and non-efficient subjects are in the interior of the frontier (Kosor, 2013). DEA is commonly used to examine the problems of measuring the performance of HEIs (Athanassopoulos and Shale, 1997; Abott and Doucouliagos, 2003; Johnes, 2006; Kuah and Wong, 2011; Kosor, 2013). However, because we compare efficiency of units over time, we apply Malmquist productivity index (MPI) along with DEA method. The method is suggested by Färe et al. (1994) and used in other studies as well (Garcia and Palomares, 2008). MPI represents total factor productivity growth of a unit reflecting change in efficiency along with change of the frontier technology over time using multiple inputs and multiple outputs.

Application of BCC model (Banker, Charnes and Cooper, 1984) with variable returns to scale ensures that only HEIs within the same size are compared to each other in the model. We use input-oriented model which answers whether the decision making units (DMUs) could yield the same outputs by using less inputs. Some authors claim to have the number of DMUs at least twice the number of inputs and outputs (Golany and Roll, 1989), others recommend at least three times the number of DMUs as the number of inputs and outputs (Bowlin, 1998). Our model implies 3 inputs and 3 outputs and the number of DMUs is 20, therefore it follows the conditions.

MPI or change in efficiency scores of HEIs are afterwards correlated to amount of funding given to HEIs during 2007 – 2015 from Structural Funds to see whether it might have some impact on their performance. We distinguish OP Education in teaching area and OP Research and Development in research area.

The inputs and outputs selection is not definitively determined in university efficiency assessment and studies have used various models so far. However, it has been agreed to consider human and physical capital as the inputs for HEIs while the outputs should result from teaching and research activities (Johnes, 1996). One might even say that HEIs have more functions and therefore the relative efficiency of each function should be considered separately. Kuah and Wong (2011) recognized the teaching efficiency model and the research efficiency model. We consider this approach to provide deeper analysis of efficiency and therefore apply it as well.

Obviously, an appropriate application of DEA is heavily dependent on the data set. The lack of the method is that there are no estimates or significance tests of the parameters. Another lack of the method is that it identifies few efficient units operating at best practice. This means that at least some higher education institutions will be given a score of one, but in reality even the best performers do not necessarily operate on the frontier (Abbott and Doucouliagos, 2003). For the purposes of this study, which is to identify whether the HEIs in convergence regions improved performance comparing to those in Bratislava region, this does not seem to be an issue.

2.1. Inputs and Outputs for Teaching Efficiency

The argument in the teaching efficiency model claims that higher education institutions employ academic staffs in order to educate enrolled students and produce graduates. Thus, it is referring to the teaching performance of higher education institutions. As inputs we apply the number of academic staffs and the financial resources given to HEIs from the government (excluding capital contribution) reflecting the university expenditures. Selected inputs appear mostly in

the higher education efficiency studies (Abbott and Doucouliagos, 2003; Johnes, 2006; Kuah and Wong, 2011). Some studies distinguish between academic and non-academic staffs. However, we are limited to do so because of the lack of data in 2007. Anyway, by including the indicator in 2015, it does not bring significantly different results. We also suggest a value of long-term assets to have an influence on the teaching and research process like Abott and Doucouliagos (2003). As outputs we choose the number of graduates as it is very often used in assessments (Kuah and Wong, 2011; Johnes, Johnes and Thanassoulis, 2008; De Witte and Rogge, 2010) but we differ the bachelor's degree and the master's degree as Abott and Doucouliagos (2003) or Johnes (2006) did. The reason is that bachelor and master level is considered as independent in Slovakia. Moreover, students may start their master level studies at different institution even in other country after finishing a bachelor's degree. In our analysis we capture the quality of university by measuring the employability of graduates as Kuah and Wong (2011) or Kosor (2013) did. Anyway, it is still not only the result of current level of educational inputs, but also of the inputs provided in earlier academic years. Students' test scores or a value-added analysis that capture changes in student performance from one to another year could be important outputs (Kuah and Wong, 2011; Gronberg, Jansen and Taylor, 2012). However, the data for such an analysis are not available in Slovak educational environment.

T a b l e 1

Input and Output Mix of Teaching Efficiency

Inputs	Outputs
X1: Number of academic staffs *X2: University expenditures (excl. capital contribution)* *X3: Long-term Assets*	*Y1: Number of graduates in bachelor's degree* *Y2: Number of graduates in master's degree* *Y3: Employment rate of graduates*

Source: Authors.

2.2. Inputs and Outputs for Research Efficiency

The argument in the research efficiency model lies in employing research staffs in order to produce research outputs such as publications or intellectual properties. For the inputs in this model, we again include the number of academic staffs, the financial resources given to HEIs from the government (excluding capital contribution) and assets since all of them influence the research activities of HEIs. Due to limiting data, it is difficult to estimate the proportion of expenditures selected just on research activities. That is why we consider the whole amount of resources as well as we suppose that all academic staffs participate on research activities. The outputs in this study are the publication counts measured as the share of university on the total number of publications produced by public

HEIs. Shares are calculated in accordance with the methodology of the Ministry of Education, where each type of publication is given a different weight and these are used for reallocating the amount of funds to HEIs from the State Budget. Due to the relative efficiency that DEA captures, relative values provide the same results as the absolute values. We capture the quality of publications by measuring the number of publications in SCOPUS database, which is considered by the national performance-based system to consist of the highest quality publications. These publications thus ensure to HEIs the most funds from the State Budget. We also imply the number of PhD. graduates. These three indicators appear mostly in the studies (Kuah and Wong, 2011; Agasisti et al., 2011). In analysis, we distinguish in publication counts and SCOPUS publications and apply the indicators in separated models since the values overlap. Therefore, we run research efficiency model twice with each publication indicator separately. This step will allow us to see whether the Slovak public HEIs improved the adjusted quality of publications rather than just a gross volume of publications. The value of intellectual property of higher education institutions might be also used in the model (Kuah and Wong, 2011), however, such an indicator is seen mostly in patents and can disadvantage HEIs which do not operate in technical areas. Moreover, according to the Web Register of the Industrial Property Office of the Slovak Republic (http://www.upv.sk), the number of granted patents for Slovak HEIs in 2007 was only 3 and in 2015 increased to 9.

T a b l e 2
Input and Output Mix of Research Efficiency (Model 1 and Model 2)

Inputs	Outputs
X1: Number of academic staffs	*Y4: Number of publications (Model 1)*
X2: University expenditures (excl. capital contribution)	*Y4: Number of publications in SCOPUS database (Model 2)*
X3: Long-term Assets	*Y5: Number of PhD. graduates*

Source: Authors.

2.3. Measurement

Our measurement is based on model for university performance measurement used in Kuah and Wong (2011), where authors distinguish between teaching and research efficiency. We run our analysis on 20 public HEIs: DMU_1, DMU_2, … and DMU_{20}. Each public HEI *j*, DMU_j, (*j* = 1, 2, 3, … 20) uses 3 inputs X_{ij}^t (*i* = 1, 2, 3) to generate 3 outputs Y_{ij}^t (*r* = 1, 2, 3) from its teaching activities in time *t* and 3 inputs X_{ij}^t (*i* = 1, 2, 3) to generate 2 outputs Y_{rj}^t (*r* = 4, 5) from its research activities in time t. Because we compare efficiency of DMUs in time, MPI represents the geometric mean of the two efficiency ratios: the one that

captures efficiency change measured by the period *t* technology and the second efficiency change measured by the period *t* + 1 technology. The equation is given as follows (1):

$$MPI = \left(\frac{\delta^{t+1}(x^{t+1}, y^{t+1})}{\delta^{t}(x^{t}, y^{t})} \right) x \left[\left(\frac{\delta^{t}(x^{t}, y^{t})}{\delta^{t+1}(x^{t}, y^{t})} \right) x \left(\frac{\delta^{t}(x^{t+1}, y^{t+1})}{\delta^{t+1}(x^{t+1}, y^{t+1})} \right) \right]^{1/2} \quad (1)$$

The components of MPI are given by the estimation of distance functions defined on a frontier technology (Färe et al., 1994). In case that there is no efficiency change, MPI = 0. MPI > 1 indicates progress in the total factor productivity of DMU from period *t* to period *t* + 1 and MPI < 1 indicates its decrease in a given period.

2.4. Data

Public higher education institutions in Slovakia are almost evenly spread across the country: 5 in Bratislava Region, 6 in Western Slovakia, 5 in Central Slovakia and 4 in Eastern Slovakia. Data collected on inputs and outputs of public HEIs for years 2007 and 2015 (as the programming period was starting and ending) form the basis of the analysis. A data for each public university in case of inputs and outputs were gathered from the official yearly reports of the Ministry of Education as well as from the indicators used for creating a funding plan for HEIs on a yearly basis by the Ministry of Education. We also used Annual Reports of University Status published yearly by the Ministry (Ministry of Education, 2008; Ministry of Education, 2016). These documents are officially available on the website of the Ministry.

Since our research question is based on comparing the convergence regions, we provide an overview of development of selected indicators of inputs and outputs on NUTS II level. We watched a development of number of academic staffs in each NUTS II region. Indicator does not show any fluctuations and is very stable over the years. Bratislava region employs around 40% of all academic staffs during the whole period and the rest is almost evenly spread among HEIs in other three regions. Almost the same situation occurs with the university expenditures.

Among our teaching outputs belong the number of graduates and employment rate. A drop of bachelor's degree graduates is seen already between years 2007 and 2008 in Bratislava region, where the share on total number decreased by 10% to 33%. Further development of indicator was relatively stable over the years, though. This is the case of master's degree graduates as well. HEIs in Bratislava region produced 34% of bachelor's degree graduates and 38% of master's

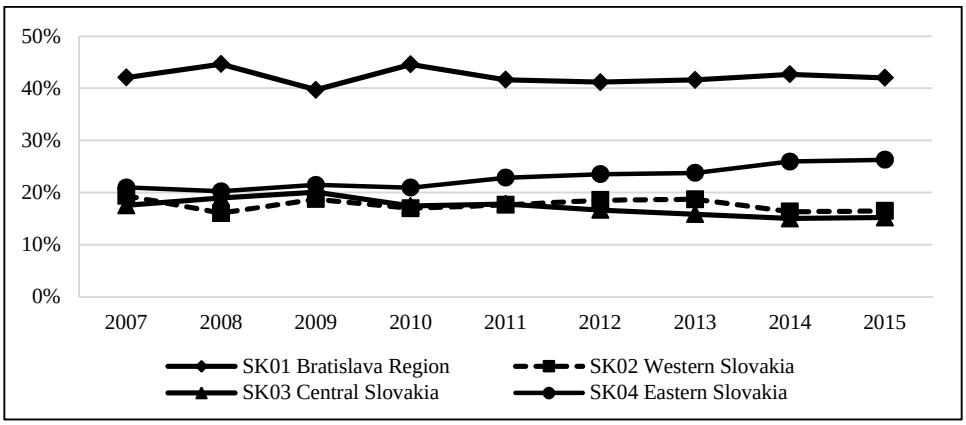
degree graduates in 2015. The rest is almost evenly spread among convergence regions. Although Western part seems to produce more graduates in bachelor's degree (25%).

Bratislava region with the best values in unemployment, wages and salaries attracts students and remains the biggest producer of graduates. On the other hand, all Slovak regions have experienced a decrease of students in absolute numbers at both levels. Since 2009 the number of graduates in Bratislava region were lowered in case of bachelor's degree graduates. The numbers changed from 7 703 in 2009 reaching its peak to 6 253 in 2015. Similar situation occurs with the students in master's degree studies – while Bratislava region produced 7 791 graduates in its peak in 2011, it was only 6 682 graduates in 2015. This is probably the impact of migration of Slovak students into the neighbouring countries like the Czech Republic or Hungary. According to the Institute for Economic and Social Reforms, 15.9% of Slovak students are studying abroad (INEKO, 2016). Quite similar situation seems to be with the PhD. graduates. The absolute numbers were decreasing since 2012 – 2013, but Bratislava region remains the biggest producer with 45% of total number of PhD. graduates. The rest is almost evenly spread in other regions.

Looking at the employment rate of graduates, the values in 2007 were the brightest for Bratislava region (94.6%). In case of convergence regions, 87% of graduates from HEIs in Western and Central Slovakia were successful in finding a job. The worst values (81%) reached graduates from Eastern Slovakia. Comparing to 2015, situation had worsened in each region. While the employment rate in Bratislava region decreased by 7%, graduates from HEIs in all three convergence regions were in 2015 successful in finding a job only at 77%.

F i g u r e 1

Share of NUTS II Regions on Gross Publications Volume in 2007 – 2015



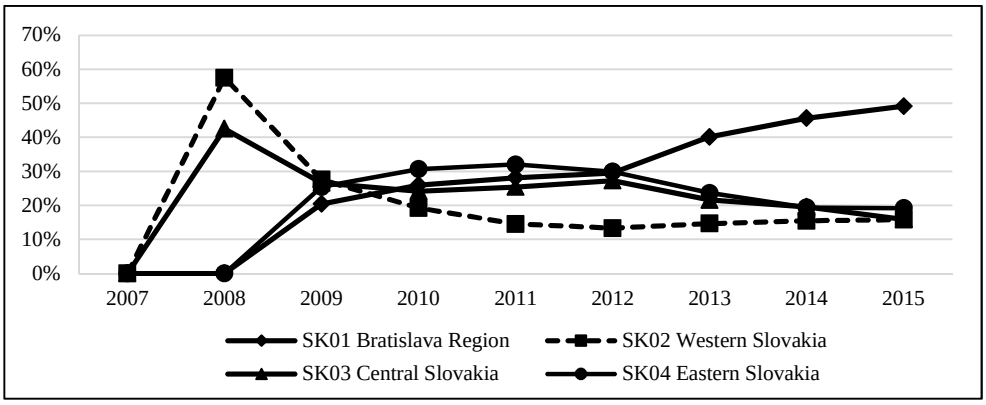
Source: Own calculations based on yearly reports of the Ministry of Education.

A share of publications of each university was included among the outputs of research activities. Although we see in Figure 1 that Bratislava region is at the forefront covering almost half of all publications, HEIs in Eastern Slovakia experienced to have a moderate growth since 2010 by more than 6%. On the other hand, HEIs in Western and Central Slovakia seems to have some decrease. Although Bratislava region holds top position among the regions in total number of publications, a share of publications in SCOPUS database has decreased by more than 10%. It is not because higher education institutions in Bratislava region publish less quality articles, but because the numbers of these articles were growing in all regions at very similar rate. Within this indicator, all convergence regions have stable position with moderate positive growth, mainly in Western Slovakia.

Figure 2 shows a development of support given to HEIs within the Structural Funds. We see that funds started to be fully used by HEIs in 2009. OP Education was mostly applied to HEIs in convergence regions with a share on whole amount of 81.5% and OP R&D provided them with almost 63% of the sources. OP R&D provided grants 10.4 times higher comparing to OP Education.

F i g u r e 2

Share of NUTS II Regions on Redistribution of Structural Funds (OP R&D and OP Education) in 2007 – 2015



Source: Own calculations based on yearly reports of the Ministry of Education.

3. Results

Results of MPI are shown in Table 3. We refer to *MPI TE* as a teaching efficiency score change of university, *MPI RE Model 1* as research efficiency score change of model with gross volume of publications and *MPI RE Model 2* as research efficiency score change of model with quality adjusted volume of

publications. Recall that MPI > 1 indicates progress in the total factor productivity of DMU from period 2007 to 2015, MPI = 1 indicates no change in total factor productivity and MPI < 1 indicates its decrease.

T a b l e 3

Malmquist Productivity Index for 20 Slovak Public HEIs

DMU	NUTS II	University	MPI TE	MPI RE Model 1	MPI RE Model 2
1.		UK Bratislava	1	0.837219	1
2.		STU Bratislava	1	1.216448	0.702220
3.	**SK 01**	EU Bratislava	1.239434	0.754834	1.401126
4.		VŠMU Bratislava	0.706724	0.278488	0.278488
5.		VŠVU Bratislava	0.875653	0.972441	0.972441
		Average	0.964362	0.811886	0.870855
6.		UCM Trnava	1.175868	0.760837	0.483672
7.		TvU Trnava	1.247226	0.784899	0.885020
8.		UKF Nitra	1.212191	0.606074	1.533663
9.	**SK 02**	SPU Nitra	1.096803	1.385322	1.631155
10.		UJS Komárno	0.494528	0.227077	0.602201
11.		TUAD Trenčín	1.189547	1.548709	1.131845
		Average	1.069361	0.885486	1.044593
12.		UMB Banská Bystrica	1.464182	1.323684	4.013946
13.		AU Banská Bystrica	0.697145	0.949580	0.897997
14.	**SK 03**	KU Ružomberok	0.882618	1.648315	1.645512
15.		ŽU Žilina	0.64009	1.375897	1.379378
16.		TU Zvolen	1.242771	1.147047	1.518751
		Average	0.985361	1.288905	1.891117
17.		UPJŠ Košice	0.747755	1.040045	0.503175
18.		UVL Košice	0.929826	0.528610	0.467761
19.	**SK 04**	TU Košice	0.982439	1.497515	1.451808
20.		PU Prešov	1.514136	0.863482	1.872192
		Average	1.043539	0.982413	1.073734

Source: Own calculations.

Looking at results of MPI TE, we see that HEIs did not improve efficiency very much in teaching activities. The changes are mostly seen in HEIs in Western Slovakia and Eastern Slovakia. In Western Slovakia, the highest cange of score was at TvU Trnava and UKF Nitra which improved by 21 – 24% comparing to 2007 and other institutions. It is caused mostly due to growth of bachelors graduates at these institutions. On the other hand, we see a decrease of efficiency in UJS Komárno in SK 02. Although this HEI experienced a high growth of number of master graduates comparing to 2007, there was also a growth of variables on input side. The highest change in Eastern Slovakia was in PU Prešov which was the only HEI improving efficiency in this region, particularly by 51%. This is caused mostly by growth of graduates at bachelor's degree. The rest of institutions worsened their efficiency scores. In Central Slovakia, we observe that only two HEIs obtained better scores and it is mostly due to increasing number of bachelors graduates. In Bratislava region, there was actually the lowest change in efficiency score on average. Two HEIs did not experience any

progress nor decrease of score, particularly the biggest institutions UK Bratislava and STU Bratislava.

Different results may be seen in research activities in Model 1. The highest changes were observed in HEIs in Central Slovakia where each institution improved the score with exception for AU Banská Bystrica. It was caused mostly by increasing numbers of PhD. graduates. In Eastern Slovakia are better score values seen only in UPJŠ Košice and TU Košice. Although these institutions were experiencing a growth in number of PhD. graduates, there was also an increase of gross volume of publications, especially in TU Košice. In Western Slovakia, HEIs were on average less efficient comparing to previous period and other institutions. The only exceptions are SPU Nitra and TUAD Trenčín with increasing number of PhD. graduates. HEIs in Bratislava region obtained the worst scores on average comparing to 2007 and other regions. The only HEI receiving better score was STU Bratislava having more PhD. graduates, gross volume of publications and less academic stuff. The rest of HEIs worsened their efficiency.

MPI for research efficiency in Model 2 suggest the highest changes on average in NUTS II regions. The best results are seen in Central Slovakia with UMB Banská Bystrica having incredible progress. This is caused by increasing outputs and decreasing inputs at the same time, particularly academic stuff and assets. Among HEIs in Eastern Slovakia, the highest changes may be seen in PU Prešov and TU Košice. Both institutions obtained much better values in both output indicators. In Western Slovakia, there was on average a progress in performance of HEIs, mostly by SPU Nitra and UKF Nitra. In Bratislava region, we observe that HEIs worsened their efficiency scores comparing to 2007 and other HEIs. Only EU Bratislava obtained better score which is caused mostly by increasing share on Scopus publications.

T a b l e 4

Correlation Matrix for Volume of Funding from Structural Funds (OP Education, OP Research and Development) for University and MPI Value

	Correlation coefficient (MPI TE and Structural Funds)	**Correlation coefficient (MPI RE Model 1 and Structural Funds)**	**Correlation coefficient (MPI RE Model 2 and Structural Funds)**
SK 01 Bratislava region	0.130129	0.544629	0.092838
SK 02 Western Slovakia	0.894312	0.471898	0.663572
SK 03 Central Slovakia	–0.08398	0.352713	–0.14759
SK 04 Eastern Slovakia	–0.12305	0.967109	0.163492
Overall correlation	0.103951	0.340558	–0.01748

Source: Own calculations.

When we correlate MPI for each HEI to volume of funding from OP received by HEI during 2007 – 2015 from Structural Funds, we see in Table 4 the lowest values in research efficiency with quality adjusted publications (Model 2). Looking at correlation coefficient separately in regions, the best values are captured in Western Slovakia while there is a moderate correlation in other NUTS II regions. Looking at correlation coefficient of MPI TE and Structural Funds, overall value is still low. There is a stronger relationship suggested separately in each region with higher values in Western Slovakia. While Western Slovakia and Bratislava region have positive relationship, Central and Eastern Slovakia indicate negative relationship between variables. The highest correlation may be seen in MPI for gross publication counts (Model 1) and volume of funding from OP R&D. There is a high positive correlation seen in each region with the highest values in Eastern Slovakia.

4. Discussion

Studies dealing with convergence within post-communist countries conclude that there is no clear evidence of such a phenomenon (Paas et al., 2007; Abrahám, 2011; Monastiriotis, 2014). They usually rely on economic indicators like GDP per capita or income. Our approach is quite different with focus on measuring institutional development of specific institutions strongly related to regional development – higher education institutions. According to results of our study, there is a convergence occurring among NUTS II regions of Slovakia. We observed that HEIs in convergence regions improved their performance more than institutions in Bratislava region and it was confirmed mostly in research activities.

The results suggest that teaching efficiency remained very similar in each region and did not experience any progress nor decrease. This indicates that there is no pattern observed neither on regional level or given by focus of HEI. Teaching performance of HEI is thus more or less affected by individual effort of institution. Although there was a support from OP Education provided to HEIs from Structural Funds, the volume of funding was quite low and probably did not influence their performance. A small improvement in education area could be due to less attention that HEIs have devoted to this area in recent years, while research has become a priority from a national perspective. This has been reflected also in the overall changes in the funding of universities and led to a significant outflow of students, which was not sufficiently compensated by lowering the input of universities.

Some progress could be seen in Model 1 capturing gross volume of publications. HEIs in convergence regions performed better comparing to each other

and year 2007. There might be some effect of Structural Funds and OP R&D which provided 10.4 times higher sources for universities comparing to OP Education. Some effect was slightly confirmed by correlation coefficients and suggests that EU support that focused mostly on support of infrastructure in HEI had some impact.

The biggest change was seen in Research Model 2 including quality adjusted publications, though. HEIs in convergence regions improved their performance much more comparing to institutions in Bratislava region. It is not because institutions in Bratislava region published less but due to increasing share on publications by other HEIs. This could be influenced by strong support given to institutions from OP R&D. Correlation coefficient does not directly confirm that, though and shows some relationship mostly in Western Slovakia. Quality adjusted publications were probably influenced also by institutional funding putting more pressure on HEIs in research area.

Results thus confirm that stronger convergence among regions was observed in more supported area – research. This may indicate that if EU aimed to decrease regional disparities, it reached the goal to some extent by decreasing disparities of institutions crucial for regional development. However, thinking of high support given to HEIs in Bratislava region then arises a question whether HEIs in convergence regions could not improve better if more money was allocated to convergence regions.

Conclusion

Joining the European Union in 2004 brought for Slovakia and other post--communist countries a challenge in catching up to the EU average. Deichman et al. (2017) confirm on selected macro-level indicators that Slovakia has been successful at converging to EU standards. On the other hand, studies highlights that there is no clear evidence on convergence within post-communist countries. Measuring a convergence on institutional level within country may then provide additional findings, especially a convergence of HEIs which play important role in regional development.

From 2007 to 2015, EU funds provided Slovak HEIs with additional financial sources to improve their performance. In comparison with national funding that covers most of the current expenditures, grants from EU had mostly a character of development projects. Moreover, 63% of EU funding was reallocated within convergence regions. These sources focused mostly on assets of HEIs and creating research centres. After receiving significant support from these funds, we expected from HEIs to obtain better results in their performance.

Our teaching efficiency model showed that HEIs in all regions did not improve their performance significantly and remained at the similar level. We saw that they have experienced during the years a drop in a number of students, who are more attracted by foreign universities. This is an impact of Slovakia joining EU and freedom of movement of Union citizens. With a lower number of students and thus graduates, universities slightly adjusted the number of inputs accordingly.

Two research efficiency models showed that the performance of higher education institutions are different when we capture the quality of publications and not only the quantity. A positive growth of higher education institutions in convergence regions was suggested by both models and higher changes in values were gained in case of quality indicators.

To conclude, we confirmed relative improvements of higher education institutions comparing to Bratislava region. According to our mix of inputs and outputs, HEIs in convergence regions became on average more efficient comparing to Bratislava region mostly in research area. Since research area was mostly supported by EU funds, it thus seems to positively influence performance of public HEIs in convergence regions.

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