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EFFICIENCY OF HEALTHCARE SYSTEMS IN CZECH REPUBLIC AND SLOVAKIA AFTER THE DISSOLUTION OF CZECHOSLOVAKIA

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Abstract
The dissolution of Czechoslovakia, which took effect on January 1, 1993, split Czechoslovakia into two independent countries - the Czech Republic and Slovakia. Thenceforth the Czech and Slovak healthcare systems have undergone major and important changes which were expected to have a positive effect on healthcare outcomes of the population.
Our goal is to analyse the change of the efficiency of healthcare systems in the Czech Republic and Slovakia after the dissolution relatively to other European countries. For this purpose we apply Data Envelopment Analysis to calculate efficiency scores and Malmquist productivity indices for the period 1995-2012. The total health expenditure is considered as input, while the number of infant death, life expectancy at birth, and the final consumption expenditure (FCE) are considered as outputs. Standard decomposition of Malmquist index into frontier shift and catching up effect gives a deeper insight into the issue. Finally, we relate the results of efficiency analysis with the health reforms carried out in both countries.

Key words: *Healthcare system efficiency, Health expenditure (HE), Data Envelopment Analysis (DEA), Malmquist index (MI).*

1. Introduction

Our objective is to compare the development of the healthcare systems of Czech Republic and Slovakia after the dissolution. We focus on the efficiency of healthcare systems, i.e. we study the effect of the HE changes over the period on selected health outcomes of the population and the economic levels of the countries measured by FCE.

An efficiency of the healthcare system can be naturally defined as the level of transformation of its financial, material, and personal inputs into desirable health outcomes of the inhabitants. The difficulty of the efficiency evaluation lies in the fact that the health conditions of the population can be significantly influenced by a wide variety of factors that may be beyond the discretionary control of the healthcare system. The healthcare system is

therefore generally considered to have only a partial effect on the health outcomes. Moreover, the real effect of changes in HE on health outcomes may not be observed in a short-time period. However, the improvement of health conditions is a key issue for the health policy and healthcare services consume a large portion of public and private financial resources in all developed economies. Hence, it is highly important to find adequate methods for the assessment of healthcare system efficiency and its development. Due to multi-input and output character and the difficulty to estimate the health production function, a non-parametric approach using data envelopment analysis techniques has occurred to be a perspective tool for the assessment.

A few studies estimating the overall efficiency of national healthcare systems using this approach have been published in previous years, e.g. by Retzlaff-Roberts et al. (2004), Afonso and St Aubyn (2005), Bhat (2005), Economou and Giorno (2009), Schwellnus (2009), Spinks and Hollingsworth (2009), Hadad et al. (2013). Most of the authors include HE per capita as one of the inputs, and measure healthcare outcome by life expectancy at birth. Some of them also include socio-economic factors like GDP per capita as inputs and an infant survival rate as additional output in their models.

In our study we aim at designing a comprehensive model of health production process with a minimized number of inputs and outputs characterizing the system's performance as well as the economic environment. For this reason we consider the total HE as a unique input of the national healthcare system since it covers all used labour and capital resources. In accordance with previous papers, we measure the health outcomes by life expectancy at birth and the infant mortality.

We also take into consideration the economic level of the country. In contrast with previous studies, we measure the economic level by FCE. This indicator is supposed to be more stable since GDP depends on the other expenditure components (e.g. foreign trade, investment) that do not have an impact on the efficiency of health services. A high correlation between HE and FCE is usually observed. It is generally interpreted in such a way that countries with a higher level of economic performance can afford higher HE. Thus, it may be better to avoid using both the two highly correlated indicators as inputs in healthcare system efficiency models. Instead, a share of health expenditure on FCE (HE % FCE) may be taken as an input, which also eliminates the discrimination of rich countries in the analysis. This approach, using HE as a share of GDP, was discussed by Grausová et al. (2015).

The paper is organized as follows. In Section 2 we present a brief history of the two national healthcare systems. Section 3 introduces data on health expenditure and health outcomes used for the comparison of both countries after the dissolution. In Section 4 the methodology applied to analyse the change of healthcare systems efficiency in the Czech Republic and Slovakia is described. In Section 5 we present and discuss the results and in Section 6 we summarize our observations with respect to national health policies.

2. History of healthcare systems of Czech Republic and Slovakia

The Czech Republic and Slovakia inherited the healthcare system which was built for decades on the same economic, legal, and medical principles in both parts of Czechoslovakia. The Law on Public Health in former Austria-Hungary was first adopted in 1887 and the health insurance system based on the model of German health system was established in 1888. The system was expanded and well defined in the first Czechoslovak Republic, with adjusted insurance in 1924. After 1948 the socialist health care passed fully into the hands of the state.

The insurance system was changed to a tax system. The development up to 1989 and even long after was common, but soon after the Velvet Revolution Czechoslovakia went back to Bismarck's insurance model of health financing.

As independent countries, the Czech Republic and Slovakia started to implement their own policies to maintain and develop their healthcare systems. In the Czech Republic a law on public health insurance was adopted, and it has been amended many times. The Czech healthcare system has undergone several non-system improvisations, including extensive privatization of healthcare facilities, restructuring and reform of the public sector. In 2008 the Czech system introduced regulatory fees, but not to such an extent as the Slovak reform. An overview of the history and organization of Czech health system is described by Kinkorová and Topolčan (2012).

By 2003, the Slovak health care and especially its financing developed similarly to the Czech system. At the beginning of the transformation process, 26 health insurance companies were established in the Czech Republic and 13 in Slovakia, but currently operate only 8 and 3 of them, respectively. In the Slovak Republic, however, a comprehensive reform was carried out. It was based on the system of six reform laws which covered all areas of the health system - providing, production and financing of health services and health-related services. It is the charges for these related services, partial and full direct payments by patients for certain types of medical services (for administrative purposes, medicines, dental fees, doctor visits, hospital stay, health emergencies visits, etc.) that caused a large increase in spending on health, mainly from private sources. A detailed overview of the structure and development of HE in Slovakia is given by Štrangfeldová (2013).

3. Development of health expenditure and health outcomes after the dissolution

For better understanding the health situation in the Czech Republic and Slovakia we chart their data over the period 1995-2012 and compare them with other European countries. We divide 30 compared countries onto three groups by the date of entry into the European Union. The group OLD 15 includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom (date of entry until 1995). The group NEW 10 consists of Croatia, Cyprus, the Czech Republic, Estonia, Hungary, Lithuania, Malta, Poland, Slovakia, and Slovenia (date of entry in 2004 or later). The other 5 countries included into our analysis are Iceland, Macedonia, Norway, Serbia, and Switzerland (non EU members). Although there are available data for other European countries, we have excluded them from our analysis since they could negatively influence the DEA results (small countries or countries with too low values of health system inputs and outputs, e.g. Bulgaria and Romania).

First we introduce data on the total health expenditure[1], then we discuss the health outcomes, i.e. life expectancy at birth and infant mortality rate. Data for the analysis have been collected from the World Bank database (2015) where data on health expenditure since 1995 are available.

[1] Total health expenditure is the sum of public and private health expenditure. It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health but does not include provision of water and sanitation. Data are in constant 2005 U.S. dollars.

In assessing the HE we consider two alternative views. First, we analyse the total HE as a share of FCE[2] (Figure 1). The share in both countries has developed similarly. In the Czech Republic the share slightly decreased till 1999 and then it started to moderately increase. In Slovakia the decrease was deeper (in 2001 nearly to the minimum of all compared countries), but since 2003 it has sharply increased up to 12%. Until 2006, the Czech Republic had shown a higher percentage of the share, but since 2007 the HE%FCE has been higher in Slovakia (except 2011).

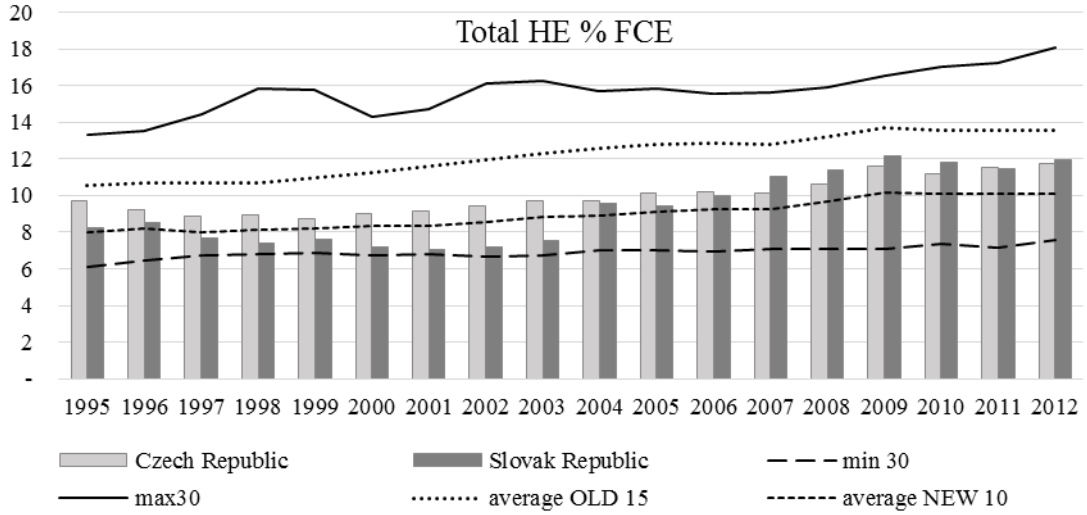

Figure 1. Development of total health expenditure expressed in % of FCE.
Source: World Bank (2015), processed by the Authors.

Based on the previous considerations we assume that the reason for this change consists in the complex reform of the Slovak healthcare system which introduced new fees for services related to health care and also applied partial or complete charges for certain medical services. Currently it is estimated that up to 35% of spending on healthcare in Slovakia comes from private sources. This observation is also confirmed by the development of expenditure per capita (Figure 2). We see that the public HE per capita in the Czech Republic is still higher, but the private expenditure is much lower than in Slovakia. This fact coincides with the experience of other countries that the higher share of private expenditure in the health system increases the share of total HE to FCE.

However, note that the share of HE to FCE in both the Czech Republic and Slovakia at the end of the period is above the average of NEW10 but still far below the average of OLD 15 group of countries.

Figure 2 shows a sharp increase in total health expenditure per capita (HEpCap) in Slovakia after the health reform. In2007, the health spending per capita first exceeded that in the Czech Republic which has developed more evenly though also in the increasing trend.

[2] Final consumption expenditure is the sum of household final consumption expenditure and general government final consumption expenditure. Data are in constant 2005 U.S. dollars (World Bank, 2015).

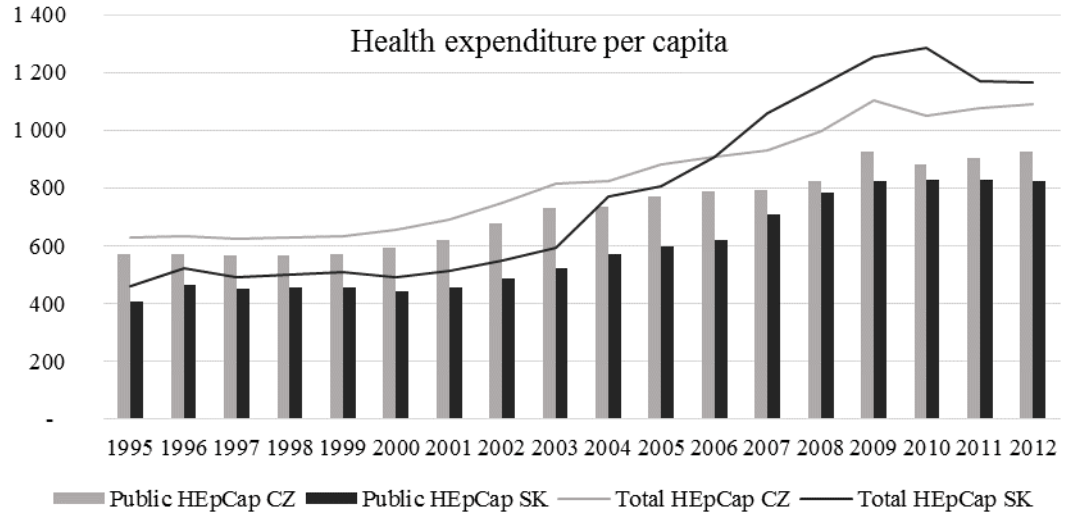

Figure 2. Development of public and total health expenditure per capita.
Source: World Bank (2015), processed by the Authors.

Although Slovakia has already spent on health care a higher share of total HE to FCE, the life expectancy[3] is not growing at such a pace that in the Czech Republic and remains lower than the average of the NEW 10 group of transforming countries (Figure 3). It should be noted that the life expectancy, however, may be substantially influenced by many factors outside the health sector, e.g. by lifestyle, genetics, and other environmental variables.

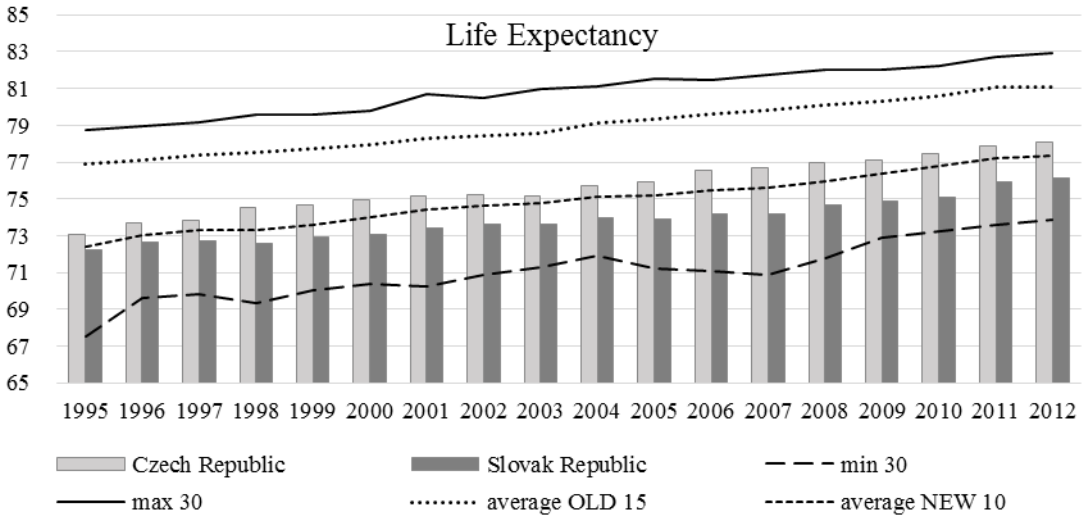

Figure 3. Development of life expectancy.
Source: World Bank (2015), processed by the Authors.

[3] Life expectancy at birth indicates the number of years a new born infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life (World Bank, 2015).

Despite the steady decline during the observed period, the infant mortality[4] in Slovakia is still much higher than in the Czech Republic, and also in comparison with the average of OLD 15 as well as NEW 10 countries (Figure 4). Thus, the value of this indicator is unfavourable for Slovakia. Moreover, we must admit that health care provided to infants in their early age has a more significant impact on this indicator than the factors outside the health system.

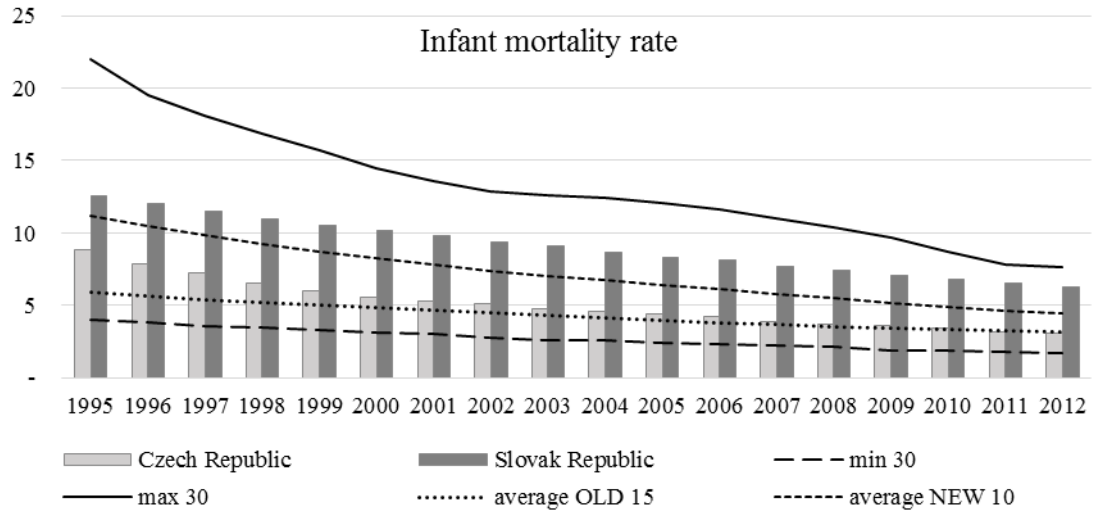

Figure 4. Development of infant mortality rate.
Source: World Bank (2015), processed by the Authors.

Based on the comparison of HE and the performance of healthcare systems measured by life expectancy and infant mortality, we see that in spite of increasing expenditure on healthcare in the Slovak Republic in the second half of the period, the health outcomes have not significantly improved compared with other countries and still are at a much lower level than in the Czech Republic. However, this may be caused by a natural lag between the spending and the improvement of health outcomes which is difficult to estimate.

4. Methodology

To achieve our goal to identify changes in the efficiency of the healthcare systems of Czech and Slovak Republic over time we use the Malmquist index which evaluates the efficiency change between two time periods. We compute MI by means of DEA technology.

In this section we first introduce a designed DEA model, discuss the indicators, and finally we present the Malmquist index based on the chosen DEA model. The data is analysed using DEA-Solver software (www.saitech-inc.com).

[4] Infant mortality rate is the number of infants dying before reaching one year of age (number of infant deaths), per 1,000 live births in a given year (World Bank, 2015).

4.1 DEA model

We apply DEA to calculate the efficiencies of healthcare systems for each year of selected period. The 30 countries listed in Section 3 are considered to be decision making units (DMU) for DEA. For the health financing is natural that the change in spending on health does not imply the same rate of change in health indicators. Therefore we utilize a radial and input-oriented model with non-increasing returns to scale. For the linear program of this model see (Cooper et al., 2007).

Papers dealing with the study of healthcare system efficiency often used ratio data in their analysis. It was shown that using ratios in standard DEA models may lead to incorrect results since they do not comply with the convexity axiom which is one of the main underlying assumptions of the production possibility set in DEA (see (Emrouznejad and Amin, 2009) for details). Therefore we modify our DEA model as shown in Table 1.

Table 1. The design of DEA model.

Inputs	Outputs
Model with ratio data	
• Total HE % FCE (ratio data)	• Infant mortality rate (ratio data) • Life expectancy
⇩	
Model with non-ratio data	
• Total HE	• Number of infant death (undesirable output) • Life expectancy • FCE
⇩	
Model with non-ratio data and desirable outputs	
• Total HE • Number of infant death	• Life expectancy • FCE

Source: the Authors.

Table 2 displays the minimum and maximum values of correlation coefficients calculated for all 30 countries and for each year of the period 1995 – 2012. The correlation matrix shows a significant positive correlation between total HE and number of infant death. A high correlation between total HE and FCE is also observed in spite of the fact that the share of total HE on FCE differs in individual countries (see Figure 1). The correlation between life expectancy and number of infant death shows a weak level of relationship, suggesting the presence of underlying common factors for life expectancy and mortality rate. The correlation between total HE and life expectancy shows a moderate relationship, but this is natural since life expectancy is influenced by many other factors.

Table 2. Correlation matrix.

	Total HE	Number of infant death	Life expectancy	FCE
Total HE	1	0.65 – 0.86	0.35 – 0.40	0.98 – 0.99
Number of infant death		1	0.03 – 0.22	0.70 – 0.91
Life expectancy			1	0.36 – 0.40
FCE				1

Source: the Authors, based on data from the World Bank database (2015).

4.2 Malmquist index

Based on the radial input-oriented DEA model with non-increasing returns to scale using non-ratio data and desirable outputs presented in Table 1, we calculate the Malmquist index for the 30 countries listed in Section 3 as DMUs.

The MI evaluates the efficiency change of a DMU between two time periods. It is an index representing the change in Total Factor Productivity (TFP) of the DMU, in that it reflects progress or regress in relative efficiency of the DMU along with progress or regress of the production frontier technology. It is defined as the product of "Catch-up" and "Frontier-shift" terms.

We denote the activities of DMU_o at the time period 1 and 2 by $(x_o, y_o)^1$ and $(x_o, y_o)^2$, respectively. Then we develop the numerical measures for which we employ the notation $\delta^s((x_o, y_o)^t)$ (t = 1, 2 and s = 1, 2), for the efficiency score of DMU_o at the time period t measured by the frontier technology s. If $t = s$, we speak about the measurements within the same time period while $t \neq s$ is for intertemporal comparison.

Using this notation, MI can be expressed by the following formula:

$$\mathrm{MI} = \frac{\delta^2((x_o, y_o)^2)}{\delta^1((x_o, y_o)^1)} \times \left[\frac{\delta^1((x_o, y_o)^1)}{\delta^2((x_o, y_o)^1)} \times \frac{\delta^1((x_o, y_o)^2)}{\delta^2((x_o, y_o)^2)} \right]^{1/2} = Catch-up \times Frontier\ shift \qquad (1)$$

For MI and each of its components, a value greater than one indicates an improvement of the DMU_o from period 1 to 2, while a value equal to one or less than one indicates the status quo or a decrease, respectively. For the more detailed study of MI see Cooper et al. (2007).

5. Results and discussion

Figure 5 shows the annual percent change in HE%FCE drawn by grey lines, and the values of MI drawn by black lines (lines for Czech Republic are dashed). Let us recall that MI > 1 indicates progress in the TFP of the country between two consecutive years, while MI = 1 and MI < 1 respectively indicate the status quo and deterioration in the TFP.

We can see the changes in TFP follow the changes in HE%FCE in both countries. For example, the HE%FCE decrease by 5.7% in Slovakia between 1999 and 2000 caused an increase in TFP ($\mathrm{MI} \approx 1.06$). Indeed, a high negative correlation between annual percent change in HE%FCE and MI is observed, with correlation coefficients -0.98 for both countries.

There are some interesting points worth explanation. The preparation of healthcare reform in Slovakia required the settlement of debts of hospitals. This process started in 2003 and caused a high jump in HE, and consequently the fall in TFP. In the year 2009 MI in both

countries decreased because the HE per capita as well as the HE%FCE significantly increased. The effect was strengthened by the influence of economic crisis on the development of FCE. The development of TFP in Slovakia was influenced by the decrease of private HE when some of healthcare fees were cancelled in 2010.

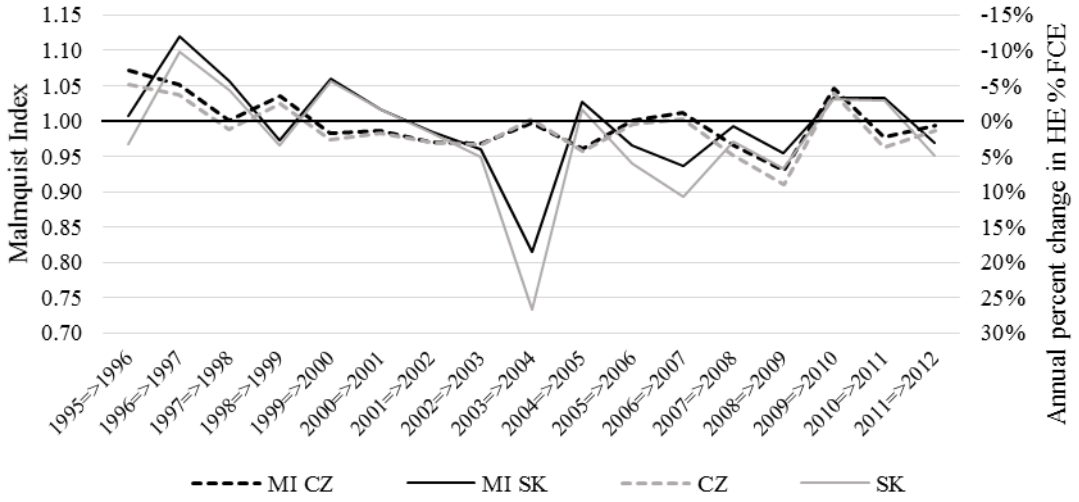

Figure 5. Comparison of Malmquist index and the annual percent change in HE%FCE.
Source: the Authors.

The decompositions of year-on-year MI to catch-up and frontier shift components for the Czech Republic and Slovakia are shown in Figure 6. We can see that the changes of the catch-up component were more jumpy in Slovakia, with a sharp fall in 2004 when the transformation process began. On the other hand, the frontier shift component was relatively stable for both countries during the whole period, with a significant drop in the crisis years 2008 and 2009. A high correlation between frontier shift components (correlation coefficient = 0.856) indicates that the efficiency frontier changed similarly for both countries. Thus the changes of MI were more dependent on the changes of catch-up components, i.e. the changes in the efficiency of the countries.

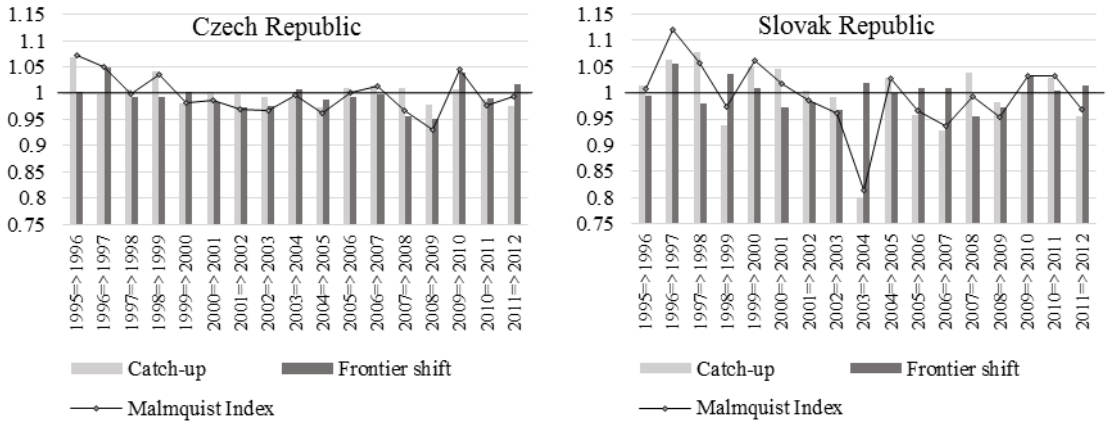

Figure 6. Decomposition of Malmquist index for the Czech Republic and Slovakia.
Source: the Authors.

Table 3 summarizes the values of MI and its components for the whole observed period. The TFP measured by MI decreased in both countries, but the fall is much more significant in Slovakia. The efficiency frontier got worse for the Czech Republic as well as for Slovakia. However, the two countries show a different behavior in catch-up. While the Czech Republic managed to slightly approach the efficiency frontier and its MI is drawn up by the catch-up component, the regress of TFP in Slovakia is strengthened by a low value of catch-up.

Table 3. Decomposition of Malmquist index for the period 1995-2012.

1995=>2012	Catch-up	Frontier shift	MI
Czech Republic	1.031	0.940	0.969
Slovak Republic	0.878	0.893	0.784

Source: the Authors.

6. Conclusion

The main characteristics of healthcare systems in the Czech Republic and Slovakia have developed similarly and followed the trends in HE and health outcomes observed in other European countries. The key health outcomes have been continuously improving in both countries during the whole period 1995-2012. However, due to differences in national health policies, the amount of HE (expressed in % of FCE or per capita) in Slovakia became higher than in the Czech Republic during the period, with a highly bigger share of private resources.

In our research, we focused on the efficiency change in healthcare systems. In order to assess the efficiency of HE with respect to health outcomes of the population, we compared the Czech Republic and Slovakia with other European countries. We applied MI calculated on the base of DEA methodology to identify the changes in TFP. In both countries, the MI indicates the fall in TFP between the beginning and the end of the investigated period. The efficiency frontier went down for both countries, but the efficiency changes of the national healthcare systems indicated by the catch-up component of MI were rather different. While the Czech Republic slightly improved its efficiency relatively to the frontier, Slovakia significantly fell down in efficiency relatively to reference countries forming the efficiency frontier. We also observed that MI was strongly influenced by the changes in HE in both countries. This underlines the importance of optimisation of HE and their structure.

Building an economical healthcare system that is capable to provide high quality health services to the population is a crucial social and political issue in each country. It requires a careful identification of key factors that determine the process of healthcare production and the relations among them with respect to national specificities. Hence, an improvement of methodology for the assessment of healthcare system efficiency to provide valuable results for experts, policy makers and the public is a challenge for further research.

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References

1. AFONSO, A., ST AUBYN, M. 2005. Non-parametric approaches to education and health efficiency in OECD countries. J. Appl. Econ. 8, pp. 227-246.
2. BHAT, V.N., 2005. Institutional arrangements and efficiency of health care delivery systems. Eur. J. Health Econ. 6, pp. 215-222.
3. COOPER, W.W., SEIFORD, L.M., TONE, K. 2007. Data envelopment analysis, A comprehensive text with models, applications, references and DEA-Solver Software, second ed.. Springer, New York 2007. ISBN 978-0-387-45281-4.
4. ECONOMOU, C., GIORNO, C. 2009. Improving the performance of the public health care system in Greece, OECD Economics Department Working Papers, pp. 722. Paris: OECD Publishing. doi:10.1787/221250170007.
5. EMROUZNEJAD, A., AMIN, G. R. 2009. DEA models for ratio data: Convexity consideration. Applied Mathematical Modelling, 33, pp. 486-498.
6. GRAUSOVÁ, M., HUŽVÁR, M., ŠTRANGFELDOVÁ, J. 2015. The impact of health expenditure to the healthcare system efficiency. 2014 M-Sphere Book of Papers, pp. 202-211. ISBN 978-953-7930-06-6. http://issuu.com/tvranes/docs/2014_m-sphere_book_-of_papers/7?e=0/11610397.
7. HADAD, S., HADAD, Y., SIMON-TUVAL, T. 2013. Determinants of healthcare system's efficiency in OECD countries. Eur. J. Health Econ. vol. 14, iss. 2, pp. 253-265.
8. KINKOROVÁ, J., TOPOLČAN, O. 2012. Overview of healthcare system in the Czech Republic. The EPMA Journal 2012, 3:4, http://www.epmajournal.com/content/3/1/4.
9. RETZLAFF-ROBERTS, D., CHANG, C. F., RUBIN, R. M. 2004. Technical efficiency in the use of health care resources: A comparison of OECD countries. Health Policy, 69, pp. 55–72.
10. SCHWELLNUS, C. 2009. Achieving higher performance: Enhancing spending efficiency in health and education in Mexico. OECD Economics Department Working Papers, pp. 732. Paris: OECD Publishing. doi:10.1787/220731242856.
11. SPINKS, J., HOLLINGSWORTH, B., 2009. Cross-country comparisons of technical efficiency of health production: A demonstration of pitfalls. Applied Economics, 41, pp. 417-427.
12. ŠTRANGFELDOVÁ, J. 2013. Výdavky na zdravotníctvo v Slovenskej republike (in Slovak). IURA Edition, Bratislava, 2013. ISBN 978-80-8078-585-7.
13. World Bank Data Indicators, 2015. Retrieved May 25, 2015, from http://data.worldbank.org/indicator.