COST EFFICIENCY IN EUROPEAN BANKING

KRISTÍNA KOČIŠOVÁ
Technical University of Košice, Faculty of Economics,
Department of Banking and Investments,
Němcovej 32, Košice, Slovakia
e-mail: kristina.kocisova@tuke.sk

Abstract

This paper analyses cost efficiency of the banking sectors in the European Union countries over the period 2008 – 2014. The Data Envelopment Analysis (DEA) method is applied. The results show a decrease of average cost efficiency in the whole sample. The results of the DEA, by country, indicate that the efficiency ranged from 20.9% in the case of Poland to 100% in the case of the United Kingdom, the Netherlands, Sweden, Malta, and Luxembourg. Cost efficiency was also analyzed in three groups of banking sectors, classified according to the volume of total assets. Large banking sectors seem to be most efficient, where the average cost efficiency during the whole analyzed period was 94.8%. On the second place, there were banking sectors within the medium-sized group (76.2%) and the least efficient were banking sectors in the small sized group (47.9%). In the last part of our analysis four main European "regions" were determined, and average cost efficiency was analyzed within them. According to the results of the analysis, the levels of efficiency in the case of the Northern (78.6%) and Western European (86.3%) banking sectors were higher than the average in the whole sample (64.3%); on the other hand, the average cost efficiencies in the case of the Southern (59.4%) and Eastern European (32.3%) banking sectors were under the total average.

Key words: *banking sector, cost efficiency, DEA.*

1. Introduction

The efficiency of banks is one of the most important issues in the financial market, as their efficiency can affect the stability of banking industry and thus the effectiveness of a whole monetary system.

In modern society, there exists a number of approaches how to define efficiency. Our definition is based on the study of Farrell (1957), who stated that the efficiency of a firm consists of two components: technical efficiency and allocative efficiency. Technical efficiency reflects the ability of a firm to obtain maximal output from a given set of inputs. On the other hand, allocative efficiency reflects the ability of a firm to use the inputs in optimal proportions, given their prices and the production technology. These two types of efficiency are then combined into an overall economic efficiency, which can be examined from the perspective of input or output based models. Then, we can talk about overall cost efficiency (input perspective) or overall revenue efficiency (output perspective).

The paper by Farrell (1957) paper led to the development of many approaches of measuring the input and output efficiency. Greatest importance was assigned to a Stochastic Frontier Approach (SFA) and Data Envelopment Analysis (DEA).

The conventional banking theories assume that banks earn profits by purchasing transactions deposits from the depositors at a low-interest rate and then reselling those funds

to the borrowers at higher interest rate. In other words, banks make profits from the spread between the interest rate received from borrowers and the interest rate paid to depositors.

Using DEA we can assess the bank's profitability from a different perspective. In our paper, we will discuss the profitability in the form of cost efficiency. Cost efficiency gives a measure of how close a bank's cost is to what a best-practice bank´s cost would be for producing the same bundle of output under the same conditions. The other forms of profitability could be profit or revenue efficiency. Profit efficiency indicates how well a bank is predicted to perform in terms of profit in relation to other banks in the same period for producing the same set of outputs. We can also define cost efficiency and revenue efficiency. Revenue efficiency indicates how well a bank is predicted to perform in terms of revenue relative to other banks in the same period for producing the same set of outputs.

This paper deals with DEA method and describes its application in measuring cost efficiency. The structure of the paper is as follows. The review of relevant literature is described in section 2. Used methodology is discussed in detail in section 3. Section 4 contains the practical application of DEA method for measuring cost efficiency in European banking sector during years 2008 – 2014 using the R software. Finally, the paper ends with some concluding remarks.

2. Literature Review

Data envelopment analysis (DEA) is a non-parametric mathematical (linear) programming approach to frontier estimation. The basic DEA model developed by Charnes et al. (1978) was based on the assumption of a constant return to scale. This basic model has been modified by Banker et al. (1984) and based on the assumption of a variable return to scale. Both these DEA models have been created in both forms – the input and output oriented.

Sherman and Gold (1985) applied DEA to banking as the first. They used DEA analysis to evaluate technical efficiency of 14 saving bank branches. As the result of the analysis, they not only measured the level of efficiency but also defined how to eliminate inefficiency by adjusting input and output of inefficient bank branches. Motivated by the DEA results, management indicated that the service outputs and the resources used to provide these would be further evaluated as distinct from the liquidity issues.

For example, Weill (2004) in his study used intermediation approach to evaluate cost efficiency of banks from five European countries (France, Germany, Italy, Spain and Switzerland) for the period 1992 – 1998. He measured the cost efficiency by application of three approaches: SFA, DEA, and Distribution-Free Approach. In the analysis there were included two outputs: loans and investment assets. The inputs, whose prices were used to estimate cost frontier, included labor, physical capital, and borrowed funds. Overall, the results showed relatively low average efficiency scores. The lowest level of cost efficiency was observed in the case of banks in France, the highest level in case of banks in Spain. The results of the analysis showed, that the frontier techniques didn't provide comparable average efficiency scores, but they were positively correlated.

In the case of authors from the Slovak Republic as well as from the Czech Republic, efficiency was examined for example in works of Stavárek (2006), Pančurová and Lyócsa (2013), Řepková (2013), Boďa and Zimková (2015), Palečková (2015), Zimková (2015) and Štefko et al. (2016).

Pančurová and Lyócsa (2013) measured bank cost and revenue efficiencies using DEA. Their estimated efficiencies and their determinants for a sample of 11 Central and Eastern European countries over the 2005 – 2008 period. They adopted the intermediation approach and assumed that banks produce two outputs: total loans and other earning assets. The prices

of those outputs were represented by the ratios of interest received on loans to total performing loans and noninterest income to other earning assets, respectively. Total deposits and total costs represented the two inputs. The prices of those inputs were total interest expenses to total deposits and total costs to total assets, respectively. They found out no dramatic changes in the average cost and revenue efficiencies during the analyzed period, although cost efficiency declined slightly and revenue efficiency increased. The average cost efficiency was higher for the Baltic countries and the Czech Republic. Lower values were observed for Romania and Hungary.

Řepková (2013) estimated the cost and profit efficiency of the Czech commercial banks in the period 2001 – 2010 using SFA. The average cost efficiency ranged the value 78 – 91% and the average profit efficiency ranged 64 – 99%. The highest average cost efficiency achieved the group of the medium-sized banks following by the group of small banks and the highest average profit efficiency achieved the group of small banks. The largest banks were the lowest efficient in the case of the cost and profit efficiency. The reason for the inefficiency of the Czech banks was mainly an excess of client deposits in the balance sheet of banks and improperly chosen size (range of operation) of individual banks (especially the largest one).

Boďa and Zimková (2015) used three approaches: the services-oriented approach, intermediation approach and the profit oriented approach to investigated efficiency of the Slovak banking industry over the years 2000 – 2011. They used DEA models to measure technical efficiency of eleven commercial banks in three sub-periods: 2000 – 2003, 2004 – 2008 and 2009 – 2011. In each of these periods, banks were pooled together in one data frame.

Palečková (2015) estimated banking efficiency of Czech commercial banks during the period 2001-2013. She used two alternative specifications of the DEA method, specially CCR model and BCC model that differ in return to scale. During the period 2001 – 2013 the average efficiency computed using the constant return to scale (CCR model) ranges from 61 to 92% and the average efficiency computed using the variable return to scale (BCC model) ranges from 85 to 98%. The average efficiency increased during the period 2001 to 2008. In 2009, the average efficiency decreased, which was a result of the financial crisis. In the last years, the efficiency started to increase.

3. Methodology

In this paper, we discuss some popular extensions of basic DEA models. If price data are available then it is possible to measure allocative, technical efficiency as well as overall cost, revenue, and profit efficiency. To calculate these main types of efficiency, a set of linear programs should be solved.

The input-oriented DEA model under the assumption of a variable return to scale can be used for calculation of input-oriented technical efficiency and cost efficiency. Input-oriented model under the assumption of variable return to scale is often termed as BCC model, which can be written in the following form (Coelli et al., 2005):

$$\begin{aligned} &\text{Min } \theta_q && (1)\\ &\text{s.t. } \sum_{j=1}^{n} x_{ij}\lambda_j \le \theta_q x_{iq}, && i = 1,2,...,m,\\ &\sum_{j=1}^{n} y_{rj}\lambda_j \ge y_{rq}, && r = 1,2,...,s,\\ &\sum_{j=1}^{n} \lambda_j = 1,\\ &\lambda_j \ge 0, && j = 1,2,...,n, \end{aligned}$$

where θ_q is input-oriented technical efficiency (TE_q) of Decision Making Unit (DMU_q) in the input-oriented DEA model, y_{rq} is produced amounts of the r-th output (r = 1,2,...,s) for DMU_q, x_{iq} is consumed amounts of the i-th input (i = 1,2,...,m) for DMU_q, y_{rj} is produced amounts of the r-th output (r = 1,2,...,s) for DMU_j (j = 1, 2,...,n), x_{ij} is consumed amounts of the i-th input (i = 1,2,...,m) for DMU_j (j = 1, 2,...,n), λ_j is the weight assigned to the DMU_j (j = 1,2,…,n).

To calculate cost efficiency is necessary to solve the following cost minimization DEA model (Coelli et al., 2005):

$$\begin{aligned} &\text{Min } \sum_{i=1}^{m} w_{iq} x_{iq}^{*} && (2)\\ &\text{s.t. } \sum_{j=1}^{n} x_{ij}\lambda_j \le x_{iq}^{*}, && i = 1,2,...,m,\\ &\sum_{j=1}^{n} y_{rj}\lambda_j \ge y_{rq}, && r = 1,2,...,s,\\ &\sum_{j=1}^{n} \lambda_j = 1,\\ &\lambda_j \ge 0, && j = 1,2,...,n, \end{aligned}$$

where w_{iq} is a vector of input prices of DMU_q and is the cost minimizing vector of input quantities for DMU_q, given the input prices w_{iq} and the output levels y_{rq}.

The overall cost efficiency (CE_q) is defined as the ratio of minimum cost of producing the outputs to observed cost of producing the outputs for the DMU_q (Coelli et al., 2005):

$$CE_q = \frac{\sum_{i=1}^{m} w_{iq} x_{iq}^{*}}{\sum_{i=1}^{m} w_{iq} x_{iq}} \qquad (3)$$

The overall cost efficiency can be expressed as a product of technical and allocative efficiency. Therefore, the allocative efficiency of the DMU_q can be calculated as the ratio of overall cost efficiency (CE_q) to input-oriented technical efficiency (TE_q). These three measures (technical, allocative and overall cost efficiency) can take values ranging from zero to one, where a value of one in the case of *TE*, *AE* and *CE* indicates full efficiency. If production unit is fully technically efficient (TE_q = 1) and displays allocative efficiency (AE_q = 1); it is also overall cost efficient (CE_q = 1). This production unit uses a minimum amount of inputs for producing of given outputs while the proportion of inputs will guarantee the minimum possible costs. The production unit which is technically efficient (TE_q = 1) but

doesn't demonstrate allocative efficiency ($AE_q < 1$) isn't also overall cost efficient ($CE_q < 1$). This production unit uses a minimum amount of inputs for producing the given outputs, but the proportion of inputs will not guarantee the minimum possible costs. The production unit which reaches allocative efficiency ($AE_q = 1$), but doesn't reach technical efficiency ($TE_q < 1$) cannot be marked as overall cost efficient ($CE_q < 1$). The proportion of inputs will guarantee the minimum possible costs, but this combination of inputs is not minimal for a producing of given outputs. If the production unit fails to demonstrate any of these three types of efficiency ($TE_q < 1$; $AE_q < 1$; $CE_q < 1$), then the value of overall cost efficiency can be interpreted as potential costs saving that can be achieved if the production unit uses the inputs in optimal combination. Potential costs saving can be calculated by subtracting the value of overall cost efficiency from the number one.

4. Empirical Analysis and Results

This section describes the practical application of DEA method for measuring cost efficiency in the European banking sector using the R software (R Core Team, 2013). R is a free software environment for statistical computing and graphics. It is very much a vehicle for newly developing methods of interactive data analysis. It is developing fast and has been extended by a large collection of packages. However, most programs written in R software are essentially ephemeral, written for a single piece of data analysis. In our analysis the package "Benchmarking" was used. This package contains methods to estimate technologies and measure efficiency using DEA while supporting different technology assumptions (free disposability hull, variable return to scale, constant return to scale, decreasing return to scale, increasing return to scale), and using different efficiency measures (input based, output based, hyperbolic graph, additive, super, directional).

The study evaluates a cross-country level data of 28 European Union (EU) banking sectors for the period 2008 – 2014 compiled from the database of European Central Bank. To evaluate banking sectors the intermediation approach was used. This approach views bank as an intermediary of financial services and assumes that banks collect funds (deposits and purchases funds) with the assistance of labor and capital and transform them into loans and other assets.

For each banking sector in the sample, it was necessary to select inputs, outputs and input prices. Input and output variables, and selected types of costs are measured in thousands of EUR. We consider three inputs, namely, total deposits (x_1), the number of employees (x_2) and fixed assets (x_3). Each of these inputs generates costs, referred to total interest expenses, staff costs and other operating expenses. Therefore, we can easily calculate prices for each input as a ratio of the particular cost to the selected input. The price of deposits (w_1) can be calculated as the ratio of total interest expenses to total deposits; the price of labor (w_2) as the ratio of staff costs to a number of employees; and the price of physical capital (w_3) as the ratio of other operating expenses to the value of fixed assets. On the output side, we consider two types of outputs: total loans (y_1) and other earning assets (y_2), which refer to non-lending activities. We provide report - descriptive statistics of these variables in Table 1.

To solve the cost minimization problem using R, we first load the data from MS Excel file that must be saved in the CSV (comma-separated values) format. The solution of the cost minimization DEA model requires using the procedure cost.opt from the Benchmarking package. This command estimates the optimal input vector that minimizes cost in the context of the DEA technology. The part of the command is to define which variables will act as inputs (the matrix of inputs, x), outputs (the matrix of outputs, y), input prices (as a matrix, w) and used technology (variable return to scale "vrs") of applied model. To calculate overall

cost efficiency, we have to find the actual costs and the optimal costs. By dividing these values we obtain overall cost efficiency of evaluated production units.

Table 1: Descriptive statistics on variables used for efficiency measurement

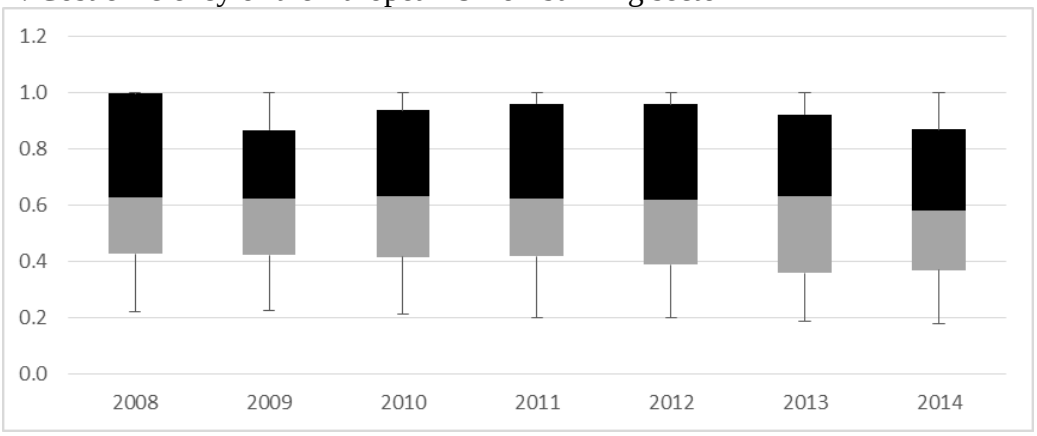
	2008 Median St. Dev.	2009 Median St. Dev.	2010 Median St. Dev.	2011 Median St. Dev.	2012 Median St. Dev.	2013 Median St. Dev.	2014 Median St. Dev.
x_1	240312093 1284356617	248539075 1320342027	291347367 1268715989	369801699 1268783569	347438554 1273874047	304318664 1213028318	302247600 1390628680
x_2	48225 175591	46355 171094	44633 168809	47224 165774	44900 163196	40192 158636	39895 155267
x_3	4870202 37904651	4713382 38762231	3425078 39035584	3300813 36171705	3153898 33160002	2727871 30424700	3870481 31028193
y_1	299813730 1486490426	277920299 1373800520	285051947 1301285922	320466788 1355198970	283790791 1246882380	253405963 1173323097	260561049 1346364169
y_2	47617027 461593841	61875814 634485666	70472509 665328545	62089110 613265781	66554877 587518571	71213517 571723447	75258656 580064604
w_1	0.053160 0.040030	0.035658 0.029109	0.028940 0.013588	0.031700 0.014203	0.030260 0.012605	0.024699 0.010331	0.020286 0.008964
w_2	664.1143 431.0230	674.3838 412.3031	709.5410 428.1407	759.8598 462.6587	696.5970 458.9502	721.0181 467.1260	564.2582 476.1254
w_3	0.544601 0.189757	0.537280 0.202918	0.566768 0.219310	0.581150 0.353334	0.602621 0.313480	0.595599 0.313968	0.592950 0.237631

Notes: Total deposits (x_1), number of employees (x_2), fixed assets (x_3), total loans (y_1), other earning assets (y_2), price of deposits (w_1), price of labor (w_2), price of physical capital (w_3). Total deposits, fixed assets, total loans and other earning assets are reported in thousands of €. The prices of input variables are per unit.

Source: the author.

Figure 1 shows the development of average cost efficiency of the EU banking sector during years 2008-2014. We observed no dramatic changes in the average cost efficiency during the analyzed period (see Panel A in Table 2), but we can see notable differences among observed countries (see Panel B in Table 2). During the whole analyzed period, the cost efficiency was skewed towards lower values, which reflected in the Figure 1 by moving the median values (horizontal line in the rectangle a restrictive value of 25th percentile and 75th percentile) down. This fact was also confirmed by the descriptive statistics of the average cost efficiency. The difference between the median value and the 25th percentile value was lower than the difference between the median value and the 75th percentile value.

Figure 1: Cost efficiency of the European Union banking sector



Source: the author.

Figure 1 and Table 2 show the results of average cost efficiency obtained relative to the whole sample during the analyzed period. The minimum average value was reached in 2014, the maximum average value in 2009. Results showed that the average cost efficiency decreased from 65.6822% in 2009 to 61.9581% in 2014 which can be a result of financial crisis.

Table 2: Cost efficiency of the European Union banking sector

Panel A	2008	2009	2010	2011	2012	2013	2014	2008-2014
Mean	0.651160	0.656822	0.650464	0.650979	0.643244	0.629764	0.619581	0.642794
Median	0.626805	0.623993	0.630642	0.620535	0.618257	0.630342	0.580731	0.618240
Min.	0.218765	0.225211	0.209970	0.196933	0.198961	0.187964	0.177368	0.177368
Max.	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
St. Dev.	0.278513	0.267051	0.282268	0.286585	0.287691	0.291698	0.287129	0.278986

Panel B	Mean	Median	Min.	Max.	St. Dev.
Austria	0.588745	0.601547	0.544715	0.637710	0.036923
Belgium	0.743973	0.668040	0.619942	1.000000	0.142568
Bulgaria	0.317373	0.321194	0.248434	0.387302	0.044747
Cyprus	0.604913	0.608389	0.563940	0.643901	0.024962
Czech Republic	0.277223	0.274430	0.265446	0.299370	0.012113
Germany	0.924600	1.000000	0.780693	1.000000	0.097088
Denmark	0.817469	0.783675	0.695700	0.991613	0.099522
Estonia	0.923218	0.996323	0.738845	1.000000	0.103379
Spain	0.828193	0.839007	0.711388	0.908985	0.069280
Finland	0.644585	0.618257	0.528377	0.803676	0.097542
France	0.920070	0.921010	0.826725	0.993302	0.065007
United Kingdom	1.000000	1.000000	1.000000	1.000000	0.000000
Greece	0.377152	0.376351	0.330503	0.414228	0.035496
Croatia	0.357879	0.357879	0.353693	0.362065	0.005920
Hungary	0.299497	0.291643	0.253237	0.355060	0.035762
Ireland	0.926251	0.955475	0.794101	1.000000	0.085087
Italy	0.467953	0.456490	0.417203	0.553993	0.042794
Lithuania	0.692901	0.719610	0.566759	0.774308	0.071496
Luxembourg	0.999658	1.000000	0.997604	1.000000	0.000905
Latvia	0.513023	0.506633	0.458326	0.573520	0.041209
Malta	1.000000	1.000000	1.000000	1.000000	0.000000
Netherlands	1.000000	1.000000	1.000000	1.000000	0.000000
Poland	0.209027	0.203015	0.200657	0.225211	0.009502
Portugal	0.467693	0.472322	0.385302	0.537508	0.059778
Romania	0.212335	0.198961	0.177368	0.288069	0.036634
Sweden	1.000000	1.000000	1.000000	1.000000	0.000000
Slovenia	0.491207	0.487719	0.472904	0.514730	0.013957
Slovakia	0.342874	0.339782	0.306153	0.374625	0.023874

Panel C	Mean	Median	Min.	Max.	St. Dev.
Large	0.948223	1.000000	0.780693	1.000000	0.074207
Medium-sized	0.762049	0.788495	0.385302	1.000000	0.207109
Small	0.478935	0.376351	0.177368	1.000000	0.251191

Panel D	Mean	Median	Min.	Max.	St. Dev.
Northern Europe	0.786078	0.778991	0.458326	1.000000	0.186873
Western Europe	0.862841	0.968315	0.544715	1.000000	0.167419
Southern Europe	0.594117	0.485896	0.330503	1.000000	0.233541
Eastern Europe	0.323320	0.288069	0.177368	0.643901	0.128356

Source: the author.

The average cost efficiency in the beginning of the analyzed period was 65.116% indicating that on average banking sectors could save 34.884% of their costs by using the inputs in optimal combination while maintaining a given input prices. In average the European banking sector did not use minimum amount of inputs for producing of given

outputs, and the proportion of inputs did not guarantee the minimum possible costs. When we looked at the costs of the European banking sector we can see, that the average observed value of costs was € 161.494 billion and the average optimal value of costs was € 140.696 billion. The potential cost saving could be achieved by decreasing total deposits on average by 3.58%, by reducing the number of employees on average by 46.02% and by reducing fixed assets on average by 43.77%, while maintaining a given input prices. This optimal combination of inputs allowed to achieve minimum cost and shift on efficiency frontier.

In the end of the analyzed period, the average cost efficiency was 61.9581% indicating potential cost-saving equal to 38.0418%. This potential cost saving could be achieved by decreasing total deposits on average by 10.32%, by reducing the number of employees on average by 43.44% and by reducing fixed assets on average by 33.56%, while maintaining a given input prices.

The results of DEA analysis, per country, are shown in Table 2 (see Panel B). The average cost efficiency ranged from 20.9027% in case of Poland to 100%. The highest cost efficiency scores were recorded in case of countries like the United Kingdom, Netherlands, Sweden, Malta, and Luxembourg. On the other hand, the lowest cost efficiency scores were observed in the case of countries like Poland, Romania, Bulgaria, Hungary and the Czech Republic. In case of fourteen countries (Belgium, Germany, Denmark, Estonia, Spain, Finland, France, United Kingdom, Ireland, Lithuania, Luxembourg, Malta, Netherlands and Sweden) the average cost efficiency was higher than the average in the whole sample (64.2794%), in other fourteen countries (Austria, Bulgaria, Cyprus, Czech Republic, Greece, Croatia, Hungary, Italy, Latvia, Poland, Portugal, Romania, Slovenia and Slovakia) the average cost efficiency was lower than the average in the whole sample.

An improvement in cost efficiency over the analyzed period can be seen in Cyprus, Denmark, Estonia, Finland, Latvia, and Slovenia. While the decline of efficiency in Austria, Belgium, Bulgaria, Czech Republic, Germany, Spain, France, Greece, Croatia, Hungary, Ireland, Italy, Lithuania, Poland, Portugal, Romania, and Slovakia. The countries like the United Kingdom, Malta, Netherlands and Sweden were cost efficient through the whole analyzed period. The greatest decrease between the years 2008 and 2014 occurred in case of Belgium, where the cost efficiency decreased from 100% to 63.2461%. On the other hand, the greatest increase recorded Denmark, where the cost efficiency increased from 69.570% to 99.1613%.

In the next part of our study, we calculated average cost efficiency scores derived from the model for three groups of banking sectors classified according to the volume of total assets. We adopt part of the methodology to determine significant banking sectors applied by the European Central Bank. We divided banking sectors into three groups: large, medium-sized, and small banking sectors. Large banking sectors are defined as the three most significant banking sectors in the European Union. It means, that these three banking sectors have three highest shares of total assets in the European banking sector. Medium-sized banking sectors are defined as banking sectors with share of total assets on the total assets of the European banking sector higher than 1%, but not involved in the group of large banking sectors. The last group of small banking sectors is defined as the banking sectors with share of total assets on the total assets of the European banking sector less than 1%. In the first group, there are three banking sectors: German, French banking sector, and banking sectors in the United Kingdom. In the second group, there were involved eleven banking sectors: Austria, Belgium, Denmark, Spain, Finland, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Sweden. In the last group, there were banking sectors of Bulgaria, Cyprus, Czech Republic, Estonia, Greece, Croatia, Hungary, Lithuania, Latvia, Malta, Poland, Romania, Slovenia, and Slovakia. Large banking sectors seem to be the most cost efficient, where the average cost

efficiency during the whole analyzed period was 94.8223% (see Panel C in Table 2). On the second place, there was average cost efficiency within the medium-sized banking sectors, where the average efficiency reached 76.2049%. The least efficient were banking sectors in the last group, where the average cost efficiency during the whole analyzed period was only 47.8935% (the average efficiency in this group was lower than the average in the whole sample). The greatest volatility was evident in the group of small banking sectors.

The development of the average efficiency in three groups of banking sectors is practically stable. There can be seen a decrease of the average cost efficiency within the group of large banking sectors from the value 99.5105% in 2008 to the value 86.9139% in 2014 which can be a result of financial crisis. The decrease can be also seen within the group of medium-sized banking sectors, where the average cost efficiency decreased from 81.9991% in 2008 to 73.7174% in 2014. A relative stable development was evident in the case of small banking sectors group, where the average cost efficiency decreased insignificantly from 46.5325% in 2008 to 45.8644% in 2014.

In the last part of our analysis there were determined the four main European "regions" (Northern, Western, Southern and Eastern Europe) and we analyzed the average cost efficiency within them (see Panel D in Table 2). The United Nations defines Northern Europe as consisting of the following eight European Union countries: Denmark, Estonia, Finland, Ireland, Lithuania, Latvia, Sweden and the United Kingdom. The Western Europe is created of next six EU countries: Austria, Belgium, France, Germany, Luxembourg, and Netherlands. Countries that are part of the Southern Europe are Croatia, Greece, Italy, Malta, Portugal, Slovenia and Spain. The Eastern Europe is defined as consisting of seven countries: Bulgaria, Cyprus, Czech Republic, Hungary, Poland, Romania, and Slovakia. As can be seen in the table, levels of average cost efficiency in case of Northern (78.6078%) and Western European (86.2841%) banking sectors were higher than the average in the whole sample (64.2794%); on the other hand, the average cost efficiencies in case of Southern (59.4117%) and Eastern European (32.3320%) banking sectors were under the total average. The Western European banking sectors appeared as the most efficient. On the other hand, the last place was mainly occupied by banking sectors from Eastern Europe. The explanation of generally lower efficiency of Eastern European banking sectors can be found in a couple of factors. Above all, imprudent mortgage lending, non-performing loans of the past, lack of transparency and accountability in mortgage financing, shadow banking activities, failure of risk management systems, no systematic risk regulations and other reasons which led to the financial crisis in American and European financial markets.

The development of the average efficiency in four groups of banking sectors indicates a decline in efficiency in case of Western, Southern and Eastern Europe while the efficiency in Northern Europe increased. There can be seen a decrease of the average cost efficiency within the Western European banking sectors from 93.2731% in 2008 to 79.8914% in 2014. The decrease can be also seen within the group of Southern European banking sectors, where the average cost efficiency decreased from 62.6178% in 2008 to 53.8639% in 2014. A relative stable development was evident in the case of Eastern European banking sectors, where the average cost efficiency decreased no dramatically from 33.1907% in 2008 to 30.3148% in 2014. The significant improvement in average cost efficiency could be seen in the case of Northern European banking sectors, where the value of efficiency increased from 75.2417% in 2008 to 80.8897% in 2014.

5. Conclusion

The efficiency of banks and other financial institutions is very frequently discussed topic in literature. Most studies have analyzed only the basic technical efficiency (e.g. Sherman and Gold, 1985; Stavárek, 2006; Boďa and Zimková, 2015; Palečková, 2015; Zimková, 2015), or have focused on the selected sample of countries (e.g. Weill, 2004; Pančurová and Lyócsa, 2013; Řepková, 2013). In our study, we were dealing with DEA method and described its application in measuring cost efficiency. As a contribution of our study compared to previous studies can be considered the analysis of cost efficiency on a sample of 28 banking sectors in all European Union Member states.

We analyzed the development of the average cost efficiency of the European Union banking sector during years 2008 – 2014. We observed no dramatic changes in the average cost efficiency during the analyzed period, but we can see notable differences among observed countries. The minimum average value of cost efficiency in a whole sample was reached in 2014, the maximum average value in 2009. The average cost efficiency in the beginning of the analyzed period was 65.12% indicating that banking sectors on average could save 34.88% of their costs by using the inputs in optimal combination while maintaining a given input prices. In average European banking sector didn't use minimum amount of inputs for producing of given outputs, and the proportion of inputs didn't guarantee the minimum possible costs. The potential cost saving could be achieved by decreasing total deposits, by reducing the number of employees and by reducing fixed assets, while maintaining a given input prices. This optimal combination of inputs allowed to achieve minimum cost and shift on efficiency frontier. At the end of analyzed period the average cost efficiency was reduction of inputs, while maintaining a given input prices.

The results of DEA analysis, by country, indicated that the average cost efficiency moved from 20.90% in case of Poland to 100% in case of United Kingdom, Netherlands, Sweden, Malta, and Luxembourg. The results according the size of banking sectors show that large banking sectors seem to be most cost efficient. On the second place, there was average cost efficiency within the medium-sized banking sectors and the last efficient were banking sectors in the last group. Development of the average efficiency in three groups of banking sectors is practically stable. In the last part of our analysis there were determined four main European "regions and we analyzed the average cost efficiency within them. The results of the analysis pointed to the fact, that levels of the average cost efficiency in case of Northern European banking sector and Western European banking sector were higher than the average in the whole sample; on the other hand, the average cost efficiencies in case Southern and Eastern European banking sectors were under the total average. The development of the average efficiency in four groups of banking sectors indicates decline in efficiency in case of Western, Southern and Eastern Europe, while the efficiency in Northern Europe increased.

We are aware of the fact that the paper be influenced by several limitations. First, the analysis may suffer from a sample selection bias problem resulting from the fact that the analysis is performed using data of whole banking sector. The selection of variables and analyzed period are determined by the availability of data (data only for the period since 2008 were available). Therefore, we couldn't analyze the impact of financial crisis on the cost efficiency in the European banking sector, as well as in the banking sectors of individual countries. In our study, we also used only one methodology, DEA. Maybe it would be interesting to check whether a similar progress in the cost efficiency scores would be obtained through a parametric method, SFA.

As a continuation of this work, it would be interesting to analyze the determinants which affected cost efficiencies in analyzed countries as a whole, or partially in the defined groups

of countries (according to total assets, or according to their location in European regions), or analyze the banking sector using bank level data.

Acknowledgements

This work was supported by the Slovak Scientific Grant Agency as part of the research project VEGA 1/0446/15.

References

[1] BANKER, R.D., CHARNES, A., COOPER, W.W. 1984. Some models for estimating technical and scale inefficiencies in data envelopment analysis. In Management Science, 1984, vol. 30, iss. 9, pp. 1078-1092.

[2] BOĎA, M., ZIMKOVÁ, E. 2015. Efficiency in the Slovak banking industry : A comparison of three approaches. In Prague Economic Papers, 2015, vol. 24, iss. 4, pp. 434-451.

[3] CHARNES, A., COOPER, W., RHODES, E. 1978. Measuring the efficiency of decision making units. In European Journal of Operational Research, 1978, vol. 2, iss. 6, pp. 429-444.

[4] COELLI, T. et al. 2005. An introduction to efficiency and productivity analysis. New York: Springer, 2005. ISBN 0-387-24265-1.

[5] FARRELL, M. J. 1957. The measurement of productive efficiency. In Journal of the Royal Statistical Society, 1957, vol. 120, iss. 3, pp. 253-290.

[6] PALEČKOVÁ, I. 2015. Estimation of banking efficiency determinants in the Czech Republic. In Journal of Applied Economic Sciences, 2015, vol. 10, iss. 2, pp. 234-242.

[7] PANČUROVÁ, D., LYÓCSA, Š. 2013. Determinants of commercial bank's efficiency : Evidence from 11 CEE countries. In Finance a úvěr : Czech Journal of Economics and Finance, 2013, vol. 63, iss. 2, pp. 152-179.

[8] R CORE TEAM. 2013. R: a language and environment for statistical computing. Vienna : R Foundation for Statistical Computing, 2013, http://www.r-project.org/.

[9] ŘEPKOVÁ, I. 2013. Cost and profit efficiency of the Czech commercial banks. In International Journal of Mathematical Models and Methods in Applied Sciences, 2013, vol. 7, iss. 3, pp. 286-294.

[10] SHERMAN, D., GOLD, F. 1985. Bank branch operating efficiency: evaluation with data envelopment analysis. In Journal of Banking and Finance, 1985, vol. 9, iss. 2, pp. 297-315.

[11] STAVÁREK, D. 2006. Banking efficiency in the context of European integration. In Eastern European Economics, 2006, vol. 44, iss. 4, pp. 5-31.

[12] ŠTEFKO, R., GAVUROVÁ, B., KORÓNY, S. 2016. Efficiency measurement in healthcare work management using Malmquist indices. In Polish Journal of Management Studies, 2016, vol. 3, iss. 1, pp. 168-180.

[13] WEILL, L. 2004. Measuring cost efficiency in European banking : A comparison of frontier techniques. In Journal of Productivity Analysis, 2004, vol. 21, iss. 2, pp. 133-152.

[14] ZIMKOVÁ, E. 2015. Technical efficiency and super-efficiency of the insurance sector in Slovakia. In Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 2015, vol. 65, iss. 6, pp. 2205-2211.