Non-Parametric Approach to Measuring the Efficiency of Banking Sectors in European Union Countries

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Abstract: The European banking sector has been in the center of interest for the last ten years. There are several reasons for this: An impact of global financial crisis on banks stability; Fundamental influence of banking sector on the effectiveness of governments' anti-crisis actions, Vulnerability of banking institutions to the crisis of the Euro currency and last, but not least, the problems of the biggest banks in Italy and Germany, which for the last decades have been considered as the most efficient. The financial crisis and its negative influence, not only on the small national banks, but also on the strongest International Institutions, has shown that the problem of measurement of efficiency of the banking sector is still a current topic, important not only from the perspective of academic research, but also form the point of view of National and International Regulators. In this context, the objective of this study is to propose a methodology for a comprehensive evaluation of operational efficiency of the banking sectors in EU countries. The pointed problem is often discussed in a nonlinear fashion. Thus, the potential methodological proposal should be based on the interaction of multiple inputs with multiple outputs, without the knowledge of the functional relationships between them. In the research, Data Envelopment Analysis, is given as a suitable instrument for this purpose. Thanks to this methodology we measured the degree of (in)efficiency of banking sectors in the EU countries. Additionally, we proposed measures to increase their efficiency. We found that there are differences between the efficiency of banking sectors of "old" fifteen and "new" EU member countries. We also confirmed that there is a noticeable difference between the efficiency of banking sectors within the European Monetary Union members and Countries which do not belong to the Euro-zone.

Keywords: efficiency; banking sector; Data Envelopment Analysis; Malmquist Index

1 Introduction

Banks are business entities, but they have a special meaning and role in national economies. Banking institutions can be classified as financial intermediaries, which are involved in allocation of excess liquidity among entities. They take deposits from entities with excess liquidity and they provide these resources to the deficient entities, in the form of loans, which is crucial, both from a micro and a macroeconomic perspective. During "normal" times, it significantly influences financial effectiveness and growth potential of enterprises, but what is more during the periods of market turbulence or crisis, the liquidity of the banking system determines an effectiveness measure of monetary authorities, governments' stabilization and anti-crisis actions [8, 21]. However, from the perspective of measuring efficiency of banking institutions, the range of banking services is currently much more diverse than simple financial intermediation. This is the reason why it is very difficult to define or to measure the bank "production" outcomes.

The logical consequence of the fact, that banks and banking sectors, have an extremely important role in National Economies, is the interest of the professional public in this issue, which is presented in many studies dedicated to the problem of measurement and evaluation of the efficiency of banks [6, 7, 15, 25, 34, 24]. The fundamental trends in recent years, such as deregulation; increased competition due to the globalization process; the global financial crisis of the years 2007-2008 and its long term consequences, have resulted in higher pressure in the sector and have forced banks to reduce costs and increase the efficiency of operational activities. In the past, ratio indicators such as liquidity, profitability, capital adequacy and so on, depending on the needs of the specific analysis, were treated as standard instruments for measuring of the banks performance. The results were usually a subject of comparison for a given bank in different time points or they were used as a benchmark tool with other banks.

These traditional indicators are attractive, as they have a quite easy interpretation and are simple from a methodological perspective. However, they have several limitations which should be considered. One is the assumption that all the rated banks are comparable, it means they should operate under conditions of similar returns of scale [39]. Another disadvantage is that each group of indicators is devoted to measurement of just a part of the banking activities. For this reason, these indicators often provide contradictory results, which can be confusing and provide inappropriate assessment of overall performance. Therefore, the simplistic analytical methods cannot offer an objective identification of ineffective banks, which could enable to separate them from the effective once. Simple financial indicators cannot capture the multiple natures of inputs and outputs, thus, the multivariate nature of efficiency phenomenon [2, 3]. These factors decrease the usefulness of standard financial ratios as tools for assessing the effectiveness of the group of banks.

The limitations which we mentioned above, led to the application of more sophisticated instruments for detecting single bank efficiency or the efficiency of whole banking sectors, which enable the measurement of the relative effectiveness of individual bank against to effectiveness of the best banks within examined group. For the case of all the methods, an objective problem relates to the determination of "the best" bank benchmark, which should be empirically pointed, as a theoretical "the best" bank model has not yet been developed. However, analysis of the production boundary enables to determine the comprehensive banks performance, and then divide them into the effective and ineffective groups. Subsequently, this analysis enables discovery of the causes of inefficiency. At the same time, the methods can provide specific recommendations which lead to the fact that an ineffective bank moves to the boundary of efficiency. We can divide the sophisticated methods for determining the efficiency into the following categories [14]: (i) parametric methods (Stochastic Frontier Analysis (SFA), Distribution-Free Approach (DFA)); (ii) nonparametric methods (Data Envelopment Analysis (DEA)), which will be applied in the article.

Therefore, the objective of the current research is to propose a methodology for a comprehensive evaluation of operational efficiency of the banking sectors in EU countries, which is based on the Data Envelopment Analysis and Malmquist index. From the strictly empirical perspective, the aim of the study is to measure the degree of (in)efficiency of European banking sectors and to verify potential differences between the efficiency of banking sectors of the “old” fifteen and the “new” EU member countries, the banking sectors in the European Monetary Union States and the “once outside” the Euro area.

The application of the DEA methodology to analysis of sectorial efficiency – also in the case of banking sector – is not a novel idea. However, in relation to the research on banking sector efficiency most of recent papers concentrate on single countries or even the micro-cases of single banks [1, 5, 14, 20, 23, 26, 31, 33, 37, 38, 41, 42]. The actuality and empirical contribution of this article to the current state of the art relates to the scope and scale of the research. To our best knowledge, in recent years, it is unique research that is devoted to the efficiency of the banking sector in the entire EU, with special consideration to the differences between the original countries of the EU and the new member states and member and non-member countries of the Euro zone.

2 Theoretical Framework

Efficiency is defined as a condition, where it is not possible to produce additional unit of a good with current resources, unless one reduces production of another good. It can be related to the microeconomic production frontier framework. Thus, under the mentioned condition an entity is on the edge of its production capabilities. Evaluation of efficiency is an integral part of rational behavior of the

production units that aims to survive in a challenging competitive environment in a long term. In practice it is possible to apply several methods to verify the level of efficiency [7, 22, 27, 28], namely: (i) financial ratios; (ii) indexes; (iii) multi-criteria evaluation of variants; (iv) statistical-econometric methods; (v) simulation.

The advantage of the first two instruments is their simple design and measurability. Other advantages are the clear explanatory power for a wide range of users and easy identification of deviations from targets or planned values. However, these instruments also have some important disadvantages, for example, they work with only two factors, or just with a few factors. It means that they are not useful for identifying simultaneous presence of several factors. From the quantitative perspective, a common problem is attributed to the fact that they are often not measurable together and they cannot be aggregated. The mentioned problems can be solved to some extent with application of many multi-criteria evaluation methods. But these methods are also far from perfect. Their important disadvantage is usually seen in the complicated interpretability of the obtained results [35].

However, econometric methods have also several drawbacks. One of them is defining inefficiency as the random variable that follows a certain probability distribution, which must be specified a priori, as well as the form of dependence transformation of input to the output. In the case of baking sector it is often stressed that the form of transformation of an input to an output is often nonlinear and difficult to specify [30]. Thus, the assumptions about the form of dependence and probability distribution of inefficiency are not usually known in practice. As a result, incorrect estimation of these parameters can lead to a situation, where the model has no relation to reality [6]. That problem was especially visible during the last global financial crisis.

Conversely, simulations can also have an important disadvantage – they are an application for one specific example. It means that simulation does not offer the rating for the set of several production units. This approach compares reading frame of one unit in the system and not the system of units as a whole [28].

2.1 Data Envelopment Analysis

Data Envelopment Analysis (DEA) enables to reduce the mentioned disadvantages of the traditional approaches. This is a group of methods which represents a special area of application of linear programming. DEA measures the efficiency of the various entities or organizational units. Investigation of efficiency is not only related to profitability of entity in a private sector. In general, one can examine the effectiveness of any entity that transforms an input to an output in some way. In a study [16] authors state that DEA analysis is most often applied in the following sectors: agriculture, banking, supply chain management, transportation, and public policy. The popularity of the method has

increased significantly in recent years. In the mentioned study the authors show that to 2016 there were 9881 scientific papers with DEA applications registered in Scopus and WoS databases. In the first phase, 1978-1994, only several dozen of papers per year were published. In the second phase, 1995-2003 the average number of published papers was about 134 per year. Interesting is the last phase 2004-present, where there is an exponential increase of published articles. Even within the three year period of 2014, 2015 and 2016, about 1,000 scientific applications of the method per year were published.

Although DEA method was originally created to evaluate the effectiveness of non-profit organizations, it began to be intensively used for an evaluation of business entities including banking institutions. As the first the possibility of measuring the efficiency of banks based on DEA investigated [39]. However, as a pioneering study in the area of measuring the efficiency of banks one can point [6], who analyzed the efficiency of 14,000 US banks. First, who carried the analysis of efficiency of bank branches were [9]. Detailed analysis of the historical development and application of DEA for analyzing banking sector was carried by [36], where 80 published studies from 24 countries were analyzed. Another study is [22] who verified 196 studies, which concentrated on the efficiency of banks and banking sectors of which 151 were based on DEA applications.

The aim of DEA method is to eliminate or exclude subjectivity of using output measurements in relation to input. The process of output and input selection, which are intended for comparison, changes the process of analysis to objectivity and eliminates subjectivity. Through the linear mathematical model weights to the input and output of individual production units (Decision Making Units DMU) – for example banks – are assigned, which reflect the efficiency of the bank. Models relating to the relevant banks have the same shape, but with the different efficiency they will have a different value of weights. According to these weights, banks will be compared and sorted. Given that, weights are the index numbers, it does not matter in which units they are expressed.

Basic ideas come from Farel [18] and later they were reformulated by Charnes, Cooper & Rhodes [10] (model DEA CCR) and Banker, Charnes & Cooper [4] (model DEA BCC). Because the method has few easily attainable assumptions, the proposals have opened new possibilities in the evaluation of DMU. Especially, when it is impossible to evaluate the DMU, mainly because of a complex and the unknown nature of the relationship between inputs and outputs. Cooper, Seiford & Ton [12] state that DEA models can be also applied in the cases, where other than DEA models are used for evaluation of efficiency.

All models can be oriented either to the input *(input oriented)* or to the output *(output oriented)*, or they can use a combination of the two previous options and an additive model *(slack-based models)* can be constructed.

In models which are input oriented, one detects efficiency of bank or banking systems based on the input variables (the number of banks, total assets, number of

employees, etc.). Banks whose optimal value of objective function is equal to one is considered as operating effectively within the observed group. Banks whose optimal value of objective function is less than one, are treated as inefficient. This value shows the need for a proportional reduction of inputs (improvement), so that ineffective bank became effective. It means that thanks to DEA models we are able to determine the degree of bank efficiency and also we obtain information how banks should "improve" their activities in order to become effective.

Output oriented models detect bank efficiency based on the output variables (the number of served customers, loans, interest income, and the volume of deposits). Banks whose optimal value of objective function is equal to one are considered as effective within the observed group, and banks whose optimal value of objective function is greater than one are inefficient. In output oriented models an increase of some or all of the output variables is considered as "improvement" of banks activities. Nowadays, there are a lot of modification of basic DEA models and Zhu [43] made their detailed description.

In the current research we propose to apply CCR DEA model. The model for DMU U_q can be formulated as the task for linear refracted programming:

$$\begin{aligned} &\textit{maximize} \qquad z = \frac{\sum_{i=1}^{r} u_i y_{iq}}{\sum_{j=1}^{m} v_j x_{jq}}, \\ &\textit{subject to} \qquad \frac{\sum_{i=1}^{r} u_i y_{iq}}{\sum_{j=1}^{m} v_j x_{jq}} \le 1, \qquad k = 1,2,3,\ldots,n, \\ &\qquad\qquad u_i \ge \varepsilon, \qquad i = 1,2,3,\ldots,r, \\ &\qquad\qquad v_j \ge \varepsilon, \qquad j = 1,2,3,\ldots,m, \end{aligned} \tag{1}$$

Where *z* is a measure of efficiency of the unit Uq, *e* is infinitesimal constant by which the model ensures that all weights of inputs and outputs will be positive and will be then involved in the model on at least a certain minimum level.

In the research we propose to apply output and input oriented CCR DEA model because we assume a constant returns to scale. A comparative study provided by [36] was a main argument for choosing that model. In this study authors state that from 80 DEA models which were applied in the area of measuring the efficiency of banks and banking sectors in more than 50 CCR was applied. Noulas [29] shows special advantages of applying CCR model in the context of the possibility of comparison of big and small banks or banking sectors, which is especially important form the perspective of current research. However, it should be noted

that there are also contradictory propositions. For example, in the summary [19], based on the 151 observed DEA models, the authors recommend to use the BCC DEA model (variable returns to scale). There are also some studies [11, 12, 40], where the simultaneous application of both CCR and BCC DEA is considered as a possible compromise.

2.2 Malmquist Index

An ineffective DMU can become effective, thanks to implementation of various rationalization measures. DMU which underrate the situation can be moved from effective category to the ineffective category, vice versa. However, we are not able to quantify this important fact with application of the basic DEA models. We can consider basic DEA models as static models which do not take into account the development or change in effectiveness of DMU in time. Fortunately, we are able to eliminate this problem by using Malmquist index [4]. Färe, Grosskopf, Lindgren and Roos [17] adjusted Malmquist index to measure changes in effectiveness of DMU in time. We can also formulate Malmquist index in various versions: oriented on inputs or outputs, with fixed, variables, not increasing or not decreasing returns of scale.

Malmquist input oriented index quantifies the change in effectiveness of production units q between successive periods t and t+1 and this model has following form:

$$M_q(x^{t+1}, y^{t+1}, x^t, y^t) = E_q P_q \tag{2}$$

Term Mq (x^{t+1}, y^{t+1}, x^t, y^t) is also called "Total Factor Productivity Index TFP". E_q is given as the change in relative efficiency of unit q in comparison with other DMU between period's t and t+1, P_q quantifies the change in production possibilities boundary, which is caused by the technology development between periods t and t+1. These components are defined as follows:

$$E_q = \frac{D_q{}^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_q{}^{t}\left(x^{t}, y^{t}\right)} \tag{3}$$

$$P_q = \left[\frac{D_q{}^{t}\left(x^{t+1}, y^{t+1}\right) D_q{}^{t}\left(x^{t}, y^{t}\right)}{D_q{}^{t+1}\left(x^{t+1}, y^{t+1}\right) D_q{}^{t+1}\left(x^{t}, y^{t}\right)} \right]^{1/2} \tag{4}$$

Then:

$$M_q(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_q{}^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_q{}^{t}\left(x^{t}, y^{t}\right)} \cdot \left[\frac{D_q{}^{t}\left(x^{t+1}, y^{t+1}\right) D_q{}^{t}\left(x^{t}, y^{t}\right)}{D_q{}^{t+1}\left(x^{t+1}, y^{t+1}\right) D_q{}^{t+1}\left(x^{t}, y^{t}\right)} \right]^{1/2} \tag{5}$$

The term in front of brackets is called the change of relative efficiency E and measures the distance from boundary between period's t and t+1. The section in square brackets is the technical change T or technological progress. It is the geometric average of change in production technologies between the two period's t and t+1. Färe in his paper showed how we can calculate the function of distance and Malmquist index by using DEA. This fact again lead to the task of linear programming, where for each of DMU we have to calculate four functions of distance in time periods t and t+1. This situation requires solving four tasks of mathematical programming. According to the value of E_q, P_q and mainly according to the value of Malmquist index M achieved results can be interpreted as follows: for the all indexes (technological progress, changes in economic efficiency and M index) valid if they are less than one, it means that the position of DMU in the area is worse (wrong decision), if they are equal to one (decision were neutral), greater than one, DMU made good decisions that lead to improvement of status for this DMU.

3 Application of DEA for Measuring of Efficiency of European Banking Sectors

The objective of this study is to quantify the efficiency of banking sectors in European Union Countries by application of Data Envelopment Analysis for the years 2014 and 2015 and also quantify the interaction between them through the Malmquist index. The short time span of the analysis was restricted by the data availability for the whole panel of the EU countries.

In this study we determined three hypotheses:

H1: Banking sectors in the European Union countries are not enough consolidated after the strong impact of the financial crisis. As a result, banking sectors in most of the countries are ineffective.

H2: Banking sectors in "old" EU members countries are working more effectively than the banking sectors in "new" EU members.

H3: Banking sectors of European Monetary Union countries are working more efficient than the sectors of countries which do not apply the euro.

Providing proper definition of inputs and outputs is usually considered as the most difficult operation in the process of DEA model constricting. Defining of inputs and outputs of commercial banks is not an exception. Their definition is based on the three basic bank models [9, 39]: (i) intermediation model, (ii) production model), (iii) asset model. It should be noted that except of these basic models there are also other possibilities such as a model of cost per user (User cost model) or a model of value added (Value added model).

We took into account three models mentioned above and studies [15, 37] in the process of determining the input and output characteristics. In accordance with the extent of the group (28 countries) we chose six as an appropriate number of inputs and outputs, as the number of factors involved in the analysis significantly influences the results in the application of the DEA methodology. An excessive number of variables artificially increases the number of efficient DMU and then reduces the discriminatory power and explanatory power of the analysis. Thus, it is recommended that the number of variables should not be greater than one third of the range of the group [22]. In our study we used following input variables: assets, staff, Herfindahl-Hirschman index and number of banks. In addition, we used following output variables: deposits and loans. Tables 1 and 2 show the data for 2015 and 2014. The data was obtained from the annual report of the European Central Bank and the European Banking Federation.

Table 1
Input and output variables of bank sectors in 2015

Country	INPUT				OUTPUT	
	Assets [€ mil.]	Staff	HHI	Number of banks	Deposits [€ mil.]	Loans [€ mil.]
Belgium	1102000	56611	998	103	619965	479513
Germany	7802346	647300	273	1808	4525100	4368244
Estonia	21455	4860	2409	37	14751	18582
Ireland	1079754	28871	679	446	349325	324808
Greece	397801	45654	2254	40	243789	236027
Spain	2973124	201643	896	226	2001535	1725788
France	8176956	411012	589	496	3985954	4375305
Italy	4022863	299684	435	670	2339704	2410291
Cyprus	91151	10956	1443	57	48866	65177
Latvia	30855	9374	1033	59	13945	19598
Lithuania	25487	8952	1939	89	16345	20938
Luxembourg	962871	25816	321	148	450633	387075
Malta	56872	4427	1621	27	26562	15341
Netherlands	2451308	94000	2104	218	1145010	1324449
Austria	879996	74110	397	707	503959	528696
Portugal	469053	53888	1159	150	284994	259468
Slovenia	43557	10682	1077	24	30095	28779
Slovakia	64238	18656	1250	28	46470	43118
Finland	579309	22019	2730	271	186249	273221
Bulgaria	47370	31715	2433	28	31573	31328
Croatia	57793	21190	1726	33	35788	43323
Czech Republic	195513	40334	1100	56	126154	114838
Denmark	1082400	37201	328	119	304283	639331

Hungary	113460	39456	982	189	63777	78105
Poland	379577	175972	411	679	241341	259129
Romania	90492	57732	1992	39	54825	61182
Sweden	1247067	54644	592	159	404193	697069
United Kingdom	8997563	402561	318	361	3819623	4080962

Source: European Banking Federation & European Central Bank

Table 2

Input and output variables of bank sectors in 2014

Country	**INPUT**				**OUTPUT**	
	Assets [€ mil.]	**Staff**	**HHI**	**Number of banks**	**Deposits [€ mil.]**	**Loans [€ mil.]**
Belgium	1021568	58233	982	103	617928	469940
Germany	7528947	651250	301	1842	4482598	4429237
Estonia	19951	4861	2445	31	13449	16385
Ireland	1016950	31776	667	458	386260	360963
Greece	407407	51242	2195	40	266776	246206
Spain	3150735	215663	839	290	2046168	1828885
France	7881631	415953	584	623	3908181	4334755
Italy	4047885	306313	424	694	2301355	2382174
Cyprus	90198	11142	1303	101	52635	63581
Latvia	29258	10029	1001	63	13747	20434
Lithuania	24035	8392	1818	91	13873	18348
Luxembourg	914817	26237	329	147	430624	393022
Malta	50333	4197	1648	27	19636	14922
Netherlands	2250131	96423	2131	253	1041558	1268028
Austria	915105	75980	412	731	511214	553294
Portugal	515328	57556	1164	151	308545	284089
Slovenia	46354	11218	1026	23	32216	32313
Slovakia	61129	18540	1221	28	44873	41109
Finland	525312	22402	3310	303	183439	263833
Bulgaria	47410	32756	2305	30	31150	32987
Croatia	57944	21646	1596	35	35145	44864
Czech Republic	190868	39742	1059	56	128863	114914
Denmark	1048300	36367	335	161	285992	634588
Hungary	116064	40750	1006	189	62437	65896
Poland	361627	179385	395	691	230311	250302
Romania	91396	58612	1854	39	51459	64675
Sweden	1214496	53594	572	168	395313	693523
United Kingdom	8895348	421508	315	358	3977473	4315786

Source: European Banking Federation & European Central Bank

Capital represents the total average value of fixed assets of all banks in the country. The staff is expressed by the average number of employees in a given banking sector. Herfindahl-Hirschman index is used in the context of antitrust policy to measure the concentration of the sector in the national market. Low value of the index indicates low level of sector concentration, which can be interpreted as the sign of higher competition in the sector. Punt & Van Rooij [36] provide also other possibilities of measurement the concentration in banking sector such as Lerner index, Theil coefficient of entropy or concentration ratio. The last input variable is the total number of domestic banks and foreign banks or their branches. Deposits are measured as the total amount of current and term deposits, which banks obtained from individual clients and from other financial institutions. Loans are measured as the net value of loans to population, business sector and other financial institutions.

4 Results and Discussion

As it was pointed, the main aim in this paper was to measure the efficiency of banking sectors of the European Union member countries. The results of output oriented analysis are presented in Table 3 and the results of input oriented analysis are given in Table 4. We can conclude, that from the point of view of our analysis the banking sectors are effective in 15 countries in 2015 (the rate of efficiency is equal to one) and in 13 countries they are not effective (the rate of efficiency in output oriented models is higher than one and in input oriented models is lower than one, vice versa). In 2014, 18 banking sectors were effective and only 10 sectors were not effective. Compared to 2015 the rate of efficiency of banking sectors fell from 64.29% to 53.57%.

As it was mentioned, the advantage of DEA is the ability to measure the efficiency of DMU. In addition, DEA has another important advantage, which is the ability to detect the reserves. It means in the input oriented models DEA provide information on the necessary reduction of the inputs. In the output oriented models information on the possibilities to increase the outputs is given.

The degree of inefficiency in the banking sector will be illustrated with an example of Malta, which was rated as the least efficient banking sector in 2015. As the first step we will do the analysis of output oriented models. The rate of relative inefficiency of the sector was 0.6914 (1/1.44625). The banking sector in Malta would be considered as effective if the original value of deposits was increased from 26562 million € to 38415 million € (it must be increased by 11853 million €). Furthermore, the sector should increase the volume of lending from 15 341 million € to 33244 million € (the difference is 17903 million €). In the analysis for Malta, the Spanish banking sector is used as a benchmark.

Table 3
The efficiency of banking sectors in 2015 - output oriented model

Country	Efficiency	Benchmarks	OUTPUT	
			Deposits [€ mil.]	Loans [€ mil.]
Belgium	1.01704	Spain	10561	112288
Germany	1.00000	---	0	0
Estonia	1.00000	---	0	0
Ireland	1.35501	Luxembourg	124013	115309
Greece	1.00000	---	0	0
Spain	1.00000	---	0	0
France	1.00000	---	0	0
Italy	1.00000	---	0	0
Cyprus	1.00000	---	0	0
Latvia	1.18413	Cyprus	4636	3609
Lithuania	1.00000	---	0	0
Luxembourg	1.00000	---	0	0
Malta	1.44625	Spain	11853	17903
Netherlands	1.00000	---	0	0
Austria	1.00434	Italy	8108	2294
Portugal	1.09048	Spain	25786	23476
Slovenia	1.02310	Estonia	695	665
Slovakia	1.00000	---	0	0
Finland	1.20294	Spain	37798	55448
Bulgaria	1.06088	Estonia	1922	1907
Croatia	1.00000	---	0	0
Czech Republic	1.04639	Spain	5853	5328
Denmark	1.00000	---	0	0
Hungary	1.01642	Cyprus	4685	1282
Poland	1.00000	---	0	0
Romania	1.03857	Greece	2115	2360
Sweden	1.06255	Italy	25454	43605
United Kingdom	1.00000	---	0	0

Table 4 shows the results of input oriented analysis. The number of efficient banking sectors must be the same as the benchmark for ineffective sectors. But the rate of inefficiency is expressed directly. When we use the example of Malta, it is 0.69144. It means that the banking sector has to reduce the following inputs: the assets must fall by 17 548 million €, from the amount of 56872 million € to 39324 million €. The number of employees must be reduced from the original amount of 4427 by 1366, which means that the employment level in the sector should be equal to 3 061. The degree of concentration of banking sector in Malta, which is

expressed by Herfindahl-Hirschman index, must fall by 1575, it means from the amount of 1621 to the final amount 46. Finally, the number of banks should fall by 13, it means from the original amount of 27 to 14.

Table 4
The efficiency of banking sectors in 2015 - input oriented model

Country	Efficiency	INPUT			
		Assets [€ mil.]	Staff	HHI	Number of Banks
Belgium	0.98325	18458	948	473	2
Germany	1.00000	0	0	0	0
Estonia	1.00000	0	0	0	0
Ireland	0.73800	305042	7564	423	330
Greece	1.00000	0	0	0	0
Spain	1.00000	0	0	0	0
France	1.00000	0	0	0	0
Italy	1.00000	0	0	0	0
Cyprus	1.00000	0	0	0	0
Latvia	0.84450	4798	1458	161	32
Lithuania	1.00000	0	0	0	0
Luxembourg	1.00000	0	0	0	0
Malta	0.69144	17548	1366	1575	13
Netherlands	1.00000	0	0	0	0
Austria	0.99568	3802	320	2	521
Portugal	0.91703	38918	4471	96	32
Slovenia	0.97742	983	241	24	3
Slovakia	1.00000	0	0	0	0
Finland	0.83130	97732	3715	2463	224
Bulgaria	0.94261	2719	18649	1061	2
Croatia	1.00000	0	0	0	0
Czech Republic	0.95566	8668	13317	49	2
Denmark	1.00000	0	0	0	0
Hungary	0.98385	1833	637	16	44
Poland	1.00000	0	0	0	0
Romania	0.96286	3361	32894	87	1
Sweden	0.94113	73417	3217	35	9
United Kingdom	1.00000	0	0	0	0

In 2015, 15 banking sectors were effective, it means that there are no specific recommendations for changes in inputs and outputs in their case. This does not mean that it is not necessary to optimize their business continuously, as they can become ineffective in the future. Eventually, the results in 2014 were worse than

in 2015. We reviewed the change in efficiency between the two years by using Malmquist index. We investigated the development of the rate of efficiency in individual banking sectors in 2015 compared to 2014. In addition, we investigated whether the decisions of bank management, regulators or other uncontrollable exogenous factors had a positive, negative or neutral influence.

Table 5
Malmquist index in time 2014-2015

Country	Efficiency		Malmquist INDEX
	2014	2015	
Belgium	1.00000	1.01704	**1.01319**
Germany	1.00000	1.00000	**1.03165**
Estonia	1.00000	1.00000	**1.05003**
Ireland	1.25519	1.35501	**0.93079**
Greece	1.00000	1.00000	**0.98142**
Spain	1.00000	1.00000	**1.07352**
France	1.00000	1.00000	**1.00630**
Italy	1.00000	1.00000	**1.01858**
Cyprus	1.00000	1.00000	**1.02416**
Latvia	1.10606	1.18413	**0.91714**
Lithuania	1.04542	1.00000	**1.07547**
Luxembourg	1.00000	1.00000	**1.02479**
Malta	1.67847	1.44625	**1.20013**
Netherlands	1.00000	1.00000	**1.06005**
Austria	1.00000	1.00434	**0.99585**
Portugal	1.08703	1.09048	**1.00622**
Slovenia	1.00000	1.02310	**0.96794**
Slovakia	1.00000	1.00000	**0.99288**
Finland	1.16184	1.20294	**0.96327**
Bulgaria	1.04074	1.06088	**0.97850**
Croatia	1.00000	1.00000	**0.97598**
Czech Republic	1.00000	1.04639	**0.96515**
Denmark	1.00000	1.00000	**1.05840**
Hungary	1.20889	1.01642	**1.18109**
Poland	1.00000	1.00000	**0.99206**
Romania	1.00998	1.03857	**0.95625**
Sweden	1.04995	1.06255	**0.98773**
United Kingdom	1.00000	1.00000	**0.96846**

The first two columns of Table 5 express the efficiency of banking sectors in 2014 and 2015 separately. The third column presents the quantified change of effectiveness over time. Based on the Malmquist index we are able to downwardly classify the banking sectors of individual countries. The values of Malmquist

index, which are higher than one show the increasing rate of efficiency against other DMU. The values of Malmquist index lower than one show decreasing rate of efficiency. The value of index equal to one or around one expresses that the effects of endogenous and exogenous factors on the bank sector were neutral.

Starting again with the example of Malta, the banking system achieved the highest value of Malmquist index 1.20013. Despite of the fact that in 2014 (1.67847) and 2015 (1.44625) it was ineffective, this system achieved the most significant increase in efficiency. This situation can be considered as a positive phenomenon. The banking sector of Latvia was also ineffective in both years 2014 (1.10606) and 2015 (1.18413). However, unlike Malta, this sector had decreasing effectiveness, the value of Malmquist index was at the level of 0.91714. Banking sector of Poland was effective in both years and the value of Malmquist index equal to one informs us about this situation. Interesting is that Malmquist index of Czech Republic (0.96515) and Great Britain (0.96846) was almost the same. However, in the case of Czech Republic this situation expresses the inclusion of its banking sector into the category of ineffective bank sectors.

In regard to our findings, the rate of efficiency of banking sectors in the EU member countries was in 2015 at the level of 53.57%, whereas in 2014 it was at the level of 64.29%. According to papers [22, 36] we considered as effective these banking sectors which work with the rate of effectiveness higher than 70%.

Based on the obtained results we can state that the hypothesis H1 was confirmed, which means that the banking sectors of the EU member countries are still not sufficiently consolidated. Taking into consideration the pre-crisis research conducted by Pastor [32], when the banking sector of the EU members achieved an average rate of effectiveness equal to 86%, we can state that our results confirm the negative long term consequences of the financial crisis.

In regard to the H2 hypothesis, we divided our sample into two groups. The first group consists of "old" EU member states and in the second group the countries that joined the EU after 2004 are found. From the 15 original member countries the banking sectors in Germany, Greece, Spain, France, Italy, Luxembourg, Netherlands, Denmark and United Kingdom can be considered as efficient, and this situation reflects the rate of effectiveness at the level of 60%. From the countries that joined to the EU after 2004 the banking sectors were effective in Poland, Croatia, Slovakia, Lithuania, Cyprus and Estonia and this situation reflects the rate of effectiveness at the level of 46.15%. Based on these results it should be noted that the second hypothesis H2 was confirmed – the banking sectors of the old EU members were more effective from the operational point of view.

Finally, with regard to the H3 hypothesis we investigated whether the banking sectors of the Eurozone members are more efficient than banking sectors of countries, which have not applied the euro. For this reason we again divided our sample into two groups. From the 18 countries in the Eurozone the banking

sectors in Germany, Estonia, Greece, Spain, France, Italy, Cyprus, Lithuania, Luxembourg, Netherlands and Slovakia worked effective and this situation reflects the rate of effectiveness at the level of 57.89%. From the 9 countries outside the euro area the banking sectors of Croatia, Denmark, Poland and United Kingdom worked effective and this situation reflects the rate of effectiveness at the level of 44.44%. Therefore, it should be noted that the hypothesis H3 was confirmed – the banking sectors of the Eurozone members can be considered as more efficient than the once outside euro area.

In the end the obtained results especially pointing to the efficiency of such banking sectors as the once in Greece, Spain or Italy should be also commented form the perspective of banking sector stability. It should be stressed that in the present research the problem of undesirable output – for example, in the case of banking sector, the share of non-performing loans in the portfolio, which is important from the perspective of banking sector stability and capital adequacy requirements – was deliberately omitted, which is considered as a standard approach form the perspective of the objectives of the article [compare 40], and still present controversies of data interpretation in this regard. So the obtained results should be interpreted from the perspective of operational efficiency of the banking sectors not form the perspective of their stability.

Conclusion

This paper was focused on the issue of measuring the efficiency of banking sectors, especially on the issue of measuring the operational effectiveness of banking sectors in the European Union member countries. The objective of this paper was to suggest a relevant methodology for measuring bank efficiency based on the Data Envelopment Analysis and Malmquist index.

The conducted empirical research confirms that the banking sectors in the EU countries are characterized with relatively low levels of efficiency in 2015. Empirical evidence suggests that the banking sectors are not enough consolidated. The research confirms still visible negative impact of the last global financial crisis, and probable negative implications of some other exogenous factors, where one can point relatively low effectiveness of monetary stabilization policy of the European Central Bank and the National Central Banks, and low effectiveness of regulation efforts at the European Union level.

With regard to the comparative analysis of efficiency of banking sectors in the Euro Area and outside the Monetary Union, we confirm that the banking sectors of the Eurozone members are more efficient than the banking sectors of countries which have not yet applied for the euro. In the case of comparison of banking sector efficiency of the old 15 EU members and the member states admitted to the EU after 2004, the first group can be considered as more efficient.

In the end, one should also point the restrictions of the research, the potential applications of the proposed methodology and areas of possible future studies.

When we tried to create a model for measuring the efficiency of banking sectors, we encountered several objective problems. This is the reason why we did not include all the variables for which we planned. For example, we were not able to obtain an average rate of profitability, the volume of non-performing loans, capital adequacy for the whole set of countries. In our opinion, the achievement of the assumption concerning homogeneity of DMU can be questionable, in the case of banking sectors. It should be also remembered that explanatory power of some variables, which we also used in the research, can also be questioned. For example, loans are commonly accepted and designated as outputs of banking activity, which is expressed in monetary units in the net value. However, this value itself does not provide information on the quality of loans, that is important from the perspective of sectors stability, which has been already stressed in a previous section.

Despite the barriers and the problems we can state that obtained results can be used for a variety of purposes, starting with continuous monitoring of the rate of efficiency of banking sectors, in the EU countries and comparative research between the countries. Interesting results, especially form a managerial perspective, could be obtained at the lower aggregation level – if we were able to assess for example the rate of effectiveness of individual banks within each country of the EU. Another important area of future research would involve addressing the problems with the development of technical, cost and overall efficiency. As it has been already stressed, the validity of the model could be also increased after expansion, including the undesirable output or the uncontrollable variables.

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