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DEA APPLICATION IN BANKING: RELATIONSHIP BETWEEN EFFICIENCY SCORES AND BANK SIZE

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Abstract. The paper aims to investigate the relationship between banks' size and efficiency scores. The study applies Data Envelopment Analysis (DEA) as a tool for measuring bank relative efficiency. Sample includes European banks and the data for the analysis was extracted form BankScope data base. Intermediation approach to banking has taken as a conceptual basis for the choice of variables. Input-oriented DEA model under the assumption of variable returns to scale (VRS) was applied. Besides, the relationship between bank efficiency scores and traditional performance ratios was examined. The paper contributes to the existing literature, filling the gap in regard to bank efficiency measuring in new member states of the European Union.

Keywords: efficiency, DEA, bank size, European banks.

JEL classification: C14, C67, G21.

1. Introduction

Banks perform the main functions of the financial system: provide opportunities for resource allocation, operate as intermediaries between ultimate savers and borrowers, settle payments and act as risk managers (Sinkey 2007; Heffernan 2005; Howells, Bain 2005). Considering also banks' predominance over other financial sector institutions in the New Member States (NMS) of the EU, the issues of bank performance measuring and enhancing are still on the agenda.

Performance of banks can be expressed "in terms of competition, concentration, efficiency, productivity and profitability" (Bikker, Bos 2008). Ambiguous interpretation of the concept yielded a wide range of underlying methods and ratios used for measuring bank performance.

The most popular measures are return on equity (ROE) ratio, net interest margin (NIM) and other single-ratio measures (Greuning, Bratanovic 2009; Kosmidou, Zopounidis 2008; Bikker 2010). However, considering the complex environment where banks operate, it is reasonable to apply methods with multiple variables. Besides, it should be considered that integral goal of any company is value maximization (Copeland *et al.* 2000). In turn, to achieve this goal, as Mester (2008) points, "the bank should minimize the cost of producing a given output bundle, but that output bundle should be chosen to maximize profits."

Thus, methods for measuring bank performance should incorporate multiple inputs and outputs. Efficiency measuring techniques based on the frontier approach meet this requirement. Both parametric (for instance, stochastic frontier approach) and non-parametric (data envelopment analysis) methods represent this approach.

In the current paper Data Envelopment Analysis (DEA) is applied to measure relative efficiency of European banks. Data sample includes financial institutions representing banking sector of seven new member states (NMS) of the European Union (EU): Latvia (LV), Lithuania (LT), Estonia (EE), Bulgaria (BG), Malta (MT), Slovakia (SK) and Slovenia (SI).

Two research hypotheses are developed by the author. Various studies provide strong evidence that bank size positively correlates with efficiency (Drake *et al.* 2006; Karray, Chichi 2013; Zreika, Elkanj 2011; Pancurova, Lyocsa 2013).

First hypothesis aims to test the relationship between bank size and efficiency score in the banking sector of the Baltics and states, as follows:

H1: There is a significant positive relationship between bank size and its demonstrated efficiency.

Based on the theory, profit-maximizing company tends to choose an optimal combination of

inputs and outputs to get the efficient frontier. This statement is aligned with the x-efficiency theory and relative efficiency hypothesis (Bikker, Bos 2008; Bikker 2010). Companies with a greater efficiency are able to lower costs and, consequently, to offer lower prices, gain market share and earn more profit (Heffernan 2005). Relationship between bank efficiency and profitability, expressed by traditional performance ratios, was tested empirically by many researchers (Fiorentino *et al.* 2006; Kosak *et al.* 2009; Toci 2009). However, the unambiguous conclusion cannot be made due to the contoversial results of the correlation analysis. The second research hypothesis aims to test the relationship between DEA efficiency scores and profitability ratios (ROE and ROA) on the sample of European banks and is stated, as follows:

H2: There is a significant positive relationship between bank efficiency scores and profitability ratios.

The current research continues the series of studies in the area of measuring bank efficiency. The paper contributes to the existing academic literature, providing latest empirical data on DEA efficiency scores of banking sector in the NMS. Up-to-date information is absolutely necessary, because the most studies in this field explore banking data till 2008.

2. Efficiency analysis using DEA

One of the most important contributions in the field of measuring of efficiency was done by M. J. Farrell. In 1957 he published the work "The Measurement of Productive Efficiency" (Farrell 1957) with the introduction of the term "efficient production function", that is the function constructed from the empirical data.

Operating (productive) efficiency denotes whether a firm is cost minimising (consuming less inputs for the same level of outputs) or profit maximising (producing more outputs for the same amount of inputs) (Beccalli *et al.* 2006). Thus, there are two types of technical efficiency based on the orientation: input-oriented and output-oriented.

The approach proposed by Farrell was empirically applied and extended by Charnes *et al.* (1978). They proposed a model that was called Data Envelopment Analysis (DEA). In academic literature it is referred to as CCR model. In the original paper the authors used the term „decision making units" (DMU) to emphasize their interest to measuring performance of non-profit organizations. DEA helps to identify efficient DMU and to construct efficient production frontier. DEA models measure the relative efficiency that is the efficiency of each DMU relative to similar DMUs in the sample. Thus, applying DEA in evaluating performance of a set of companies, it is possible to form two clusters: companies that comprise an efficient frontier and inefficient companies lying below the frontier.

Applying DEA model, the efficiency score is estimated as the ratio of weighted outputs to weighted inputs (Charnes *et al.* 1978). Weights are selected for each variable of every DMU in order maximize its efficiency score.

$$\max h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \quad (1)$$

subject to:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1; \quad (2)$$

$u_r , v_i \ge 0; \quad r = 1,\ldots, s; \quad i = 1,\ldots, m; \quad j = 1,\ldots, n.$

The efficiency rate for each DMU of the reference set of j=1,…,n DMU's is evaluated relative to other set members (Charnes *et al.* 1978). The maximal efficiency score is equal to 1, and the lower values indicate relative inefficiency of analyzed objects.

Depending on the optimization task – either to maximize output (profit) or minimize input (costs) – DEA model can have both output and input orientation.

Efficiency scores calculated through the application of DEA also differ while using different scale assumptions: variable return to scale (VRS) or constant return to scale (CRS). The choice of return-to-scale possibilities has an impact on the shape of the envelopment surface and, consequently, on the number of efficient DMU. Return to scale is constant if a proportional increase in all the inputs results the proportional increase in output. In turn, variable return to scale (increasing or decreasing) means that proportional increase in factor inputs yields a greater (or less) than proportional increase in output (Daraio, Simar 2007).

The most debated issue regards to application of DEA method in measuring efficiency is the selection of model variables. As for banking, the question is even more disputable, because the definition of outputs and inputs in banking studies is controversial (Heffernan 2005; Grigorian, Manole 2006). The most attention is paid to deposits and their contribution to bank performance. There is no unambiguous viewpoint among experts about

the way how to treat bank deposits – as inputs or as outputs (Karray, Chichti 2013; Staub *et al.* 2009; Thagunna, Poudel 2013).

The choice of outputs and inputs is based on the theoretical conceptualization of banking business. There is a range of proposed approaches: intermediation (asset) approach (Sealey, Lindley 1977), production approach (Berg *et al.* 1991), user-cost approach (Hancock 1991), value-added or profitability approach (Berger *et al.* 1993).

According to the intermediation approach, bank primary role is to act as intermediary between lenders and borrowers. It is assumed that a bank attracts deposits and other funds and transforms them into loans and securities (investments), using inputs such as labor, capital and materials. Interest rate paid on deposits (interest expenses) is treated as inputs. Loans and investments are the output components (Bikker, Bos 2008). The production approach assumes that banks use capital and labour to produce different categories of deposit and loan accounts (Heffernan 2005). The profitability approach is profit-oriented. Interest, non-interest revenues and other income-related measures are used as outputs. In turn, costs are treated as inputs (Nenovsky *et al.* 2008). Measuring bank efficiency with DEA, intermediation and production approaches are most frequently used by researches (Portela, Thanassoulis 2007; Camanho, Dyson 2008; Giokas 2008; Nigmonov 2010; Thagunna, Poudel 2013; Titko, Jureviciene 2014).

The choice of the approach and underlying variables for DEA model depends on the subjective preferences of a researcher. However, it should be emphasized that results may differ widely, using different approaches (Nenovsky *et al.* 2008; Karray, Chichti 2013).

3. DEA application in banking

To measure bank efficiency various parametric and non-parametric techniques are applied in the studies. For instance, stochastic frontier approach (SFA) is very popular among the researchers (Kosak *et al.* 2009; Fang *et al.* 2011; Andries, Capraru 2012; Yildirim, Philippatos 2003; Weill 2003; Kasman, Yildirim 2006).

However, DEA is most widely applied method in the literature on bank efficiency. There are plenty of studies, exploring the concept and providing empirical investigation at the national level (Hogue, Rayan 2012; Nenovsky *et al.* 2008; Kosmidou, Zopounidis 2008; Thagunna, Poudel 2013; Nigmonov 2010; Fiorentino *et al.* 2006 and others).

DEA is frequently used also for benchmarking studies. The information about several cross-coutry comparison studies conducted by means of DEA is presented in the Table 1.

Table 1. DEA application at cross-country studies

Author(s)	Region, countries	Research period
Pancurova, Lyocsa (2013)	EU 11 countries	2005-2008
Ferreira (2012)	EU 27 countries	1994-2008
Erina, Erins (2013)	EU 7 countries	2006-2011
Stavárek (2006)	EU 11 countries	2001-2003
Kenjegalieva *et al.* (2009)	EU 8 countries	1999-2003
Anayiotos *et al.* (2010)	14 countries (CEE)	2004-2009

Results of cross-country comparison differ in various studies. In average, banking sectors in Eastern Europe lag behind in terms of efficiency, comparing with old members of EU (Bikker, Bos 2008; Ferreira 2012). However, analysis of national series shows that some of NMS demonstrate rather high efficiency scores within the sample (Erina, Erins 2013; Pancurova, Lyocsa 2013).

The gap in efficiency scores calculated by different researchers can be explained by the fact that the DEA model specification varies significantly.

Firstly, the unique combination of variables is used in each particular case. However, the analysis of the related literature made by the author yielded a conclusion that basically deposits are treated as inputs, if DEA is used to measure bank efficiency (Stavarek 2006; Shahooth, Battall 2006; Nigmonov 2010; Singh *et al.* 2008; Anayiotos *et al.* 2010).

Besides, analysts apply both input- and outpur-oriented DEA model. The choice of the orientation primarily is based on industry specifics. As for banking, some researchers measure efficiency with output-oriented models (Thagunna, Poudel 2013; Casu, Girardone 2005) or apply both in their studies (Beccalli *et al.* 2006). However, the input-orientated models are the most frequently used in measuring bank efficiency with DEA (Arshinova 2011; Zreika, Elkanj 2011; Nigmonov 2010). The possible reason assumed by Fethy and Pasiouras (2010) is that bank managers have higher control over inputs rather than outputs.

Another disputable question is the choice of return-to-scale assumption. Noulas (1997) asserts that CRS assumption provides more accurate results, because allows comparing small and large banks. "In a sample where a few large banks are present, the use of VRS framework raises the possibility that these large banks will appear as being efficient for the simple reason that there are no truly efficient banks". Avkiran (1999) stated that under VRS each unit is compared only against other units of similar size, instead of against all

units. Thus, this assumption is more suitable for large samples. In turn, according to McAllister and McManus (1993) for developed banking systems VRS assumption is more preferable.

It also should be mentioned that input- and output-oriented models yield the same values of efficiency scores under CRS assumption, but unequal when VRS is assumed.

Considering that the choice of DEA model specification can heavily impact the received results, cross-country comparison should be conducted with extreme caution due to the fact that "a firm's technical efficiency is relative to the set of firms from which the function is estimated" (Farrell 1957). Consequently, banking sector with less number of banks can demonstrate higher efficiency comparing with larger banking sector.

4. Research methodology and results

The current study employed DEA method for measuring bank efficiency in banking sector of new member states of the European Union. To define the variables for the model, we use the intermediation approach and assume bank deposits to be an input and loans to be an output.

Research sample consists of 117 banks operating in seven European countries. Data set comprises 1496 observations over the period of 2006-2012. Data was extracted from BankScope data base. To increase the consistency of the sample, such countries, as Poland, Romania and Czech Republic, were not included into the sample. The number of banks in these countries substantially exceeds the number of banks in the analyzed banking sectors.

Input-oriented DEA model under VRS assumption was applied in this paper. The VRS assumption was chosen due to the high concentration ratio in the most banking sectors of NMS. Thus, bank size within the sample varies from very small to very large banks.

Efficiency scores were estimated for individual banks within each particular banking sector. Average DEA scores in the period of 2006-2012 are summarized in the Table 2.

Table 2. DEA efficiency in the banking sector of NMS 2006-2012 (source: estimated by the author)

Country	2006	2007	2008	2009	2010	2011	2012
Latvia	0,42079	0,47260	0,55526	0,22067	0,26546	0,17932	0,34557
Lithuania	0,83660	0,72381	0,78367	0,68098	0,57668	0,69589	0,76693
Estonia	0,89246	1	0,97506	0,88216	0,33714	0,78531	0,81700
Malta	0,46590	0,49686	0,64539	0,22317	0,09129	0,49654	0,08453
Bulgaria	0,34404	0,67206	0,66200	0,63448	0,54175	0,77141	0,69860
Slovenia	0,42788	0,55367	0,33149	0,33472	0,39937	0,63056	0,64315
Slovakia	0,73096	0,72689	0,17652	0,15730	0,14553	0,35258	0,67055

Analyzing the results, the obvious conclusion is that Estonia and Lithuania demonstrate the best results within the peer group. Taking into account the theoretical grounding of the relative efficiency (Farrell 1957), this could be associated with the small size of banking sector.

The information about 8 Estoniand 8 Lithuanian banks was available as for 2012. To compare, banking sector of Latvia in 2012 was represented by 17 banks. However, received results allow observing trend changes of banking sector efficiency in time series data (Fig. 1).

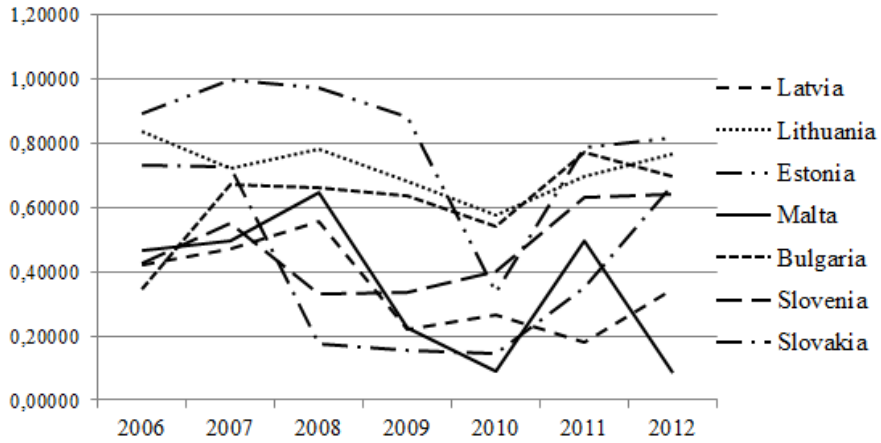

Fig. 1. DEA scores for banking sector of NMS 2006-2012 (source: compiled by the author)

Period 2008-2010 is characterized by decreasing efficiency demonstrated by almost all the countries within the sample. These results are logically to be compared with the results of the evaluation of banking sector performance, applying traditional measures, such as return-on-equity ratio. The data for the trend analysis was extracted from the statistical data warehouse provided by the European Central Bank.

The information on the banking sector ROE from BankScope was not used due to the fact that aggregated indices have been calculated, summarizing the available information about individual banks. In turn, BankScope does not contain the data about all the banks. Statistics on the banking sector ROE of seven European counries in 2007-2012 is graphically reflected in Fig. 2.

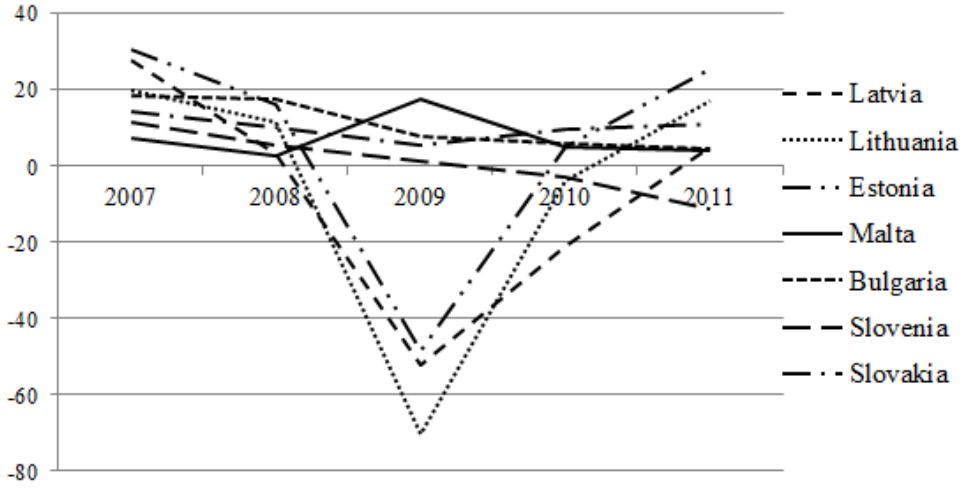

Fig. 2. ROE for banking sector of NMS 2007-2012 (source: compiled by the author)

The most observable changes in ROE value are demonstrated by the Baltic States. Bank performance in these countries decreased dramatically affected by the global financial crisis and the value of ROE reached its minimum in 2009. However, it is impossible to make an unambiguous conclusion about the relationship between efficiency scores and values of traditional performance ratios without making statistical analysis.

The results of the bivariate correlation analysis conducted in SPSS (estimated values of Spearman correlation coefficient) are presented in the Table 3.

Table 3. Values of Spearman correlation coefficient (source: estimated by the author)

Country	Relationship between	
	DEA score and ROE	DEA score and ROA
Latvia	0,371	0,371
Lithuania	0,486	0,371
Estonia	0,429	0,086
Malta	-0,371	-0,829
Bulgaria	-0,429	-0,486
Slovenia	-0,657	-0,657
Slovakia	0,543	0,143

Correlation analysis did not yield any statistically significant correlation coefficients to assume the relationship between bank efficiency scores and traditional performance ratios – ROE and ROA. Besides, estimated coefficients are of different sign that indicates no correlation between the variables. Estimated correlation cofficients for data on all the countries are equal to 0,279 and 0,236 for variable pairs DEA-ROE and DEA-ROA, respectively.

To test the relationship between bank size and efficiency score, data only about banking sector of the Baltic States was processed. Based on the available information provided by BankScope, all the banks within each particular year were grouped into four quarters (Q1, Q2, Q3 and Q4) according to the volume of their total assets. The first quartile (minimum value to 25th percentile) separates the smallest banks of Latvia, Lithuania and Estonia in terms of assets. The range of the forth quartile (75th percentile to maximum value) contains the largest banks. The list of banks within particular quartile's range differs slightly in different years. However, banks of all three countries representing Swedbank group and SEB group are always amongst the largest ones. In turn, such banks as ABLV bank (Latvia) and DNB bank (Latvia and Lithuania) interchange their location in the 3rd quarter with the place in the 4th quarter.

Average efficiency scores were estimated for each quartile for the period 2006-2012 (Table 4).

Table 4. DEA scores for bank groups
(source: estimated by author)

Year	Q1	Q2	Q3	Q4
2006	0,7050	0,2386	0,8522	1,0000
2007	0,5243	0,2386	0,8522	1,0000
2008	0,8791	0,4082	0,7105	0,9501
2009	0,4591	0,2065	0,2146	1,0000
2010	0,4148	0,2655	0,2156	1,0000
2011	0,7178	0,1748	0,2005	1,0000
2012	0,6340	0,3456	0,4554	1,0000

Obviously, largest banks demonstrate the highest efficiency. This result is aligned with the results of previously conducted studies on testing the relationship between efficiency and bank size (Allen, Rai 1996; Karray, Chichi 2013; Nenovsky *et al.* 2008; Zreika, Elkanj 2011). However, there is no consistency in results demonstrated by groups of smaller banks. To increase the reliability of results, the iterated testing of the hypothesis about the link between DEA scores and bank size should be performed. The sample should be extended with the banks of other countries. The research can be conducted also within national banking sectors, but only the countries with sufficiently large number of financial institutions should be chosen. Such countries, as Lithuania or Malta (11 banks and 8 banks as for 2012, respectively), cannot be analysed separately.

5. Conclusions

The current paper demonstrates the application of data envelopment analysis (DEA) in measuring relative efficiency of banks. Study yielded estimated efficiency scores for the sample of banking sector of seven European countries over the period 2006-2012.

The research questions addressed in this paper were: "Are larger banks more efficient than the smaller ones?" and "Is there a correlation between estimated DEA scores and traditional performance measures, such as ROE and ROA?" Two research hypotheses were stated, based on these questions.

The first hypothesis can be confirmed due the fact that the largest banks in the sample in terms of assets (banks of the Baltic countries representing the range of the 1st quartile) are more efficient than the banks of the remaining three quarters. Over the tested period (except of 2008) the most of the largest banks in Latvia, Lithuania and Estonia are lying on the efficient frontier. To avoid the negative effect of inefficient banks, average efficiency scores were calculated using the median function.

The second hypothesis is rejected. There were no statistically significant correlation cofficients among DEA scores and the values of ROE and ROA. It means that DEA cannot be applied complimentary to the traditional measures to evaluate performance of banking sector in NMS. However, it would be reasonable to extend the study by testing the relationship between efficiency and performance, expressed by other measures. For instance, such ratios, as cost-to-income ratio or net interest margin, can be used as proxies for bank performance. Besides, the only one DEA model was used in the current study to get the empirical results. Probably, another combination of model variables can yield the scores consistent with ROE. The choice of the input-ouput combination for each particular banking sector also should be substantiated with the results of additional investigations.

Considering all the limitations of DEA application to cross-country benchmarking (large difference in the size of national banking sectors and their peculiarities), DEA method should be used with caution. Probably, the researchers should avoid comparing banking sectors of developed and developing countries (old member states of EU and NMS), because the efficient banks of developing countries actually will lag far behind the inefficient banks (based on DEA results) of developed countries.

Considering the wide opportunities of DEA application to detect the possibilities to raise the efficiency of banks, it is necesary to extent the research at the national level. The future studies should be aimed to test the applicability of DEA approach to measuring bank efficiency in Latvian banking sector, specifically to define the most appropriate DEA model for Latvian banks. In particular, the aim of the further research could be to test the results' sensitivity to the choice of the combination of variables. Besides, the interesting topic for the future investigation is the relationship between Latvian banking sector concentration and efficiency.

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