ПРИЛОЗИ. ОДДЕЛЕНИЕ ЗА ОПШТЕСТВЕНИ НАУКИ
CONTRIBUTIONS. SECTION OF SOCIAL SCIENCES

МАКЕДОНСКА АКАДЕМИЈА НА НАУКИТЕ И УМЕТНОСТИТЕ
СКОПЈЕ

ISSN 0350-1698

МАКЕДОНСКА АКАДЕМИЈА НА НАУКИТЕ И УМЕТНОСТИТЕ
MACEDONIAN ACADEMY OF SCIENCES AND ARTS

ОДДЕЛЕНИЕ ЗА ОПШТЕСТВЕНИ НАУКИ
SECTION OF SOCIAL SCIENCES

ПРИЛОЗИ
CONTRIBUTIONS

XLIX 1-2 2018

ОВОЈ БРОЈ Е ПОСВЕТЕН
НА АКАДЕМИК КСЕНТЕ БОГОЕВ
ПО ПОВОД 100 ГОДИНИ ОД НЕГОВОТО РАЃАЊЕ

СКОПЈЕ – SKOPJE
2019

СОДРЖИНА
CONTENTS

Violeta CVETKOSKA[*]

EVALUATING THE EFFICIENCY OF BANK BRANCHES WITHIN ONE BANK: A MATHEMATICAL PROGRAMMING APPROACH

Abstract:
The purpose of the paper is to evaluate the relative efficiency of the branches of Komercijalna Banka AD Skopje using the mathematical programming approach data envelopment analysis (DEA). Because the number of the branches of the bank was small there was a need to increase it. To deal with this problem and to include time dimension in the model a valuable DEA technique known as window analysis was used. The time period covered in the analysis was from 2009 to 2011. The results of the relative efficiency for the included branches were presented in the bank and it was determined that they reflect the real situation.

Keywords: *Relative Efficiency, Data Envelopment Analysis, Window Analysis, Profitability Approach, Bank Branches.*

1. Introduction

The word efficiency has Latin origin "efficax" and it indicates success, so in order to be able to determine which entities are characterized as efficient in operation, and which need improvement of efficiency, it is necessary to measure this indicator of success. Hubbard (2010, p.3) states: "Anything can be measured. If a thing can be observed in any way at all, it lends itself to some type of measurement method."

For an analysis of the efficiency of the entities there are two approaches: parametric (econometric) and non-parametric (mathematical programming) approach. In this paper, the focus is on the second approach, or specifically on the non-parametric approach data envelopment analysis (DEA).

DEA is a mathematical programming technique introduced by Charnes et al. (1978) that can be used to measure the relative efficiency of homogenous entities, known as Decision Making Units (DMUs) and based on the empirical data about used resources, or inputs and results, or outputs of DMUs that comprise the sample for analysis the empirical efficient frontier can be constructed. DEA does not require any assumption about the functional form. Decision making units which have result of efficiency 1.00 (or 100 %) are considered relatively efficient, and these units create the efficient frontier, while for those which are inefficient, DEA allows identification of sources of inefficiency and level of inefficiency for each selected input and output, details can be found in Charnes et al. (1994, p.6).

A full list of DEA publications, i.e. 10.300 DEA-related articles that have been published in journals in the period from 1978 to the end of 2016 is given in Emrouznejad & Yang (2018). Approximately, there have been found 11.961 distinct authors and 25.137 distinct key words. Agriculture, banking, supply chain, transportation, and public policy are the 5 fields where the greatest number of journal articles are applied.

In this paper DEA is used to evaluate the relative efficiency of the branches of the Komercijalna Banka AD Skopje which are located throughout the Republic of North Macedonia.

Komercijalna Banka AD Skopje has a total number of 11 branches: Bitola, Veles, Gostivar, Kavadarci, Kocani, Kumanovo, Ohrid, Prilep, Strumica, Tetovo and Stip. The analysis covered a period of three years, from 2009 to 2011, and the sample consists of 8 branches which in this period performed the same financial activities (excluding branches Bitola, Gostivar and Tetovo, which began operating in 2010).

The literature review regarding the application of DEA in bank branches has been made by Eken & Kale (2011). For application of DEA on sample that counts from 20 to 50 branches see: (Athanassopoulos & Giokas, 2000; Cook et al., 2000; Cook & Hababou, 2001; Hartman et al., 2001; Portela et al., 2003; Barth & Staat, 2005; Camanho & Dyson, 2008).

When DEA is applied the following should be taken into account: ... "the number of DMUs should be at least two to three times of the total number of inputs

[*] Associate Professor, Ss. Cyril and Methodius University in Skopje, Faculty of Economics – Skopje, contact e-mail: vcvetkoska@eccf.ukim.edu.mk

plus outputs used in the models." (Paradi et al., 2004, p.359). To increase the number of branches of Komercijalna Banka AD Skopje and to include a time dimension in the model a DEA technique window analysis is used.

The paper is structured as follows. In Section 2 the objectives of the research are established and the research methodology is pointed out. In Section 3 the technique window analysis is described, and Section 4 is devoted to the data used. In Section 5 are presented and discussed the empirical results. The conclusion is given in Section 6.

2. Objectives and research methodology

The objectives of the empirical research are:

- To identify the inputs and outputs for the profitability approach in order to evaluate the relative efficiency of the branches;
- To assess the importance of the identified inputs and outputs;
- To develop a DEA window analysis model, and
- To make recommendations to the branches which are relatively inefficient.

In order to realize the objectives of the research, the following sub-objectives are identified:

- To conduct an interview with the Manager of the Independent Branch Network Management Department to identify inputs and outputs for profitability approach;
- To survey respondents to evaluate the importance of the identified inputs and outputs;
- To conduct an interview with the Manager of the Independent Branch Network Management Department to choose inputs and outputs for DEA window analysis model;
- To apply software tool Efficiency Measurement System (EMS) to solve the model.

In this paper an attempt is made to verify the following two assumptions:

1. Data envelopment analysis methodology can be used to evaluate the relative efficiency of the branches of Komercijalna Banka AD Skopje, as well as for identification of the sources of inefficiency and determining the amounts of inefficiency;
2. Through the DEA window analysis model the change in the relative efficiency of the branches of the Komercijalna Banka AD Skopje during the observed period can be determined.

In order to identify the inputs and outputs of the profitability approach the method of interview was used, for assessment of their importance a survey was used (it was designed a questionnaire which was distributed to participants electronically), and on the basis of given answers, measures of central tendency (mean, median, and mode) were calculated. The selection of inputs and outputs for DEA window analysis model was made based on their average score of importance, and the model was solved with the EMS software, for more details about this software see Scheel (2000).

3. Window Analysis

Including the time dimension in the model makes it possible to examine whether the efficiency of the entities change over time. Window analysis is a valuable DEA technique which can be used for this purpose.

When using this technique, each decision making unit in each observed period is accounted as "different" DMU (Charnes et al., 1994). "Specifically, a DMU's performance in a particular period is contrasted with its performance in other periods in addition to the performance of the other DMUs" (Charnes et al., 1994, p.57). For the number of decision making units the symbol n is used, the number of periods considered in the analysis is denoted by k, the length of the window is denoted by the symbol p, where $p \leq k$, the number of windows is denoted by w and it can be determined using the formula: $w = k\text{-}p+1$, while the number of decision making units in each window is calculated by multiplying the number of DMUs and the length of the window (np), and the number of "different" DMUs is calculated by multiplying the number of DMUs, the length of the window and number of windows (npw) (Cooper et al., 2007, pp.326-327).

In this empirical research, the number of DMUs (branches) is 8 ($n = 8$), three years (2009, 2010 and 2011) represent the number of periods ($k = 3$), the length of the window is determined at two years ($p = 2$), the number of windows is 2 ($w = 2$), in each window there are 16 branches, while the number of "different" branches is 32. At first, the data for the first two years are taken into account and then the data for the first year are released and the data for the third year are added. An output-oriented DEA window analysis model with variable returns to scale (VRS) assumption is used in the paper. When the increase in the inputs of the observed DMU does not necessarily result in a proportional change in the outputs, it is about variable returns to scale.

4. Data

To measure the efficiency of the branches of Komercijalna Banka AD Skopje profitability approach is used. "Profitability approach measures the efficiency of using resources to maximize profit of a branch" (Eken & Kale, 2011, p.889). To evaluate the relative efficiency of branches it is necessary to choose inputs and outputs. To realize this objective of the empirical research an interview with the Manager of the Independent Branch Network Management Department was conducted. At the interview DEA as well as the profitability approach were described and 3 inputs were identified: interest expenses, commission and fees expenses, and impairment of receivables, and the following 3 outputs were identified: interest income, commission and fees income, and release of impairment provision.

To realize the second objective of the research, a questionnaire was constructed in which was given a scale of 1 to 5, where 1 represents the least importance and 5 represents the highest importance, and respondents based on their expertise in banking were supposed to give the most appropriate assessment of the importance for each input and output. Also, there was an opportunity to add input and /or output which is not covered in the above inputs and outputs, but they were considered as important by the profitability approach. As respondents were selected managers of all branches of the Komercijalna Banka Skopje AD (their number is 11). The questionnaire was sent to the respondents by e-mail, and they submitted it in the same way after they filled it. Each respondent has assessed the importance of the identified inputs and outputs and there was not an additional input and / or output written. Based on the collected data the measures of central tendency were calculated: mean, median, and mode, as well as statistical indicators: frequency, percentage, and cumulative percentage for each input and output (Appendix 1: Tables 1-8).

From Table 1 it can be seen that the value of the mode of each input is 5 ($M_o = 5$), while the median for the input commission and the fees expenses is 4 ($M_e = 4$), and for the other two inputs is 5 ($M_e = 5$).

The average grade of importance is the highest for the input interest expenses ($\bar{x} = 4.73$), the input impairment of receivables has an average grade of 4.36 ($\bar{x} = 4.36$), and the lowest average grade of importance is calculated for input commission and fees expenses ($\bar{x} = 3.91$). (Figure 1).

For the outputs of the profitability approach (Table 5), the value of the mode and the median is 5. The highest average grade of importance has output commission and fees income ($\bar{x} = 4.73$), followed by output interest income ($\bar{x} = 4.64$), and the lowest average grade of importance has output release of impairment provision ($\bar{x} = 4.45$). (Figure 2).

Based on the above it can be seen that for the inputs and outputs high grades of importance were assigned which confirms that they have been chosen most appropriately.

To realize the third objective of the empirical research, that is to develop DEA window analysis model, an interview with the Manager of the Independent Branch Network Management Department was conducted. It was decided that the choice of inputs and outputs will be according to the calculated average grades of importance by which inputs and outputs of two models were selected.

For the first DEA window analysis model the following inputs were selected: interest expenses and impairment of receivables, i.e. those with the highest average grades of importance and as outputs were selected those corresponding to them: interest income and release of impairment provision. For the second

Figure 1. AVERAGE GRADE OF IMPORTANCE FOR THE INPUTS OF THE PROFITABILITY APPROACH

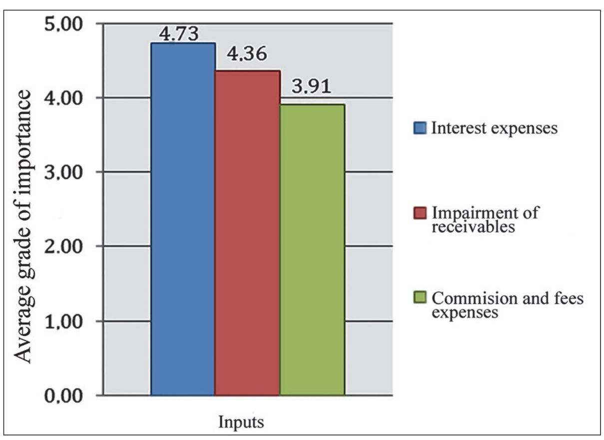
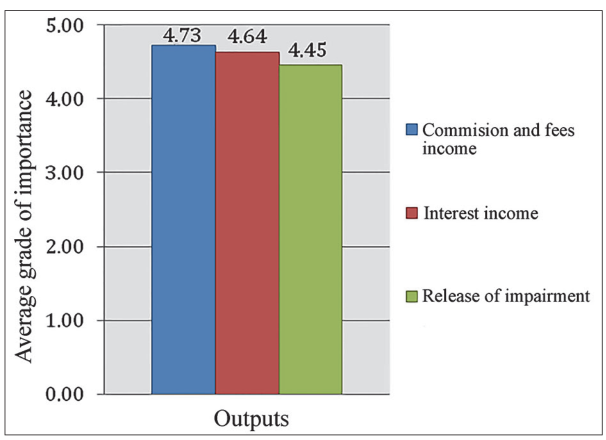


Figure 2. AVERAGE GRADE OF IMPORTANCE FOR THE OUTPUTS OF THE PROFITABILITY APPROACH



DEA window analysis model as inputs were chosen: interest expenses and commission and fees expenses, and as outputs: interest income and commission and fees income.

In this paper the first model was comprised and data for the observed period of three years were collected, so it was found that the branches have no missing data, no negative values and 0 values. The data collected for inputs and outputs are not made public and as such are considered confidential, for that reason they are not shown in the paper and instead of the actual names of the bank's branches numbers are used. The prepared data base enabled running the DEA window analysis model in the software tool EMS.

5. Empirical results and discussion

The obtained results are arranged and presented in Table 1. The overall efficiency by windows is obtained as an average of the four results for each branch. For three branches: 2, 3 and 8 the overall efficiency for the entire observed period is 100 %, and as least efficient is identified branch 4. Branch 4, according to the overall efficiency by years (111.34%) should increase outputs for 11.34% proportionally to improve its efficiency. For branch 4 it can be noted that in 2009 it was relatively efficient, and in the next two years it was relatively inefficient. Interpretation of the results for the other relatively not efficient branches is on an analog way.

Table 1. RESULTS OF THE OUTPUT-ORIENTED DEA WINDOW ANALYSIS MODEL WITH VRS ASSUMPTION

	Efficiency results (%)			Overall efficiency	
Branches	**2009**	**2010**	**2011**	**by windows**	**by years**
Branch 1	100.00	100.00 116.28	100.00	104.07	102.71
Branch 2	100.00	100.00 100.00	100.00	100.00	100.00
Branch 3	100.00	100.00 100.00	100.00	100.00	100.00
Branch 4	100.00	120.80 112.93	117.16	112.72	111.34
Branch 5	105.53	116.48 100.00	100.00	105.50	104.59
Branch 6	100.00	120.68 112.20	100.00	108.22	105.48
Branch 7	100.00	112.27 111.15	100.00	105.86	103.90
Branch 8	100.00	100.00 100.00	100.00	100.00	100.00

Source: Author's calculation

The obtained results were presented to the Manager of the Independent Branch Network Management Department and the employees in this Department and it was obtained information that correspond to the actual situation. Accordingly, DEA window analysis model can continue to be applied in the Bank because it enables identification of relatively efficient and relatively inefficient branches, as well as the sources and amounts of inefficiency by which appropriate steps for further successful operation of this bank will be taken. Based on the above, both assumptions in Section 2 can be verified.

6. Conclusion

In this paper the relative efficiency of the branches of Komercijalna Banka AD Skopje was evaluated by using the leading mathematical-programming methodology for evaluating the performance of decision-making units - DEA.

Komercijalna Banka AD Skopje has 11 branches, but 8 of them in the time period covered in the analysis (2009-2011) made the same financial activities and therefore they constitute the sample. Since the number of bank branches is small, and also the data on inputs and outputs for the monitoring period of 3 years are collected, within the empirical research as the most appropriate DEA technique - window analysis was selected.

The output-oriented DEA window analysis model was used which was solved with the software Efficiency Measurement System. Based on the obtained efficiency results it was determined that three branches (2, 3, and 8) are relatively efficient, while other need to make change in the outputs in order to improve efficiency.

The established objectives in the empirical research are realized and the assumptions are verified.

The developed model has been proposed for further use in the Bank in order to monitor which branches are working relatively efficiently and should serve as a model for others, but also to take appropriate steps to improve the efficiency of those identified as relatively inefficient.

In the further research, the idea is to cover a longer period of time and to make a combination of DEA with methods of multi-criteria decision-making.

APPENDIX 1

Measures of central tendency and statistical indicators for inputs and outputs of the profitability approach

Table 1. MEASURES OF CENTRAL TENDENCY (MEAN, MEDIAN AND MODE) FOR INPUTS OF PROFITABILITY APPROACH

		Interest expenses 1	Commission and fees expenses 2	Impairment of receivables 3
N	Total	11	11	11
	Missing	0	0	0
Arithmetic Mean		4.73	3.91	4.36
Median		5.00	4.00	5.00
Mode		5	5	5

Table 2. STATISTICAL INDICATORS FOR INPUT INTEREST EXPENSES

	Frequency	Percentage	Cumulative percentage
	1	2	3
4	3	27.30%	27.30%
5	8	72.70%	100.00%
Total	11	100.00%	

Table 3. STATISTICAL INDICATORS FOR INPUT COMMISSION AND FEES EXPENSES

	Frequency	Percentage	Cumulative percentage
	1	2	3
2	1	9.10%	9.10%
3	3	27.30%	36.40%
4	3	27.30%	63.70%
5	4	36.30%	100.00%
Total	11	100.00%	

Table 4. STATISTICAL INDICATORS FOR INPUT IMPAIRMENT OF RECEIVABLES

	Frequency	Percentage	Cumulative percentage
	1	2	3
3	2	18.20%	18.20%
4	3	27.30%	45.50%
5	6	54.50%	100.00%
Total	11	100.00%	

Table 5. MEASURES OF CENTRAL TENDENCY (MEAN, MEDIAN AND MODE) FOR OUTPUTS OF PROFITABILITY APPROACH

		Interest income 1	Commission and fees income 2	Release of impairment provision 3
N	Total	11	11	11
	Missing	0	0	0
Arithmetic Mean		4.64	4.73	4.45
Median		5.00	5.00	5.00
Mode		5	5	5

Table 6. STATISTICAL INDICATORS FOR OUTPUT INTEREST INCOME

	Frequency	Percentage	Cumulative percentage
	1	2	3
3	1	9.10%	9.10%
4	2	18.20%	27.30%
5	8	72.70%	100.00%
Total	11	100.00%	

Table 7. STATISTICAL INDICATORS FOR OUTPUT COMMISSION AND FEES INCOME

	Frequency	Percentage	Cumulative percentage
	1	2	3
4	3	27.30%	27.30%
5	8	72.70%	100.00%
Total	11	100.00%	

Table 8. STATISTICAL INDICATORS FOR OUTPUT RELEASE OF IMPAIRMENT PROVISION

	Frequency	Percentage	Cumulative percentage
	1	2	3
3	2	18.20%	18.20%
4	2	18.20%	36.40%
5	7	63.60%	100.00%
Total	11	100.00%	

References

Athanassopoulos, A. D., & Giokas, D. (2000). The use of data envelopment analysis in banking institutions: Evidence from the commercial bank of Greece. *Interfaces*, *30*(2) 81–95.

Barth, W., & Staat, M. (2005). Environmental variables and relative efficiency of bank branches: A DEA-Bootstrap approach. *International Journal of Business Performance Management*, *7*(3), 1–13.

Camanho, A. S., & Dyson, R. G. (2008). A generalisation of the Farrell cost efficiency measure applicable to non-fully competitive settings. *Omega-International Journal of Management Science*, *36*(1), 147–162.

Charnes, A., Cooper, W. W., & Rhodes, E. L. (1978). Measuring efficiency of decision making units. *European Journal of Operational Research*, *2*(6), 429–444.

Charnes, A., Cooper, W. W., Lewin, A. Y., & Seiford, L. M. (Eds.). (1994). *Data envelopment analysis: Theory, methodology and applications*. Boston: Kluwer Academic Publishers.

Cook, W. D., & Hababou, M. (2001). Sales performance measurement in bank branches. *Omega*, *29*(4), 299–307.

Cook, W. D., Hababou, M., & Tuenter, H. J. (2000). Multicomponent efficiency measurement and shared inputs in data envelopment analysis: An application to sales and service performance in bank branches. *Journal of Productivity Analysis*, *14*(3), 209–224.

Cooper, W. W., Seiford, L. M., & Tone, K. (2007). *Data envelopment analysis: A comprehensive text with models, applications, references and DEA-solver software*. (2 ed.). New York: Springer Science + Business Media, LLC.

Eken, M. H., & Kale, S. (2011). Measuring bank branch performance using data envelopment analysis (DEA): The case of Turkish bank branches. *African Journal of Business Management*, *5*(3), 889–901.

Emrouznejad, A., & Yang, G-l. (2018). A survey and analysis of the first 40 years of scholarly literature in DEA: 1978-2016. *Socio-Economic Planning Sciences, 61*, 4–8.

Hartman, T. E., Storbeck, J. E., & Byrnes, P. (2001). Allocative efficiency in branch banking. *European Journal of Operational Research*, *134*(2), 232–242.

Hubbard, D. W. (2010). *How to measure anything: Finding the value of "intangibles" in business*. (2 ed.). New Jersey: John Wiley & Sons, Inc.

Paradi, J. C., Vela, S., & Yang, Z. (2004). Assessing bank and branch performance. In W. W. Cooper, L. M. Seiford & J. Zhu (Eds.), *Handbook of Data Envelopment Analysis* (pp.349-394). Boston: Kluwer Academic Publishers.

Portela, M. C. A. S., Borges, P. C., & Thanassoulis, E. (2003). Finding closest targets in non-oriented DEA models: The case of convex and non-convex technologies. *Journal of Productivity Analysis*, *19*(2/3), 251–269.

Scheel, H. (2000). *EMS: Efficiency measurement system*. Retrieved from http://www.holger-scheel.de/ems/ems.pdf