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Efficiency of bank branches: empirical evidence from a two-phase research approach

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ABSTRACT

The aim of this paper is to assess the relative efficiency of the branches of Komercijalna Banka AD Skopje during a three-year period (from 2009 to 2011). The research sample consists of eight branches performing the same financial activities during the reporting period. The mathematical technique DEA window analysis was used in the first phase in order to allow monitoring of the trend of the relative efficiency of each branch under consideration. From the bank management point of view, unexpected results were obtained in this phase; to validate the results the AHP-DEA validation model was proposed and used in the second phase. The management verified the obtained results claiming they were especially valuable in the process of making justifiable decisions for the further successful performance of the bank.

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1. Introduction

Efficiency represents a performance indicator of a profit or non-profit organisation and refers to achieving the highest possible results (outputs) with the use of minimum resources (inputs).

For the management of entities under consideration, it is of a particular importance to measure the efficiency as a basis for undertaking adequate steps to improve the performance of the inefficient units. In the literature, two approaches are usually used for the efficiency measurement: parametric-econometric approach and non-parametric-mathematical programming approach. In this paper, the focus is put on the mathematical programming approach, i.e., data envelopment analysis (DEA), while for the econometric approach see Greene (1993, pp. 68–119).

The best-known non-parametric approach for measuring the relative efficiency of entities, DEA was introduced by Charnes, Cooper, and Rhodes (1978). The entities in the DEA terminology are known as decision-making units (DMUs); they should be homogeneous, that is, they should use the same resources or inputs which produce the same results or outputs (Thanassoulis, 2001). This non-parametric approach is used for measuring the

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relative efficiency of DMUs; therefore, an empirical efficiency frontier is constructed on the basis of the empirical data for the used inputs and achieved outputs of DMUs, which comprises the analysis sample. DEA allows calculating a maximal performance measure for each decision-making unit within the sample relative to all other DMUs. As a result, the efficient DMU lies at the extreme frontier and inefficient DMU lies below this frontier (Charnes, Cooper, Lewin, & Seiford, 1994, pp. 5–6). DEA enables the sources of inefficiency to be determined, as well as the level of inefficiency of the chosen inputs and outputs (Charnes et al., 1994, p. 6).

DEA is applied here for measuring the relative efficiency of the branches of Komercijalna Banka AD Skopje. Eight bank branches located throughout the Republic of Macedonia are considered in the empirical research. They performed the same financial activities over the observed period from 2009 to 2011. When the analysis sample consists of a small number of DMUs in comparison to the number of chosen inputs and outputs, the efficiency frontier is formed by a large number of DMUs, so that the discrimination power is decreased. In order to overcome this issue, the DEA technique, known as window analysis, can be used. By employing it, the number of DMUs can be increased and, at the same time, the analysis of efficiency can also include the time dimension. For this reason, the paper uses DEA window analysis and for the validation of the unexpected results, the combination of the analytic hierarchy process (AHP) and DEA model (AHP-DEA validation model) is used. The AHP is the most popular multi-criteria decision-making (MCDM) method, which allows choosing the best of the available alternatives or making their rankings. It was developed by Thomas L. Saaty in the early 1970s (Saaty, 1977, 1980).

The remainder of this paper is structured as follows. The literature review is given in Section 2 while the methodology is explained in Section 3. Section 4 describes the bank branches efficiency analysis and presents the obtained results and their analysis. The conclusion is given in Section 5.

2. Literature review

The bibliography on DEA, published in 2008 (Emrouznejad, Parker, & Tavares, 2008), encompasses over 4000 research articles which were published in the time frame since its introduction up to 2007. Consequently, 2500 different authors are identified, and it is interesting to note that 22% of all of the publications have been written by 12 authors while the largest number of publications in the reviewed journals was published in 2004. The most popular areas of application were banking, education, healthcare and hospital efficiency.

Paradi, Vela, and Yang (2004, p. 353) stated that there is '…a long list of DEA applications in the banking sector from several different angles: country-wide bank (companies) analysis, bank branch analysis within one banking organisation, cross-national banking analysis, bank merger efficiencies, branch deployment strategies.'

In this paper, DEA is used to measure the relative efficiency of the branches of Komercijalna Banka AD Skopje that are located across the Republic of Macedonia, which means that this is an issue of analysis of bank branches in a given banking organisation. Therefore special emphasis in this section is put on the application of DEA in efficiency evaluation of bank branches.

A comprehensive literature review of DEA application in efficiency evaluation of bank branches was done by Eken and Kale (2011). They analysed 39 articles, containing more than 49 studies/approaches published after 2000. In most studies (33), the production/operational approach is used; the intermediation approach and the profitability approach are used in seven studies respectively; whereas another approach is used in six studies. In 29 studies, the BCC model is applied; in 27 studies, the CCR model is applied; in 11 studies, another DEA model is applied; while other models (FDH – free disposal hull, or modified) are applied in eight studies. Regarding the orientation, 36 studies employed input-oriented approach; 12 studies employed the output-oriented, and 5 studies employed the non-oriented approach. The average number of inputs is 3.9 while the average for outputs is 4.7. The most commonly used inputs refer to the personnel, non-personnel operating expenses, location (area, rent, etc.), equipment, etc.; the most commonly used outputs are the following: deposit balance, loan balance, non-interest income and commissions, and the number of accounts/transactions. Furthermore, the review stressed that DEA was applied to a sample that includes a maximum of 50 bank branches in several articles (Sevcovic, Halicka, & Brunovsky, 2001; Cook & Hababou, 2001; Hartman, Storbeck, & Byrnes, 2001; Portela, Borges, & Thanassoulis, 2003; Barth & Staat, 2005; Camanho & Dyson, 2008; Giokas, 2008).

For measuring the relative efficiency of the branches of Komercijalna Banka AD Skopje, the DEA window analysis is employed, while for the validation of the obtained unexpected results, the AHP-DEA validation model is used. Tone (1989) points out several structural similarities between AHP and DEA, and according to the review by Ho (2008), AHP and DEA are integrated into four studies.

Kisielewska, Guzovska, Nellis, and Zarzecki (2005) scrutinised the ten largest commercial banks in Poland in order to analyse their performance over a nine-year period (from 1995 to 2003) by window analysis and the Malmquist Indexes. In a study of the Canadian banking industry, Asmild, Paradi, Aggarwall, and Schaffnit (2004) combine the Window analysis and the Malmquist Indexes. Bergendahl (1998) applies DEA and Benchmarks in 48 large Nordic banks (14 from Denmark, 13 from Finland, 12 from Norway, and 9 from Sweden) during a two-year period (1992 and 1993), while Hartman and Storbeck (1996) use the window analysis with the aim of investigating the development of loan efficiency in 12 Swedish banks during a time period of 9 years.

However, there are only a few applications of DEA window analysis in the bank branches efficiency evaluation (Arefrad & Alipoor, 2015; Savic, Radosavljevic, & Ilievski, 2012). But there are no examples of DEA integration with the AHP method for the validation of unexpected results.

3. Methodology

In this paper, we have used the output-oriented DEA window analysis model with the variable returns to scale (VRS) assumption for measuring the relative efficiency of the bank branches of Komercijalna Banka AD Skopje. According to Thanassoulis (2001, p. 40), when the proportional increase in inputs does not lead to a proportional increase in outputs, the VRS exist. Cooper, Seiford, and Tone (2007, p. 58) indicate that the output-oriented model maximises the outputs using the observed value of any input.

The Charnes-Cooper-Rhodes (CCR) model is one of the most basic models of the non-parametric methodology DEA, based on the assumption that at the efficient frontier prevails constant returns to scale (CRS), but unlike this model the Banker-Charnes-Cooper (BCC) model (due to Banker, Charnes, & Cooper, 1984) assumes VRS (Cooper et al., 2007).

Let us consider a set of n DMUs, with each DMUj, $j = 1,\ldots,n$, using m inputs x_{ij} ($i = 1,\ldots,m$) and generating s outputs y_{rj} ($r = 1,\ldots, s$). Then the primal linear program for the output-oriented VRS DEA model, that gives optimal efficiency score for DMU$_0$, can be written as (Cooper et al., 2007):

$$\min \sum_{i=1}^{m} \upsilon_{\mathrm{i}} x_{\mathrm{i0}} - \nu *$$

s.t.

$$- \sum_{r=1}^{s} u_{\mathrm{r}} y_{\mathrm{rj}} + \sum_{i=1}^{m} \upsilon_{\mathrm{i}} x_{\mathrm{ij}} - \nu * \geq 0, \quad j = 1, \ldots\ldots, n \tag{1}$$

$$\sum_{r=1}^{s} u_{\mathrm{r}} y_{\mathrm{rj}} = 0$$

$$u_{\mathrm{r}}, \quad r = 1, \ldots, s, \quad \nu_i \geq 0, \quad i = 1, \ldots, m, \nu * - \text{free - sign}$$

where ur – r is index like in the formula 1 is the weight assigned to output r, $r = 1,\ldots, s$ and vi – i is index like in formula (1) is weight assign to input i, $i = 1,\ldots,m$. This program should be solved n times, once for each DMU under evaluation. In this way, DEA determines the weights for all inputs and outputs. Basic DEA models allow total flexibility in the choice of weights for all DMUs so that they achieve maximum efficiency levels in line with its inputs and outputs. This complete flexibility in the choice of weights is important for the identification of inefficient DMUs which are below the level of efficiency even with its set of weights. However, the difficulty can be found in a conflict with the prior knowledge or the accepted standpoints for the relative values of inputs and outputs.

To overcome this problem and make a validation of the results, this paper suggests the use of AHP-DEA validation (explained in Section 3.2). An extension of DEA analysis, DEA window analysis, is chosen for the purpose of capturing efficiency results and their changes during the given period, as well as increasing the number of DMUs under evaluation. The DEA window analysis is explained in the next section.

3.1. DEA window analysis

In order to include a time dimension in the efficiency analysis, window analysis has been developed; the name and basic concept are attributed to Klopp (1985). This analysis enables to follow the change of efficiency of the DMUs over time.

The idea behind this DEA technique is that the same DMU in the period i, i.e., in the period j (for $i \neq j$) is observed as if it were two different DMUs; so if p marks the length of the window or a certain number of periods that are being observed, then in the beginning the data for the first p period is taken into consideration, while the data for the period 1 is omitted and the data for the period $p + 1$ is added; this allows the next window to appear. Then the data for the first two periods is omitted and the data for the periods $p + 1$ and $p + 2$

is added, resulting in the window, thus making the window 'move' until the time periods in the framework of the analysis have passed (Neralic, 1995, p. 207).

The symbols and formulas that are used in window analysis are the following (Cooper et al., 2007, pp. 326–327): n is the number of DMUs, k is the number of periods, p is the length of the window ($p \leq k$), while w is the number of windows; it is calculated according to the formula: $w = k - p + 1$, the number of DMUs in each window is calculated through the formula: np, the number of 'different' DMUs is calculated through the formula: npw, and Δ of the number of DMUs is calculated through the formula $n(p - 1)(k - p)$.

With window analysis, a larger number of DMUs is obtained, which is of significance if the number of DMUs is not, at least, three times larger than the total number of inputs and outputs. Cooper et al. (2007, p. 116) point out that in the envelopment model the number of DMUs (n) should be chosen to be equal to or greater than $\max\{m \times s, 3(m + s)\}$.

Through the columns of the table in which the results of the window analysis are shown, we can see that in a certain month, quarter, or year, the DEA results have changed or have not changed with the move from one window to another, while by reviewing the rows in the table, we can observe the trend. For further details, see Cooper et al. (2007, p. 326).

According to the results of the window analysis, an envelopment map can be created; each column shows the number of appearances of the efficient DMUs in the reference set of the DMUs that are inefficient while in the last row the total number of these appearances is given (Neralic, 1995). The efficiency is confirmed for those DMUs that appear relatively more often when evaluating the other DMUs while the relative inefficiency is confirmed for those DMUs that do not appear at all in the reference set.

3.2. The AHP-DEA validation

The MCDM is used for solving problems which involve multiple criteria, usually conflicting with each other (Triantaphyllou, 2000). Mardani et al. (2015) made a literature review for MCDM techniques and their applications, covering the period from 2000 to 2014. They collected a total of 393 articles published in international peer-reviewed journals, extracted from the database system Web of Science. They found that the first method in use is the AHP with 128 studies; the year 2013 was characterised by the highest number of publications (75), and the most significant role in MCDM issues has the *European Journal of Operational Research*.

AHP allows solving real complex problems of MCDM in that they are decomposed into the following components: goal, criteria (sub-criteria, if any), and alternatives which are hierarchically presented. For suggestions on the detailed design of the hierarchy, see Saaty and Vargas (1994, pp. 9–10). Once the MCDM problem is structured as a hierarchy, the decision-maker compares the elements in pairs at each level of the hierarchy, and the preferences are expressed by Saaty's scale of relative importance (a fundamental scale of absolute numbers), which is given in Cvetkoska and Danilov (2014, p. 71). On the basis of these pair-wise comparisons the weights for criteria and priorities for alternatives are calculated, and then these results are synthesised into overall priorities for alternatives.

How are the local priorities (weights) of the criteria, sub-criteria (if any), and alternatives calculated? If we assume that there are two criteria, we then compare the two criteria in pairs, and if the first criterion is strongly more important than the second one (we use Saaty's scale of relative importance) then we enter the absolute number 5 in the (1,2) position (first

Table 1. Judgment matrix for the criteria.

Goal	Criterion 1	Criterion 2
Criterion 1	1	5
Criterion 2	1/5	1

Source: Authors.

row, second column position) of the judgment matrix A, and the reciprocal value (1/5) in the (2,1) position (Table 1). For this matrix, the following features are characteristic: all of its elements are positive, the matrix is reciprocal ($a_{ij} = 1/a_{ji}$) and it has the rank 1.

Then the sum of each column is calculated, and the elements of the first column are divided by the sum of the first column while the elements of the second column are divided by the sum of the second column. The obtained values are elements of a normalised matrix. The weight of the first criterion will be calculated as an average value of the elements that comprise the first row of the normalised matrix, and analogous to this, the weight of the second criterion will be calculated. In this way, the weights of the sub-criteria (if any) and priorities of the alternatives are calculated, followed by the calculation of the overall priority for each alternative, for more details see Saaty (2004, p. 216). At each level of the structure of the hierarchy, the sum of the weight coefficients should be 1.

The AHP method makes it possible to examine whether the decision-maker was consistent when comparing elements at each hierarchical level in pairs. The inconsistency that does not exceed 10% is tolerated, as explained in Cvetkoska and Danilov (2014, p. 71). For more information about the mathematical basis of this method and the consistency of the decision-maker, see Saaty and Vargas (1994, pp. 3–9).

If the solving of the output-oriented DEA Window analysis model with VRS assumption gives unexpected results, the use of AHP-DEA validation model for the validation of the unexpected results is suggested.

Two AHP models should be built which will consist of one level (criteria); the one AHP model will cover the inputs as criteria while the other will cover the outputs of the output-oriented DEA window analysis model with VRS assumption as criteria. The importance of the inputs and outputs should be evaluated using Saaty's fundamental scale, and the sample of respondents will consist of the managers of the branches of Komercijalna Banka AD Skopje. They will all be given a questionnaire survey (distributed by e-mail), with elements of the hierarchy (criteria) in pairs, which they are to compare and assign a suitable assessment of importance from Saaty's scale. This means that each of them has to fill in the questionnaire individually, and after returning the completed questionnaires, through calculating the geometric mean, the individual assessments of the respondents will be combined. Begicevic, Divjak, and Hunjak (2011, p. 448) state that Aczel and Saaty (1983) have proved that when reciprocal assessments are used, the only way to combine the assessments is by using the geometric mean. Weights that will be obtained by the AHP method will serve for setting restrictions on the weights of the variables of the output-oriented DEA window analysis model with VRS assumption, and the model will be solved once again.

4. Bank branches efficiency analysis

The purpose of this study is to measure the efficiency of the bank branches of Komercijalna Banka AD Skopje. In order to collect relevant data and provide detailed information about the profile of these business units, the Chief Operative Officer of the bank allowed contacts with the Manager of the Independent Branch Network Management Department. During the observed time period from 2009 to 2011, eight out of 11 branches performed the identical financial activities. They operate across the Republic of Macedonia: Veles, Kavadarci, Kocani, Kumanovo, Ohrid, Prilep, Strumica and Stip. The remaining three branches in Bitola, Gostivar and Tetovo did not perform the activities such as lending to citizens and corporate lending, and they work only partially in the section of international operations, i.e., international payment operations for legal entities only. Therefore, these three branches are not taken into consideration for the analysis; consequently, the final sample consists of the eight branches mentioned above.

The *first step* in the analysis was selecting the production approach for measuring the relative efficiency of the branches. According to this approach, the bank branches use labour and capital in order to produce deposits and loans, as stated in Paradi et al. (2004, p. 355).

The *second step* is to choose inputs and outputs for this approach. For that purpose, an interview with the Manager of the Independent Branch Network Management Department was conducted, and four inputs were identified (personnel, equipment, business premises, and material expenses) and 16 outputs (lending to citizens, corporate lending, domestic payment operations – total transactions, domestic payment operations – officers, domestic payment operations – average per employee, bank cards, ATM transactions, POS terminals and imprinters transactions, denar saving passbooks, foreign currency saving passbooks and current accounts, deposits structure, realised inflows from legal entities, realised outflows from legal entities, total F/X purchase, inflows from individuals, and outgoing payments from individuals).

In the *third step*, a three-part survey questionnaire is designed. The first part consists of questions regarding the general socio-demographic data; the second part is related to the assessing of the importance of the inputs and outputs. The importance is assessed by a given 1–5 scale, where 1 refers to the least important and 5 to the most important. Also, the respondents could add inputs and/or outputs which they consider important but were not included in the questionnaire and to assess their importance. The last part of the questionnaire is an open-ended question referred to suggestions and comments by respondents.

The criterion for selection of the respondents was the expertise in banking, so 11 managers of the branches of Komercijalna Banka AD Skopje located throughout the Republic of Macedonia were selected. The survey was conducted via e-mail. Each of the respondents rated the importance of the identified inputs and outputs for the production approach, and new inputs or outputs were not added. This indicates that the choice of inputs and outputs was adequate from their point of view.

The arithmetic mean of the importance of each input and output was calculated on the basis of the collected data. Figure 1 shows the average score of the importance for the selected inputs of the production approach. The highest average score ($\overline{x} = 4.82$) has the personnel (number of employees), which means that according to the respondents it is the most important input, followed by equipment ($\overline{x} = 4.73$), and material expenses ($\overline{x} = 4.00$) while the input business premises has the average score of importance 3.91.

Figure 2 shows the average score of the importance for each output used in production approach. The three outputs, corporate lending, deposits structure and realised outflows, from legal entities are characterised by the highest average score of importance ($\overline{x} = 4.73$), which is followed by domestic payment operations - officers ($\overline{x} = 4.64$), followed by denar

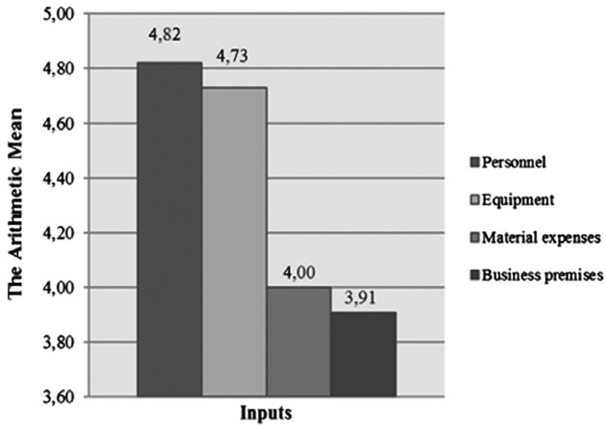


Figure 1. Average score of importance of inputs. Source: Author's calculation.

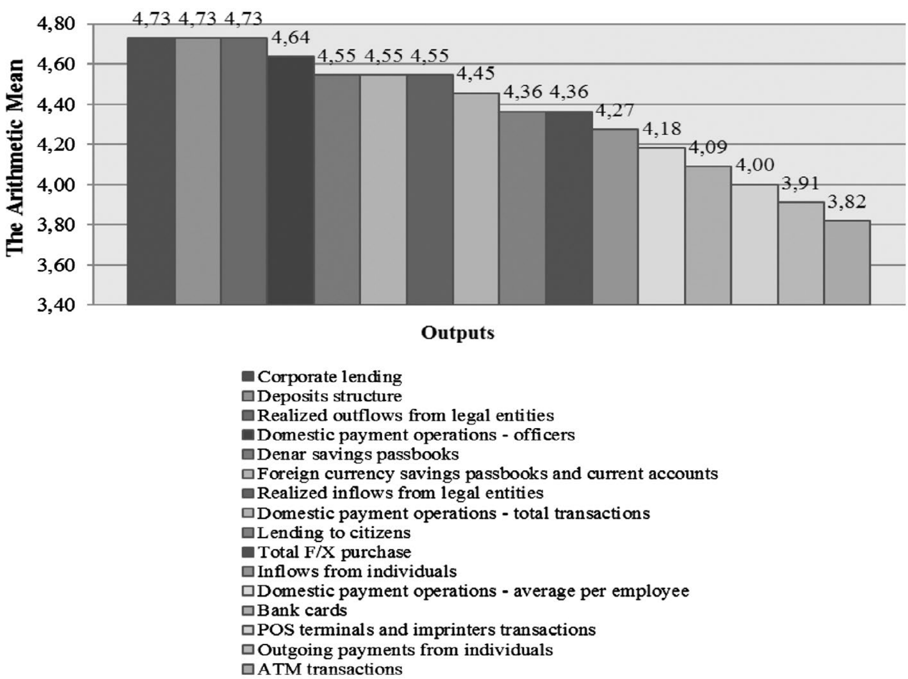


Figure 2. Average score of the importance of outputs. Source: Author's calculation.

saving passbooks, foreign currency saving passbooks and current accounts, and realised inflows from legal entities having the same average score of importance ($\overline{x} = 4.55$) etc., and the output ATM transactions has the lowest average score ($\overline{x} = 3.82$).

The *fourth step* was a selection of inputs and outputs for DEA model, based on their average score of importance. This step is of a crutial importance for efficiency analysis and results strongly rely on selected variables; their number should not be too big in comparison to the number of DMUs (bank branches). The following inputs were selected: personnel and material expenses while the most important outputs from the process were corporate lending and deposits structure. Appendix 1 gives the description of the selected inputs and outputs. The data used for analysis are not public but confidential, therefore, they are not given in this paper, and the real names of the branches are replaced with numbers.

The *fifth step* was a selection of an appropriate DEA model. We have opted for output-oriented VRS DEA model and window analyses to cover the whole period and to increase discrimination power of the selected model. In this empirical study the number of branches of Komercijalna Banka AD Skopje is 8 ($n = 8$), the number of periods is 3 (years) ($k = 3$) and the length of the window is 2 years ($p = 2$). In order to determine the length of the window, the formula $p = k + 1/2$ is used, for more details, see Cooper et al. (2007, pp. 327–328). The number of windows is 2 ($w = k - p + 1 = 3 - 2 + 1 = 2$), the number of branches in each window is 16 ($n \times p = 8 \times 2 = 16$) while the number of 'different' branches is 32 ($n \times p \times w = 8 \times 2 \times 2 = 32$).

4.1. Phase I – windows DEA efficiency analysis

The software tool EMS 1.3 is used for solving the output-oriented DEA window analysis model with VRS assumption; the details of this tool can be found in Scheel (2000).

The results of efficiency for each branch, for each year, in each window, as well as the overall efficiency by windows (an average of four results of efficiency is calculated for each branch separately) and by years (the average annual efficiency is taken into consideration) are shown in Table 2. The efficiency score of 100% indicates relatively efficient DMU while a score higher than 100% indicates relatively inefficient DMU. Branch 8 in the first year of the observed period is incomparable against other branches because the value of its output corporate lending is 0. Table 2 shows that only branch 7 is efficient for each year, in each window. The least efficient branch in the whole observed period is branch 6. It can also be noted that branch 6 shows the highest level of improvement in efficiency between 2009 and 2010.

According to the perceptions of the bank management and the employees, the results for branch 6 were unexpected, especially in 2009. Branch 6 showed high inefficiency in 2009 and

Table 2. 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	168.41	110.58		124.42	128.14
		115.95	102.74		
Branch 2	103.71	100.00		100.93	101.24
		100.00	100.00		
Branch 3	100.00	100.00		103.01	104.02
		100.00	112.05		
Branch 4	109.07	150.66		134.72	129.43
		150.50	128.64		
Branch 5	103.64	100.00		100.91	101.21
		100.00	100.00		
Branch 6	238.57	141.50		161.86	167.29
		149.69	117.69		
Branch 7	100,00	100.00		100.00	100.00
		100.00	100.00		
Branch 8	100.00	174.48	144.17	129.66	127.14
		100.00			

Source: Author's calculation.

it was also relatively inefficient in the remaining years of the observed period, but according to the perceptions of the managers, this branch worked efficiently in the observed period. For the purpose of the results validation, in the next step, the results of AHP are used for ratio-cone weights restriction in DEA model (Thompson, Singleton, Thrall, & Smith, 1986).

4.2. Phase II – AHP-DEA window analysis

As it is already mentioned, a survey of input and output was conducted. Each input and output was scored on Saaty scale by branch managers, the collected data were processed, and it was determined that:

- 55% of the respondents assigned value 1 for the criteria personnel and material expenses;
- 45% of the respondents assigned higher values (2, 3, 3, 5 and 8) for the criterion personnel;
- 82% of the respondents assigned value 1 for the criteria corporate lending and deposits structure, and
- one respondent assigned value 7 for the criterion corporate lending while another respondent assigned value 5 to the criterion deposits structure.

The weight coefficients for the criteria of the AHP models obtained by using the individual assessments of the respondents (individual judgments) are shown in Table 3. Group judgments are obtained by computing the geometric mean of the individual judgments. For example, the geometric mean of 4, 5 and 8 is $\sqrt[3]{4\ x\ 5\ x\ 8}$, which is 5.43 (5 in the Saaty's scale of relative importance). Weights of the criteria personnel and material expenses, and of the criteria corporate lending and deposits structure obtained by using group judgments are shown in Figures 3 and 4, respectively. The criterion, personnel, has gained higher importance while the difference in the obtained weights for the two output criteria (corporate lending and deposits structure) is insignificant.

Weights obtained by the AHP method allowed setting weight restrictions of the variables in the output-oriented DEA Window model with VRS assumption. Weights restrictions are set as follows:

$$v_1/v_2 \leq 0.595/0.405 \;\Rightarrow v_1/v_2 \leq 1.46 \tag{2}$$

Table 3. Weights for the criteria of the AHP models.

	Weight coefficients for the criteria of the first AHP model		Weight coefficients for the criteria of the second AHP model	
Respondents	Personnel	Material costs	Corporate lending	Deposit structure
Respondent 1	0.833	0.167	0.500	0.500
Respondent 2	0.500	0.500	0.500	0.500
Respondent 3	0.500	0.500	0.500	0.500
Respondent 4	0.899	0.111	0.500	0.500
Respondent 5	0.500	0.500	0.500	0.500
Respondent 6	0.667	0.333	0.500	0.500
Respondent 7	0.500	0.500	0.500	0.500
Respondent 8	0.750	0.250	0.500	0.500
Respondent 9	0.500	0.500	0.875	0.125
Respondent 10	0.750	0.250	0.167	0.833
Respondent 11	0.500	0.500	0.500	0.500

Source: Author's calculation.

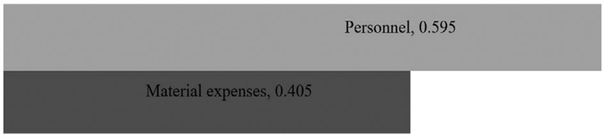


Figure 3. Weights of the criteria personnel (number of employees) and material expenses obtained by using group judgments. Source: Author's calculation.

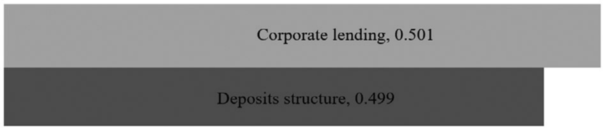


Figure 4. Weights of the criteria: corporate lending and deposits structure obtained by using group judgments. Source: Author's calculation.

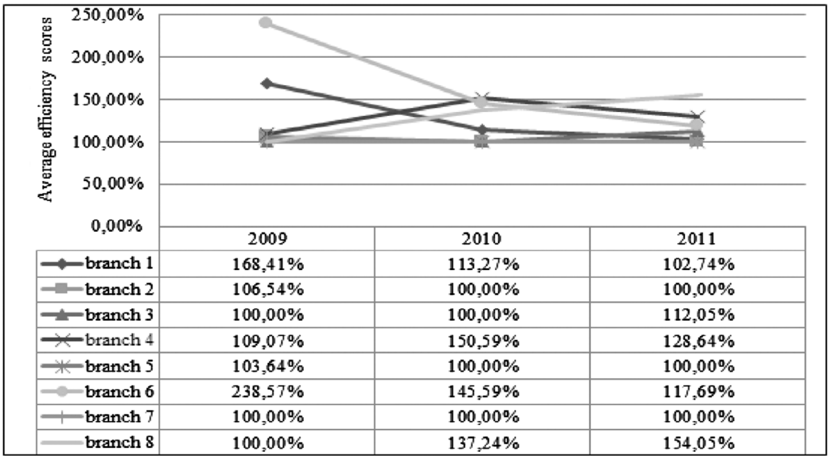
Table 4. Results of the output-oriented DEA window analysis with weight restrictions.

	Efficiency results (%)			Overall efficiency	
Branches	2009	2010	2011	by windows	by years
Branch 1	168.41	110.58		124.42	128.14
		115.95	102.74		
Branch 2	106.54	100.00		101.64	102.18
		100.00	100.00		
Branch 3	100.00	100.00		103.01	104.02
		100.00	112.05		
Branch 4	109.07	150.68		134.73	129.44
		150.51	128.64		
Branch 5	103.64	100.00		100.91	101.21
		100.00	100.00		
Branch 6	238.57	141.50		161.86	167.29
		149.69	117.69		
Branch 7	100.00	100.00		100.00	100.00
		100.00	100.00		
Branch 8	100.00	174.48		132.13	130.43
		100.00	154.05		

Source: Author's calculation.

$$u_1/u_2 \leq 0.501/0.499 \quad \Rightarrow u_1/u_2 \leq 1.004 \tag{3}$$

The new model was solved again by using a software tool EMS 1.3, and the obtained results are presented in Table 4. It can be seen that the number of relatively efficient branches in the observed period (3 years) has not changed, in other words, 11 branches are relatively efficient. On the basis of the comparison of the results in Table 2 and in Table 4, it is seen that there are no changes in the results of the efficiency of branches 1, 3, 5, 6 and 7. The high inefficiency of the branch 6 in 2009 is confirmed again. The reason for the inefficiency of branch 6 is the high value of the second input – material expenses, especially in 2009. This branch can be compared to branch 7 which is one of its benchmarks in all windows. It appears that the input material expenses of branch 6 is two to three times greater than that of branch 7, while the output deposit structure is at most half the value of a deposit



	2009	2010	2011
branch 1	168,41%	113,27%	102,74%
branch 2	106,54%	100,00%	100,00%
branch 3	100,00%	100,00%	112,05%
branch 4	109,07%	150,59%	128,64%
branch 5	103,64%	100,00%	100,00%
branch 6	238,57%	145,59%	117,69%
branch 7	100,00%	100,00%	100,00%
branch 8	100,00%	137,24%	154,05%

Figure 5. The average efficiency scores of the branches of Komercijalna Banka AD Skopje per year according to the output-oriented DEA window analysis with weight restrictions. Source: Author's calculation.

Table 5. Envelopment map.

Branches	1	2	3	4	5	6	7	8
1	0	4	4	0	0	0	4	0
2	0	1	0	0	0	0	1	0
3	0	1	1	0	0	0	1	0
4	0	3	4	0	0	0	5	1
5	0	0	1	0	1	0	0	1
6	0	4	4	0	0	0	4	0
7	0	0	0	0	0	0	0	0
8	0	0	1	0	1	0	3	1
Total	0	13	15	0	2	0	18	3

Source: Author's calculation.

structure of branch 7, indicating that branch 6 could be efficient from the management point of view but not relatively efficient.

The average efficiency of each of the branches of Komercijalna Banka AD Skopje per year is shown in Figure 5.

Table 5 gives the envelopment map. It shows that branch 7 appears most often (18 times) in reference sets of inefficient units, which further confirms its efficiency, while relative inefficiency is confirmed for branches 1, 4 and 6 that do not appear at all in the reference sets.

5. Conclusions

The aim of this paper was to assess the relative efficiency of the branches of Komercijalna Banka AD Skopje during the period from 2009 to 2011. The sample consists of eight branches of Komercijalna Banka AD Skopje, which performed the same financial activities over the observed period. Due to a small number of branches in the sample, and the data compiled over a period of three years, the DEA technique window analysis is selected as the most suitable. This is the first application of the DEA technique window analysis in the Republic of Macedonia for the purpose of measuring relative efficiency of the branches of one bank.

This technique allows an increase of the number of branches and monitoring the trend, and the stability of the results of the relative efficiency of each of the bank branches over time. The output-oriented DEA window analysis model with VRS assumption was used, and it was solved with the software tool EMS 1.3. The obtained results were interpreted in the bank and they correspond to the factual situation and the perceptions of the respondents, with the exception of one of the branches (branch 6) which, according to the results, show high inefficiency. For the validation of these unexpected results the use of AHP-DEA validation model was suggested. The results of AHP are used for ratio-cone weights restriction in the DEA model. The obtained results by this AHP-DEA validation model should be used as more valid.

The obtained results provide especially valuable information for the bank's management because the branches that are relatively efficient, as well as those that are relatively inefficient, can be identified. Additionally, the trend can be observed, and it can be seen whether the result of efficiency in a given year changes or not when moving from one window to another.

In terms of the methodological approach, the conducted research is combined (the method of interview and method of survey are applied; the data that is textual and numerical are collected and analysed; the measure of central tendency arithmetic mean (average) of the importance of each input and output for the production approach is calculated, and the window analysis and AHP method are applied). According to the source of data, this is a primary research (the data have been compiled for the first time for the purpose of this research); according to the type of analysed data, the research is empirical; according to the scope, it is micro; and according to the time the research represents research of the past period (at three-year past period was observed).

In our further research, we plan to cover a longer period of time, to use statistical methods in the selection of inputs and outputs, and to construct a model that will help managers to continuously make good decisions regarding the work of the bank.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix 1. Description of the selected inputs and outputs

Inputs	Description
Personnel	Number of employees per each branch
Material expenses	- Expendable office stationery
	- Expendable office stationery – internal forms
	- Consumed electricity
	- Consumed fuel and lubricant
	- Write-off of inventory and packaging
	- Heating and refrigeration of business premises
	- Material hygiene
	- Newspapers, magazines and specialised literature
	- Consumed water
	- Computer equipment
	- Cost of services for current and investment maintenance of the operational tools
	- Insurance premium for operational tools
	- Services costs – insurance premiums for foreign currencies payment instruments
	- Services costs – deposit insurance premium
	- Services costs – cash insurance premium of fire
	- Services costs – postal expenses
	- Phone costs
	- Costs of non-production services - utilities
	- Costs of non-production services – intellectual services
	- Costs of non-production services – personal tax
	- Costs of non-production services – hygiene maintenance of business premise
	- Costs for business trips in the country – daily allowances
	- Costs for business trips in the country – travelling expenses
	- Representation expenses
	- Costs of sponsorship in the country
	- Costs for donations in the country
	- Costs for donations – personal tax
	- Costs for sponsorship of public interest in the country
	- Costs for donations of public interest in the country
	- Other administrative expenses – property security
	- Other administrative expenses – operating and protective clothing
	- Amortisation of furnishing and office equipment
	- Amortisation of equipment, instruments, tools and devices for measurement and control
	- Amortisation of information systems and computer equipment
Outputs	Description
Deposit structure	Demand deposit (short and long terms) of legal entities and individuals
Corporate lending	Disbursed loans of legal entities

Source: Authors.