# Application of DEA Method in Measuring of Market Efficiency of Banks in Bosnia and Herzegovina and Reflection of the COVID-19

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## ABSTRACT

By using the DEA method, the paper measures market efficiency of the banks in Bosnia and Herzegovina in the period 2017-2020, in the context of challenges caused by the COVID-19. The aims of the research are: a) to measure market efficiency of the banks in Bosnia and Herzegovina and rank them using the DEA method (applying three models CCR-O, BCC-O, and Window-I-C), b) establish the effect of the COVID-19 pandemic on market efficiency of the observed banks, and c) established the link between the volume of digital banking services usage and market efficiency of the observed banks. The research results show that in 2020, when the COVID-19 appeared, CCR-O and BCC-O models revealed a decrease in market efficiency for 73.9% of the observed banks while Window-I-C model revealed lower market efficiency for all the observed banks. The regression analysis applied showed a significant link between the volume of digital banking services usage market efficiency of the observed banks. The regression model was established, pointing to a significant importance of independent variables for the prediction of the dependent variable.

**Key words:** *Market efficiency, Banks, DEA method*

**JEL Codes**: M31

## 1. INTRODUCTION

In 2020, the outbreak of the COVID-19 pandemic caused many changes in the functioning of economy but also all other aspects of the society. Due to this situation, banks as well as all other organizations were forced to undertake significant changes in the way they organize their business activities and to adapt their market approach to the newly emerged circumstances. Due to significant problems in the functioning of the economy, apart from other things banks faced lower demand for some segments of banking services as well as the inability to rationally use their capacity in providing services to clients. On the one hand, banks were forced to limit clients' visits to their offices due to restrictions imposed by state bodies aimed at the prevention of the COVID-19. On the other hand, some bank employees were not able to participate in the business process due to health-related or other issues. This affected the total business performances of banks, which is why the paper focused, bearing in mind the research aims, on identifying the consequences of the newly emerged circumstances on market efficiency of banks. Market efficiency may be analyzed pursuant to various criteria. For the purpose of this research, the following indicators were observed: four input indicators (number of employees of banks, number of branch offices, employee costs and other costs) and for output indicators (net interest income, net non-interest income, total number of clients and number of new clients in the observed business year, observing retail, SME, and

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corporate clients). Based on these data, the measurement of market efficiency of banks was made, implementing the DEA method.

## 2. THEORETICAL FRAMEWORK

The DEA method (Data Envelopment Analysis) is used for measuring the efficiency of decision-making units (DMUs), whereby DMUs may be various subjects such as organizations or their parts that transform the observed inputs into the observed outputs. The application of the DEA method (adapted by Charnes et al., 1978) in the measurement of efficiency basically includes the comparison of the ratio of output and input among the observed DMUs. This method is based on the linear programing. The result of the DEA method is DMU ranking by the defined (measured) efficiency, whereby DMUs with the efficiency of 1 are considered efficient and those DMUs whose efficiency is below 1 are considered inefficient (adapted from Paradi et al. 2004).

While measuring efficiency, the ratio of output and input is observed for every DMU, with the identification of the DMU with the best ratio value and the remaining DMUs observed are compared to the best unit. The measurement of efficiency may use two approaches (adapted from Farrell, 1957):

- to maximize output with the given set of input (output-oriented approach), which was used in this research, and
- to minimize input while keeping the given level of output (input-oriented approach).

A large number of variations (models) in efficiency measurement was developed within the DEA method. They mutually defer according to the emphasis on continuity or variability in output compared to the volume of action (using input), then according to the focus on minimizing input or maximizing output, etc. The most frequently used models are the CCR model (Charnes-Cooper-Rhodes model) and the BCC model (Banker-Charnes-Cooper model).

The basic idea of the CCR model is to form for every DMU a virtual output and input using weighting coefficients of output ($u_r$, $r = 1, 2, \dots, s$) and weighting coefficients of input ($v_i$, $i = 1, 2, \dots, m$). While doing so, the analysis aims at specifying the weights that maximize their ratio. Such measurement of the relative efficiency of the observed $DMU_0$ ($0 \in \{1, 2, \dots, n\}$) is achieved by solving the following problem of linear programing (Cooper et al, 2006):

$$\max \theta = \frac{u_1 y_{10} + u_2 y_{20} + \cdots + u_s y_{s0}}{v_1 x_{10} + v_2 x_{20} + \cdots + v_m x_{m0}},$$

$$\text{with the limitation } \frac{u_1 y_{1j} + u_2 y_{2j} + \cdots + u_s y_{sj}}{v_1 x_{1j} + v_2 x_{2j} + \cdots + v_m x_{mj}} \leq 1 \ (j = 1, \dots, n),$$

$$v_1, v_2, \dots, v_m, \geq 0,$$
$$u_1, u_2, \dots, u_s, \geq 0.$$

If the rule is applied for the observed DMUs that input increase results in proportional output increase, then this ratio is characterized by a constant output relative to the volume of activity. In this case, the application of the CCR model for the measurement of efficiency is appropriate. Otherwise, when the ratio of input and output is characterized by variable output

relative to the value of activity (input increase results in minor or higher output increase), then the application of the BCC model is appropriate for measuring efficiency. If the way in which output is modified by the change of input is not known, then it is usual to apply both models and compare their results. If the results are significantly different, it may be concluded that output change has a variable character relative to input change and the application of the BCC model is recommended.

In a mathematical form, the BCC model, when compared to the CCR model, has an additional limitation that specifies that the efficiency frontier between these two models is different. The additional limitation in a mathematical form is:

- for the BCC input-oriented model $\sum_{j=1}^{n} \lambda_j = 1,$
- for the BCC output-oriented model $\sum_{j=1}^{n} \mu_j = 1.$

To moderate the limitation related to the static character in measuring efficiency, as these two models measure efficiency on a specific day, the paper also uses the Window model. This model observes inputs and outputs through multiple time periods, with efficiency measurement for every DMU is made not only relative to other observed DMUs in a given time but also relative to the data on the same DMU over the observed time periods. Hence, DMU efficiency is measured over multiple time periods (months, quarters, years, etc.), which allows for the monitoring of dynamics in efficiency changes, i.e., whether during the observed period efficiency increased, reduced or remained the same (adapted from Cooper et al, 2011).

Authors such as Paradi et al. (2011) use various criteria in measuring banks' efficiency. Depending on the selection of inputs and outputs, one can differentiate profit, operational, market or some other aspect of business efficiency. This paper, as previously stated, focuses on inputs and outputs that enable the measurement of banks' market efficiency in the context of challenges emerged as the consequences of the COVID-19 outbreak.

## 3. RESEARCH METHODOLOGY

The subject of the research is market efficiency of the banks in Bosnia and Herzegovina (BiH) in the period 2017-2019 and reflection of the COVID-19 pandemic in 2020. The goals of the research were:

- measure market efficiency of the banks in BiH and rank them using the DEA method (with CCR-O, BCC-O and Window models),
- determine the impact of COVID-19 pandemic on market efficiency of the observed banks,
- determine the impact of using digital banking services on market efficiency of the observed banks.

In this paper secondary and empirical data were used. The secondary data were collected from banks' business reports for the period 2017-2019. The survey questionnaire was used as the form for collecting empirical data and these data were collected during October 2020. The empirical data were collected from the members of the management boards of banks in charge of market operations (especially for sales). The measurement of market efficiency of banks and their ranking was performed on the basis of the data for the period 2017-2019 (in which there was no impact of the COVID-19) and based on the assessment of the same data by the respondents in 2020 (in which there is an impact of the COVID-19). In this way, an attempt

was made to determine the differences in market efficiency (through the observed indicators), with one of the causes of these differences being the effects of the COVID-19 pandemic.

## 4. RESULTS AND DISCUSSION

The analysis covered 23 banks operating in the market in BiH. The analysis did not include the Development Bank of the Federation of BiH as it is the state investment and guarantee bank with characteristics different from other banks functioning in BiH. The applied DEA methods (CCR-O, BCC-O and Window-I-C model) were performed using DEA Solver software. The following data were used as input: 1) number of employees, 2) number of branch offices, 3) employee costs, and 4) other costs. The following data were used as output: 1) net interest income, 2) net non-interest income, 3) total number of clients, and 4) number of new clients in the observed business year (retail, SME and corporate clients). The measurement of market efficiency of the banks in BiH and their ranking was performed in two iterations, and the paper will present the following results:

- measurement and ranking of banks (first iteration of the analysis) based on the observed input and output data for the period 2017-2019 (without the impact of the COVID-19 pandemic),
- measurement and ranking of banks (second iteration of the analysis) based on the observed input and output data corrected by the respondents (board members) due to the presence of the COVID-19 pandemic,
- volume of using digital banking services under the new circumstances (observed through the number of users who actively use digital banking services and the share of digital service placement channels in the total revenue),
- relationship between the volume of usage of digital banking services and the measurement of market efficiency of the observed banks.

### 4.1. Measurement and Ranking of Banks in BiH Using the DEA Method

The key result of the DEA method application is the value (measurement) of efficiency (in this specific case market efficiency of the observed banks) and these values are given in column “Score”. According to the values in the “Score” column, the banks were ranked (see column “Rank”). As previously stated, the measurement of banks’ market efficiency was made in two iterations: a) based on the above-mentioned inputs and outputs for the period 2017 - 2019, and b) based on the same inputs and outputs for the period 2017 - 2020.

Table 1 presents the comparative results of the measurement efficiency of the observed banks and their rank by the DEA method (CCR-O model). As one can see from the presented data, for 17 banks (73.9%) the inclusion of the year 2020 in the analysis resulted in the reduction of market efficiency measurement relative to the period 2017 - 2019. For four banks (17.4%), market efficiency measurement increased and for two banks (8.7%) market efficiency measurement in both observed periods remained the same. Consequently, when the year 2020 was included in the analysis, out of the three banks (B-12, B-6, and B-11) assessed as market efficient in the period 2017-2019, only one bank remained market efficient while the remaining two experienced reduced market efficiency.

| DMU (observed banks) | 2017 - 2019 | | 2017 - 2020 | | 2017 - 2020 vs 2017 - 2019 | |
|---|---|---|---|---|---|---|
| | Score (efficiency measurement) | Rank | Score (efficiency measurement) | Rank | Score (efficiency measurement) | Rank |
| B-12 | 1 | 1 | 1 | 1 | 0.0000 | 0 |
| B-6 | 1 | 1 | 0.9750 | 2 | -0.0250 | -1 |
| B-11 | 1 | 1 | 0.9375 | 4 | -0.0625 | -3 |
| B-10 | 0.9744 | 4 | 0.9500 | 3 | -0.0244 | 1 |
| B-22 | 0.9150 | 5 | 0.8922 | 5 | -0.0228 | 0 |
| B-23 | 0.9127 | 6 | 0.8899 | 6 | -0.0228 | 0 |
| B-9 | 0.9048 | 7 | 0.8821 | 7 | -0.0227 | 0 |
| B-8 | 0.8545 | 8 | 0.8331 | 8 | -0.0214 | 0 |
| B-21 | 0.8451 | 9 | 0.8240 | 9 | -0.0211 | 0 |
| B-19 | 0.8353 | 10 | 0.8144 | 10 | -0.0209 | 0 |
| B-7 | 0.8123 | 11 | 0.8123 | 12 | 0.0000 | -1 |
| B-15 | 0.8093 | 12 | 0.7891 | 13 | -0.0202 | -1 |
| B-2 | 0.8011 | 13 | 0.7811 | 14 | -0.0200 | -1 |
| B-18 | 0.7798 | 14 | 0.7603 | 15 | -0.0195 | -1 |
| B-5 | 0.7692 | 15 | 0.7500 | 16 | -0.0192 | -1 |
| B-20 | 0.7632 | 16 | 0.8131 | 11 | 0.0499 | 5 |
| B-3 | 0.7451 | 17 | 0.7265 | 17 | -0.0186 | 0 |
| B-4 | 0.7179 | 18 | 0.7000 | 19 | -0.0179 | -1 |
| B-16 | 0.7151 | 19 | 0.7184 | 18 | 0.0033 | 1 |
| B-1 | 0.7141 | 20 | 0.6963 | 21 | -0.0178 | -1 |
| B-14 | 0.7014 | 21 | 0.6977 | 20 | -0.0037 | 1 |
| B-13 | 0.6788 | 22 | 0.6956 | 22 | 0.0168 | 0 |
| B-17 | 0.6593 | 23 | 0.6892 | 23 | 0.0299 | 0 |

**Table 1** Comparative view of indicators of banks' market efficiency and rank by the CCR-O model
Source: Author's research

The results of the application of the BCC-O model in the measurement of market efficiency and ranking of the banks for the two observed periods are given in Table 2. According to this mode, six banks were assessed as market efficient for the period 2017 - 2019. When the analysis included the year 2020, the number of market efficient banks reduced to two banks. The banks B-15, B-1 and B-14, measured by the CCR-O model with the lower score of market efficiency (0.8093; 0.7141 and 0.7014 respectively), were assessed as market efficient according to the BCC-O model (score 1). Comparing the results of the measurement of these two models, it can be concluded that there is a significant difference in the measurement of efficiency of the observed banks for the period 2017-2019 as well as for the period 2017-2020.

This points to the fact that the ratio of outputs and inputs is characterized by a variable output relative to the volume of business activities, i.e., increased inputs result in a disproportionate (lower or higher) output increase. Hence, it is more appropriate to the BCC model for the measurement of market efficiency of the banks in BiH.

| DMU (observed banks) | 2017 - 2019 | | 2017 - 2020 | | 2017 - 2020 vs 2017 - 2019 | |
|---|---|---|---|---|---|---|
| | Score (efficiency measurement) | Rank | Score (efficiency measurement) | Rank | Score (efficiency measurement) | Rank |
| B-12 | 1 | 1 | 1 | 1 | 0.0000 | 0 |
| B-14 | 1 | 1 | 1 | 1 | 0.0000 | 0 |
| B-15 | 1 | 1 | 0.9964 | 3 | -0.0036 | -2 |
| B-6 | 1 | 1 | 0.9929 | 4 | -0.0071 | -3 |
| B-1 | 1 | 1 | 0.9846 | 5 | -0.0154 | -4 |
| B-11 | 1 | 1 | 0.9403 | 9 | -0.0597 | -8 |
| B-2 | 0.9818 | 7 | 0.9780 | 7 | -0.0038 | 0 |
| B-10 | 0.9744 | 8 | 0.9675 | 8 | -0.0069 | 0 |
| B-13 | 0.9440 | 9 | 0.9841 | 6 | 0.0401 | 3 |
| B-23 | 0.9201 | 10 | 0.9137 | 10 | -0.0064 | 0 |
| B-22 | 0.9195 | 11 | 0.9131 | 11 | -0.0064 | 0 |
| B-9 | 0.9053 | 12 | 0.8989 | 12 | -0.0064 | 0 |
| B-3 | 0.8779 | 13 | 0.8739 | 15 | -0.0040 | -2 |
| B-16 | 0.8590 | 14 | 0.8856 | 14 | 0.0266 | 0 |
| B-8 | 0.8580 | 15 | 0.8520 | 16 | -0.0060 | -1 |
| B-21 | 0.8514 | 16 | 0.8455 | 17 | -0.0059 | -1 |
| B-19 | 0.8474 | 17 | 0.8415 | 18 | -0.0059 | -1 |
| B-18 | 0.8415 | 18 | 0.8365 | 21 | -0.0050 | -3 |
| B-7 | 0.8384 | 19 | 0.8380 | 20 | -0.0004 | -1 |
| B-17 | 0.8322 | 20 | 0.8973 | 13 | 0.0651 | 7 |
| B-4 | 0.8242 | 21 | 0.8201 | 22 | -0.0041 | -1 |
| B-5 | 0.8058 | 22 | 0.8006 | 23 | -0.0052 | -1 |
| B-20 | 0.7720 | 23 | 0.8400 | 19 | 0.0680 | 4 |

**Table 2** Comparative view of indicators of banks' market efficiency and rank by the BCC-O model
Source: Author's research

Table 3 presents the comparative scores of market efficiency of the observed banks for the period 2017-2019 (observed through three windows) and for the period 2017-2020 (observed through four windows). If we compare the market efficiency scores by years in the period 2017-2019 (2018 vs 2017, 2019 vs 2017, and 2019 vs 2018), it is evident that these scores are the same for the majority of the banks. However, when the scores of market efficiency in 2020 are compared to the previous three years observed (2017, 2018, and 2019), it is evident that (according to the Window-I-C model) all the banks experienced the reduction of market efficiency in 2020.

| DMU (observed banks) | Window = 3 (Score of efficiency measurement) | | | Window = 4 (Score of efficiency measurement) | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2017 | 2018 | 2019 | 2017 | 2018 | 2019 | 2020 | 2020 vs 2019 |
| B-1 | 0.696263 | 0.696263 | 0.696263 | 0.696263 | 0.696263 | 0.696263 | 0.506879 | -0.1894 |
| B-2 | 0.781064 | 0.781064 | 0.781064 | 0.781064 | 0.781064 | 0.781064 | 0.682147 | -0.0989 |
| B-3 | 0.726471 | 0.726471 | 0.726471 | 0.726471 | 0.726471 | 0.726471 | 0.528871 | -0.1976 |
| B-4 | 0.700000 | 0.700000 | 0.700000 | 0.700000 | 0.700000 | 0.700000 | 0.611350 | -0.0887 |
| B-5 | 0.750000 | 0.750000 | 0.750000 | 0.750000 | 0.750000 | 0.750000 | 0.655017 | -0.0950 |
| B-6 | 0.975000 | 0.975000 | 0.975000 | 0.975000 | 0.975000 | 0.975000 | 0.851523 | -0.1235 |
| B-7 | 0.812307 | 0.812307 | 0.812307 | 0.812307 | 0.812307 | 0.812307 | 0.551781 | -0.2605 |
| B-8 | 0.833135 | 0.833135 | 0.833135 | 0.833135 | 0.833135 | 0.833135 | 0.727624 | -0.1055 |
| B-9 | 0.882143 | 0.882143 | 0.882143 | 0.882143 | 0.882143 | 0.882143 | 0.770425 | -0.1117 |

| DMU (observed banks) | Window = 3 (Score of efficiency measurement) | | | Window = 4 (Score of efficiency measurement) | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2017 | 2018 | 2019 | 2017 | 2018 | 2019 | 2020 | 2020 vs 2019 |
| B-10 | 0.950000 | 0.950000 | 0.950000 | 0.950000 | 0.950000 | 0.950000 | 0.829689 | -0.1203 |
| B-11 | 0.937500 | 0.937500 | 0.937500 | 0.937500 | 0.937500 | 0.937500 | 0.854166 | -0.0833 |
| B-12 | 1 | 1 | 1 | 1 | 1 | 1 | 0.76079 | -0.2392 |
| B-13 | 0.695566 | 0.695566 | 0.695566 | 0.661800 | 0.661800 | 0.661800 | 0.577988 | -0.0838 |
| B-14 | 0.697698 | 0.697698 | 0.697698 | 0.683883 | 0.683883 | 0.683883 | 0.597273 | -0.0866 |
| B-15 | 0.789116 | 0.789116 | 0.789116 | 0.789116 | 0.789116 | 0.789116 | 0.689180 | -0.0999 |
| B-16 | 0.718399 | 0.718399 | 0.718399 | 0.697269 | 0.697269 | 0.697269 | 0.608965 | -0.0883 |
| B-17 | 0.689231 | 0.689231 | 0.689231 | 0.642840 | 0.642840 | 0.642840 | 0.561429 | -0.0814 |
| B-18 | 0.760274 | 0.760274 | 0.760274 | 0.760274 | 0.760274 | 0.760274 | 0.663990 | -0.0963 |
| B-19 | 0.814412 | 0.814412 | 0.814412 | 0.814412 | 0.814412 | 0.814412 | 0.711272 | -0.1031 |
| B-20 | 0.813144 | 0.813144 | 0.813144 | 0.744103 | 0.744103 | 0.744103 | 0.649868 | -0.0942 |
| B-21 | 0.823980 | 0.823980 | 0.823980 | 0.823980 | 0.823980 | 0.823980 | 0.719628 | -0.1044 |
| B-22 | 0.892167 | 0.892167 | 0.892167 | 0.892167 | 0.892167 | 0.892167 | 0.779180 | -0.1130 |
| B-23 | 0.889873 | 0.889873 | 0.889873 | 0.889873 | 0.889873 | 0.889873 | 0.777177 | -0.1127 |
| | | | | | | | | |
| Average | 0.809902 | 0.809902 | 0.809902 | 0.801896 | 0.801896 | 0.801896 | 0.68114 | -0.1208 |

**Table 3a** Comparative view of indicators of banks' market efficiency and rank by the Window-I-C model
Source: Author's research

The same conclusion is reached in terms of the reduction of market efficiency for all the banks if the average scores are compared by years (by windows) between the two observed periods (Table 3b). According to the Window-I-C model, for the period 2017-2019 bank B-12 was assessed as market efficient with the maximum average score 1. However, when the analysis included the data for the year 2020, the best ranked bank was B-6 with the average score of 0.944131, which is the average score lower than the one bank had for the period 2017-2019 (0.975).

| DMU (observed banks) | 2017 - 2019 | | 2017 - 2020 | | 2017 - 2020 vs 2017 - 2019 | |
|---|---|---|---|---|---|---|
| | Average Score (average efficiency score) | Rank | Average Score (average efficiency score) | Rank | Average Score (average efficiency score) | Rank |
| B-12 | 1 | 1 | 0.940198 | 2 | -0.0598 | -1 |
| B-6 | 0.975000 | 2 | 0.944131 | 1 | -0.0309 | 1 |
| B-10 | 0.950000 | 3 | 0.919922 | 3 | -0.0301 | 0 |
| B-11 | 0.937500 | 4 | 0.916666 | 4 | -0.0208 | 0 |
| B-22 | 0.892167 | 5 | 0.863920 | 5 | -0.0282 | 0 |
| B-23 | 0.889873 | 6 | 0.861699 | 6 | -0.0282 | 0 |
| B-9 | 0.882143 | 7 | 0.854213 | 7 | -0.0279 | 0 |
| B-8 | 0.833135 | 8 | 0.806757 | 8 | -0.0264 | 0 |
| B-21 | 0.823980 | 9 | 0.797892 | 9 | -0.0261 | 0 |
| B-19 | 0.814412 | 10 | 0.788627 | 10 | -0.0258 | 0 |
| B-20 | 0.813144 | 11 | 0.720544 | 16 | -0.0926 | -5 |
| B-7 | 0.812307 | 12 | 0.747175 | 13 | -0.0651 | -1 |
| B-15 | 0.789116 | 13 | 0.764132 | 11 | -0.0250 | 2 |
| B-2 | 0.781064 | 14 | 0.756335 | 12 | -0.0247 | 2 |
| B-18 | 0.760274 | 15 | 0.736203 | 14 | -0.0241 | 1 |
| B-5 | 0.750000 | 16 | 0.726254 | 15 | -0.0237 | 1 |

| DMU (observed banks) | 2017 - 2019 | | 2017 - 2020 | | 2017 - 2020 vs 2017 - 2019 | |
|---|---|---|---|---|---|---|
| | Average Score (average efficiency score) | Rank | Average Score (average efficiency score) | Rank | Average Score (average efficiency score) | Rank |
| B-3 | 0.726471 | 17 | 0.677071 | 18 | -0.0494 | -1 |
| B-16 | 0.718399 | 18 | 0.675193 | 19 | -0.0432 | -1 |
| B-4 | 0.700000 | 19 | 0.677837 | 17 | -0.0222 | 2 |
| B-14 | 0.697698 | 20 | 0.662230 | 20 | -0.0355 | 0 |
| B-1 | 0.696263 | 21 | 0.648917 | 21 | -0.0473 | 0 |
| B-13 | 0.695566 | 22 | 0.640847 | 22 | -0.0547 | 0 |
| B-17 | 0.689231 | 23 | 0.622487 | 23 | -0.0667 | 0 |

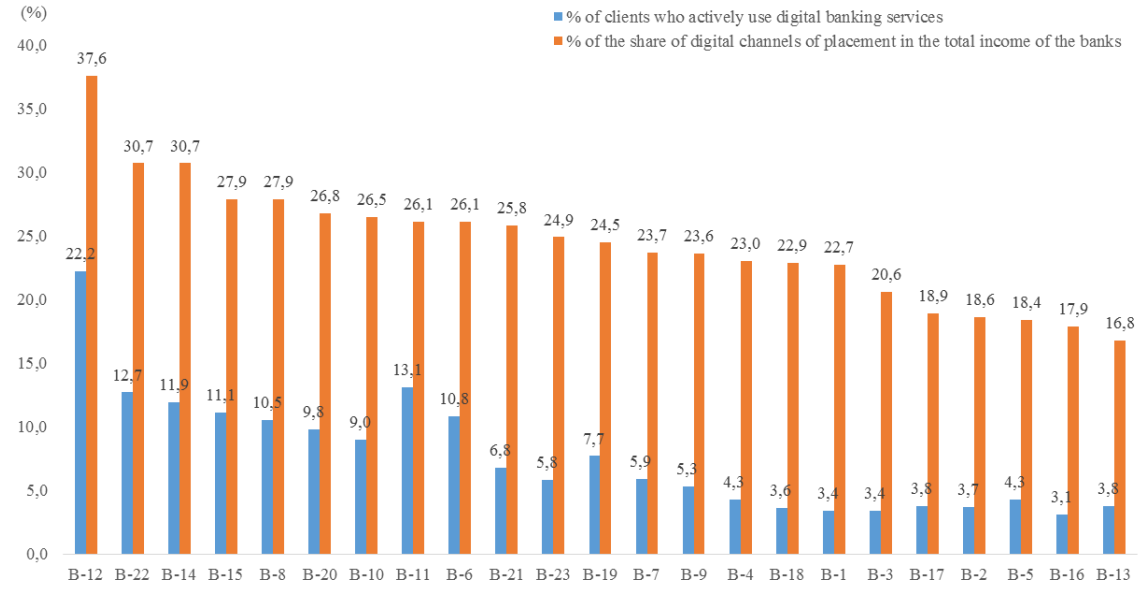
**Table 3b** Comparative view of indicators of banks' market efficiency and rank by the Window-I-C model
Source: Author's research

Hence, according to al the three models used (CCR-O, BCC-O, and Window-I-C), when the analysis included the data for the year 2020, the majority of the observed banks experienced the reduction of market efficiency. With the usage of CCR-O, BCC-O models, the reduction of market efficiency in 2020 was registered for 17 out of 23 observed banks (73.9%), while with the usage of the Window-I-C model all 23 observed banks registered the reduction of market efficiency in 2020. Bearing in mind that in 2020 the banks in BiH (as well as the largest number of other organizations globally) took the most significant changes in their business activities aimed at adapting to the changes caused by the COVID-19 pandemic, it can be clearly stated that the reduction of banks' market efficiency is largely determined by the influence of the COVID-19.

### 4.2. Volume of Digital Banking Services Usage

One of the ways in which banks attempted to respond to the challenges in their business activities with clients in the presence of the COVID-19 is stronger presence of information communication technologies in providing clients with banking services. In this regard, many banks focused, among other things, on two elements: 1) encouraging clients to use digital forms of banking services more intensively, and 2) developing digital services so as to deliver as many banking services as possible to their clients. Bearing in mind the aims of this paper, the research observed the volume of digitalization of banking services from two aspects: 1) the percentage of clients that actively use digital banking services (the reference here is made to the clients that satisfy the majority of their need for banking services by using digital banking services), and 2) presence (share) of income made on the basis of the provision of digital banking services in the total income of the bank. The research results for these two aspects of the volume of digitalization of banking services are given in Graph 1.

**Graph 1.** Presence of the observed aspects of digitalization in business activities of the banks in BiH




Source: Author's research

Banks face numerous challenges in the provision of banking services under the circumstances of the COVID-19 presence and these challenges are evident in the decrease of the total economic activity. This results in lower demand for banking services and their inability to use their full capacities in providing services (due to a limited number of clients present in branch offices and employees' absence from work). These elements directly influence the reduction of banks' market efficiency. As it was stated above, banks attempted to respond to these challenges by a more intense usage of digital services for the provision of their services. The next section of the paper attempts to answer if there is a link between banks' efforts to increase the volume of digital banking services provision and their efforts to reduce the effect of the COVID-19 pandemic on their market efficiency.

### 4.3. Analysis of the Link Between the Usage of Digital Banking Services and Market Efficiency Score

As the COVID-19 pandemic outbreak in BiH started in 2020, the same year when banks' efforts were intensified to encourage a larger volume of usage of their digital services, the analysis of the link between these two variables included the data for the year 2020. The dependent variable included the data on the measurement of banks' market efficiency according to the BCC_O model for 2020. The independent variables were: a) the percentage of clients who actively use digital banking services and b) the share of income of digital channels of placement in the total income of the bank generated by the provision of digital banking services in the total income of the bank.

The data presented in Table 4 show the value of the Pearson correlation coefficient for all the observed variables. Since the correlation coefficients between the independent variables and the dependent variable were 0.793 and 0.820 respectively and the realized significance level (Sig., 2-tailed) in both cases was 0.000, it can be concluded that the relationship had a statistically significant difference from zero with a character of strong and very strong link. On the other hand, the correlation coefficient among the independent variables was 0.208, meaning that there was multicollinearity to some extent. This is understandable as a higher

percentage of clients who actively use digital banking services may potentially lead to the growth of the share of profit based on digital services in the total income of banks, provided that the income of banks on other bases grow by a slower intensity.

| | | Market efficiency score_2020 | % clients who actively use digital banking services | % of the share of digital channels of placement in the total income of the banks |
|---|---|---|---|---|
| Pearson Correlation | Market efficiency score_2020 | 1.000 | 0.793 | 0.820 |
| | % clients who actively use digital banking services | 0.793 | 1.000 | 0.208 |
| | % of the share of digital channels of placement in the total income of the banks | 0.820 | 0.208 | 1.000 |
| Sig. (2-tailed) | Market efficiency score 2020 | . | 0.000 | 0.000 |
| | % clients who actively use digital banking services | 0.000 | . | 0.000 |
| | % of the share of digital channels of placement in the total income of the banks | 0.000 | 0.000 | . |

**Table 4** Correlations
Source: Author's research

Table 5 brings the data on the regression model with two observed dependent variables. The correlation coefficient for the dependent and independent variables was 0.849 while the determination coefficient was 0.722. Hence, 72.2% of the variability of the dependent variable can be explained by the influence of independent variables. The value of the adjusted determination coefficient was slightly lower, 0.694.

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change | |
| 1 | 0.849[a] | 0.722 | 0.694 | 0.05334 | 0.722 | 25.918 | 2 | 20 | 0.000 | 1.309 |

a. Predictors: (Constant), % of the share of digital channels of placement in the total income of the banks, % clients who actively use digital banking services

b. Dependent Variable: Market efficiency score _2020

**Table 5** Model Summary
Source: Author's research

Concerning the value in column Sig (Table 6) was 0.000, the alternative hypotheses was accepted for the regression model with the conclusion that the determination coefficient had a statistically significant difference from zero (as the ANOVA was used for testing the null hypothesis that the determination coefficient is equal to zero). In this way, the statistical significance (validity) of the regression modal was confirmed, meaning that a significant portion of the variability of the dependent variable is explained by this model.

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 0.147 | 2 | 0.074 | 25.918 | 0.000[a] |
| | Residual | 0.057 | 20 | 0.003 | | |
| | Total | 0.204 | 22 | - | | |

a. Predictors: (Constant), % of the share of digital channels of placement in the total income of the banks, % clients who actively use digital banking services

b. Dependent Variable: Market efficiency score _2020

**Table 6** ANOVA
Source: Author's research

The following table presents the coefficient that enable the precision of the mathematical form of the regression model. In other words, column B shows the regression coefficients and the regression model can be expressed in the form: $y = 0.513 + 0.008x_1 + 0.01x_2$, where: $y$ is market efficiency score in 2020, $x_1$ is the percentage of clients who actively use digital banking services and $x_2$ is the share of income based on digital banking services in the total income. The importance of individual independent variables for the prediction of the change of the dependent variable may be objectivized by the application of the standardized regression coefficient beta.

| Model | | Unstandardized Coefficients | | Standardized Coefficients | | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | t | Sig. | Tolerance | VIF |
| 1 | (Constant) | 0.513 | 0.073 | - | 7.067 | 0.000 | - | - |
| | % clients who actively use digital banking services | 0.008 | 0.005 | 0.375 | 1.872 | 0.006 | 0.347 | 2.883 |
| | % of the share of digital channels of placement in the total income of the banks | 0.010 | 0.004 | 0.517 | 2.582 | 0.008 | 0.347 | 2.883 |

a. Dependent Variable: Market efficiency score_2020

**Table 7** Coefficients
Source: Author's research

In summarizing this part of the analysis, it can be concluded that the research results point to the expressed significance of the independent variables for the prediction of the dependent variable. Namely, taking into consideration the data in Table 7, the value of beta coefficients (0.375 and 0.517) was significantly higher relative to the usual regression coefficients (0.008 and 0.01). Bearing in mind collinearity indicators (columns "Tolerance" and "VIF"), attention should be paid in the application of this model on the existence of multicollinearity of independent variables due to the above-stated reasons.

## 5. CONCLUSIONS

*Summary of the findings*: The presented results of the research scientifically confirm the expectations that the newly emerged circumstances due to the outbreak of the COVID-19 pandemic caused the reduction of banks' market efficiency on the market of BiH. In addition, the importance of the research is evident in the confirmation of the justification of the activities undertaken by the banks to encourage their clients to use digital banking services more intensely. This was the right decision as the analysis showed a strong (statistically significant) link between that decision and market efficiency.

Taking into consideration the research aims, the DEA method (CCR-O, BCC-O, and Window-I-C models) was used for the measurement of banks' market efficiency for the period 2017-2020. According to this criterion, banks' ranking was determined on the market of BiH. Comparing the results of banks' market efficiency measurement between two periods 2017-2019 and 2017-2020, it was established that the inclusion of the data for the year 2020 in the analysis resulted in the reduction of market efficiency for the majority of the banks. The key feature that in 2020 caused the biggest changes in banks' market appearance was the outbreak of the COVID-19 pandemic. Taking into account the above, it can be concluded that the reduction of market efficiency of the observed banks was, among other things, primarily determined by the outbreak of the COVID-19.

The application of the CCR-O and BCC-O models (within the DEA methods) showed that 73.9% of the observed banks experienced the reduction of market efficiency in 2020, when compared to the previous three years. A significant difference in market efficiency score between the BCC-O and CCR-O models for the entire observed period points to the conclusion that the link between the used outputs and inputs is characterized by a variable output relative to the scope of activity and serves as the recommendation for the usage of the BCC model in the measurement of market efficiency of the banks in the market of BiH. The Window model was applied in the analysis of the dynamics in the change of market efficiency of the banks per years in the observed period. The results show that there were no changes in the level of market efficiency among the banks in 2017, 2018, and 2019. However, in 2020 the reduction of market efficiency was registered (to a greater or smaller degree) for all the observed banks. This additionally leads to the conclusion that the presence of the COVID-19 pandemic determined the reduction of market efficiency on the banking market in BiH.

One of the activities that the banks used in their attempts to alleviate the negative consequences of the COVID-19 pandemic on their market appearance is an intensive encouragement of their clients to use digital banking services. The research results show that there is a statistically significant correlation between the share of the clients who actively use digital banking services in the entire number of bank clients and the share of income based on digital banking services in the total income (as independent variables) and the score of market efficiency (as a dependent variable). In other words, correlation coefficients between the independent and dependent variables were 0.793 and 0.820 respectively. In addition, it was determined that there was multicollinearity among the independent variables, with the correlation coefficient among the independent variables of 0.208. The paper presents the mathematical form of the linear regression model that explains the importance of individual independent variables for predicting the changes in a dependent variable.

*Managerial implications (management knowledge)*: The results presented in this paper, apart from other things, are important for banks' management as they provide the insight into the confirmation of the effects of the COVID-19 pandemic on banks' market efficiency. Also, the importance of the presented results is evident in the confirmation of the necessity for banks' management to focus more intensively on the activities regarding the digitalization of banking services. Namely, it was established that there was a statistically significant correlation between the higher volume of digital banking services usage and market efficiency, which has the character of stronger link.

*Research limitations and recommendation for further research*: The limitation of the research refers to the fact that it did not observe the readiness of the clients to use more intensively digital banking services compared to classic banking services, which is also the recommendation for further research. The additional recommendation for further research is the need for establishing the effect of individual changes in the organization of banks' business processes on operating efficiency that is also the assumption for the improvement of market efficiency.

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