“Measuring efficiency of banks in Saudi Arabia: A data envelopment analysis approach”

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MEASURING EFFICIENCY OF BANKS IN SAUDI ARABIA: A DATA ENVELOPMENT ANALYSIS APPROACH

Abstract

The current study investigates the efficiency of banks in Saudi Arabia in terms of technical change and change in total productivity. The study considers ten banks listed on Tadawul as a sample from 2016 to 2021. The Malmquist Data Envelopment Analysis (Malmquist DEA) model is employed to measure banks' efficiency. Customer deposits and balances with other banks and financial institutions are inputs, while the operating profit and net income are outputs to measure efficiency. The results of efficiency report that most of the Saudi Arabian banks are considerably efficient, while some are marginally efficient. The technical change report results show that Saudi Arabia's banks are enthusiastic about adopting new technologies that lead to their growth. Further, the results of the change in total productivity show great dynamism among the Saudi Arabian banks to become more productive, which ultimately leads to a more remarkable performance. The study results demonstrate the good performance of Saudi Arabian banks; however, very few banks are marginally efficient in terms of efficiency change. Therefore, the study supports the established hypothesis that there is a significant change in the technical efficiency and total productivity of Saudi Arabian banks.

Keywords efficiency of banks, technical efficiency, total productivity, DEA, Malmquist model, inputs and outputs

JEL Classification C02, C67, G21, O33

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INTRODUCTION

The banking business in the modern era has changed drastically, which might be associated with the policies related to globalization, information technology, banks operation, etc. Further, there is a considerable competition for banks in the financial market from institutions providing financial services and non-banking financial services. Therefore, to be successful in this vastly competitive market, banks have to transform themselves by providing additional services (Titko et al., 2014), such as underwriting services, managing risk, core banking solutions, and innovative banking, in addition to traditional ones, such as accepting customer deposits and lending these deposits in the form of loans and mortgages.

Financial institutions such as banks provide considerable investments to the public and private sectors, contributing significantly to the nation's economic growth. Moreover, similar to the financial goals of other organizations, such as profit maximization and shareholder wealth maximization, banks also travel in the same direction. These financial goals can be achieved when the banks are efficient regarding different aspects, such as technical and total productivity. Therefore, efficiency in the banking sector is considered vital as it leads to in-

creased performance, optimum utilization of banks' resources, and enhanced service quality. The opposite is true with inefficient banks (Berger et al., 1993). Measuring a bank's performance is a comprehensive concept consisting of issues like efficiency, technology, total productivity, etc. However, there is no agreement among the researchers considering using the standard approach in measuring the efficiency of banks (Titko et al., 2014). The performance of banks was formerly measured using different profitability and efficiency ratios. However, this measurement has certain disadvantages, as reported by Oral and Yolalan (1990), while the measurement of efficiency in banks using different mathematical approaches was proved to be beneficial because these approaches involve different inputs and outputs that affect the bank's efficiency (Iqbal & Molyneux, 2005). To measure the efficiency of banks in terms of scale, technical, and productivity, past researchers have employed parametric and non-parametric approaches. Among these approaches, Data Envelopment Analysis (DEA) is a non-parametric technique applied to a greater extent to measure the efficiency in the banking sector.

The Kingdom of Saudi Arabia, under its Vision 2030, is bringing change and growth in the financial sector in terms of transformation and digitalization, and the banks of Saudi Arabia are acknowledging this change. Moreover, the banking sector of Saudi Arabia looks encouraging and obliged to innovative activities and puts a great effort in employing technological solutions to increase their efficiencies (KPMG, 2021).

1. LITERATURE REVIEW

The banking sector is facing the challenge of environmental dynamism globally, where banks have to be efficient in order to grow, and this requires significant attention from researchers, market participants, and policymakers. The efficiency of banks is generally measured using the DEA. However, there is no agreement among the past researchers considering using different approaches in measuring the efficiency of banks.

Altun Ada and Dalkilic (2014) examined different types of efficiency in the banks of Turkey and Malaysia during the period 2009–2011. They used the Malmquist Productivity model to measure efficiency and total productivity changes. Their results reveal that the banks in Turkey were higher in terms of efficiency in 2009 compared to Malaysian banks, while in the years 2010 and 2011 the Malaysian banks are found to be efficient. Hassan et al. (2018) studied the efficiency of Islamic banks in Saudi Arabia during 2008–2016. They measured the efficiency through Data Envelopment Analysis (DEA). They initially found Al Rajhi bank to be technically efficient compared to other banks, such as Al Jazira, Al Inma, and Al Bilad, but the efficiency of the former bank decreased in the later study year. They concluded that Al Bilad bank, nevertheless a small bank, has shown an excellent performance in pure efficiency. Worimegbe et al. (2018) examined the efficiency in terms of technology in banks of Nigeria. They tried to estimate a relationship between the efficiency and performance of banks using the DEA model and SEM model. They found that technologically efficient banks attract customer satisfaction, leading to their performance. Haque and Tariq (2012) studied the efficiency of Pakistan's banking sector (conventional banks and Islamic banks) during 2006–2010 using the DEA technique. They reported that Islamic banks' efficiency was far better than conventional banks. Said (2012) examined the efficiency of Islamic banks during the financial crisis of 2006–2009. He used the DEA model to measure the efficiency. The results show that Islamic banks were efficient enough during 2006–2008, while there was a decrease in efficiency in 2009. Nevertheless, Islamic banks of middle-east and non-middle east nations were efficient during the crisis period.

Chaluvadi et al. (2018) measured the efficiency of commercial banks in India belonging to public and private sectors between 2008 and 2013 using a two-stage DEA model. They reported that the private sector banks are more efficient than the public sector banks. Moreover, one bank each from the public and private sectors is found to be less efficient. Khan et al. (2017) compared the technical efficiencies of Southeast Asian countries during the period 1998 to 2012 using the frontier concept

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in DEA analysis. They found a broad variation in the technical efficiency levels of the sample banks. Nguyen and Pham (2020) examined the consistency in banking policies in improving the efficiency in cost of Vietnamese banks during 2005–2017 using DEA and SFA models. They found that the efficiencies under the SFA technique were consistent compared to those under the DEA technique.

Moreover, the ranking of efficiency scores under the DEA technique was similar during the study period. Duho (2020) investigated the technical efficiency (slack-based) of banks in Ghana from 2000 to 2017 using the DEA technique. He reported that banks in Ghana are efficient at a score of 0.79 and need to increase their efficiency in terms of technology to be included in the race of best-performing banks. Ngo and Tripe (2017) examined cost efficiency in terms of Non Performing Loans in the banks of Vietnam during the period 2003–2010 using the SFA technique. The results differed by the inclusion and non-inclusion of NPLs into the model. The former method was moderately efficient, while the latter has shown a decrease in cost-efficiency in public sector banks and an increase in private sector banks.

Radojicic et al. (2018) studied the efficiency of the Serbian banking sector during the period 2005 to 2016 using the weighted DEA technique. They reported that the efficiency of the Serbian banking sector is average and improving over the study period. Further, the arrangement of inputs and outputs impacts the evaluation of banks. Kasim et al. (2019) evaluated the efficiency of banks in Malaysia during the period 2004–2013 using the SBM measure. The results show that the period between 2006 and 2008 experienced more efficient banks, while 2012 experienced less efficient banks.

Further, most of the sample banks are found to be inefficient. Tyas and Rusydiana (2021) examined the efficiency of Indonesian Islamic banks during the pre-merger period during 2016–2019 using the DEA technique. They reported that the efficiency of banks varies with the number of banks merged. In the merger of three banks, the banks show inefficiency in their performance, while the result is the opposite due to the merger of two banks. Abidin et al. (2021) analyzed the efficiency of banks in Indonesia during 2017–2018 using different methods of measuring efficiencies, such as DEA, Tobit regression, and the Mann-Whitney test. The results show that there are differences in results using three different models to measure the efficiency of banks. S. Sathye and M. Sathye (2017) examined the increase in technical efficiency of Indian banks by installing ATMs by employing the bootstrap DEA model. They reported a negative association between the intensity of ATMs and technical efficiency, suggesting that Indian banks be cautious in IT investment decisions. Wang et al. (2021) assessed the performance of Vietnamese banks during 2015–2019 using the DEA technique. They reported a decrease in the Malmquist efficiency indices regarding technology and total productivity. Ke et al. (2011) examined the efficiency of banks in Taiwan in terms of profitability from 1999 to 2007 using the Nerlovian profit indicator. They found a relationship between a shadow price and efficiency in profitability, and the old banks, compared to the new banks, are efficient in allocation and profitability. Shahwan and Hassan (2013) examined the efficiencies of UAE banks in terms of profitability, social disclosure, and marketing in 2009 using the DEA technique. They found that UAE banks are more efficient in terms of profitability than social disclosure and marketing. Kumar and Singh (2014) measured the efficiency of Indian banks using DEA and SPA techniques. They found the DEA technique to be an appropriate one to examine the efficiency of firms.

Alrafadi et al. (2016) intend to survey the DEA technique efficiency studies in banks in developed and developing countries. The survey results show that the efficiencies were examined in terms of cost and technical aspects. Bapat (2012) investigated the impact of the financial crisis on the efficiency of banks in India from 2007 to 2010 using the DEA technique. He found a decrease in the efficiency of banks during the middle of the financial crisis, while the banks gained efficiency during the end of the financial crisis. Vegesna and Dash (2014) studied the efficiency of the DEA approach of public-sector and private-sector banks in India. They found the former banks to be more efficient than the later ones. Jiang and He (2018) measured the efficiency of banks in China using the DEA Malmquist model. Their results reported that most banks are technically efficient except for

a few whose efficiency deteriorated to a large extent. Their results also disclosed a policy adopted by the Chinese government to prevent the banks from a financial crisis. S. Depren and Ö. Depren (2016) measured the performance of Turkish banks using the Malmquist DEA model. They found some inputs to be efficient in total productivity, while some to be efficient in intermediate efficiency method. Wanke et al. (2016) measured the total productivity of Mozambican banks using the Fuzzy-DEA technique. They found this technique more dominant in result interpretation and can be used by decision-makers. Andrieș and Cocriș (2010) analyzed the efficiency of banks in Romania using the DEA and SFA techniques. They reported a deterioration in the efficiency of banks in Romania.

The literature review highlights the efficiency of banks in different economies using different efficiency approaches. Previous studies have used non-parametric approaches, such as DEA and SFA techniques, to report the efficiency results; however, the researchers have no agreement on using the appropriate technique. Further, few studies were found to use this non-parametric technique to examine the efficiency of Saudi Arabian banks. Hence, the purpose of the present study is to examine the efficiency of banks in terms of technology and total productivity using the DEA technique in Saudi Arabia. The study determines the following hypotheses:

H_0: *There is no significant change in technical efficiency and total productivity in Saudi Arabian banks.*

H_1: *There is a significant change in technical efficiency and total productivity in Saudi Arabian banks.*

2. DATA AND METHODOLOGY

The study examines the efficiency of Saudi Arabian banks by applying the Data Envelopment Analysis (DEA) model. The data sample consists of 10 banks shown in Table 1, starting in 2015 and ending in 2021. The data required for different variables included in the DEA model have been extracted from the financial reports of sample banks.

Table 1. List of Decision-Making Units (DMUs) selected for the analysis

S. No.	DMU	Name of the Bank
1	DMU-1	Al Ahli Bank
2	DMU-2	Al Rajhi Bank
3	DMU-3	Al Riyadh Bank
4	DMU-4	Saudi British Bank (SABB)
5	DMU-5	Banque Saudi Fransi
6	DMU-6	Saudi Investment Bank (SIB)
7	DMU-7	American National Bank (ANB)
8	DMU-8	Bank Albilad
9	DMU-9	Bank Aljazira
10	DMU-10	Alinma Bank

Data Envelopment Analysis (DEA) model was recommended initially by Charnes et al. in 1978 in terms of the constant returns (CR) model. This model measures the firms' efficiency comparing with other firms in the sample, hence referred to as relative efficiency. This model estimates an efficiency score based on the ratio of outputs and inputs. The efficiency scores are calculated for each unit termed a DMU, compared to another set of firms in the sample (Charnes et al., 1978). The maximum efficiency score is equal to 1 and is presented in a fraction form as proposed by Titko et al. (2014) as follows:

$$\max k_0 = \frac{\sum_{s=1}^{t} v_s x_{s0}}{\sum_{q=1}^{p} u_q y_{q0}},$$

$$\text{Subject to: } \frac{\sum_{s=1}^{t} v_s x_{sj}}{\sum_{q=1}^{p} u_q y_{qj}} \le 1, \qquad (1)$$

$$v_s, u_q \ge 0, \quad j = 1,...n.$$

The fraction form of the efficiency model, when transformed into a Linear Programming model, looks as follows:

$$\max k_0 = \sum_{s=1}^{t} v_s x_{s0},$$

$$\text{Subject to: } \sum_{s=1}^{t} v_s x_{sj} - \sum_{q=1}^{p} u_q y_{qj} \le 0, \qquad (2)$$

$$\sum_{q=1}^{p} u_q y_{q0} = 1, \quad v_s, u_q \ge 0, \quad j = 1,...n.$$

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The DEA model is specified as follows:

1) Stage 1: Profit maximization of cost minimization;

2) Stage 2: Assumption of returns to scale (CRS or VRS);

3) Stage 3: Specifying the combination of inputs and outputs.

The efficiency of banks is measured through the CRS specification using an input-oriented DEA model (Titko et al., 2014). The reason reported is that bank managers have greater control over inputs compared to outputs (Fethi & Pasiouras, 2010; Titko et al., 2014).

The efficiency of banks with CRS or VRS assumption is measured when analyzed between different units for a single period. The current study examines the efficiency of banks using the Malmquist Productivity Index (MPI) model since this model measures the efficiency over different periods and integrates the result analysis. The DMUs are then ranked based on the generated efficiency scores.

2.1. Input and output variables selection

The selection of input and output variables, as given in Table 2, is a typical task in developing a DEA model as they impact the efficiency results. First, the study variables are selected using Pearson correlation. The study considers and selects the variables with a positive correlation, as reported in Table 3; nevertheless, there is an upper high correlation between the variables (Wang et al., 2016). Further, the selection of the number of input and output variables to be included in the DEA model determines the difference between the efficiency scores of different units. As reported by various researchers in the literature, there is a rule of thumb in selecting the number of input and output variables. The current study follows the rule of thumb proposed by Golany and Roll (1989), where the number of DMUs should be twice the total of inputs and outputs. The study sample is ten banks; hence the study selects two input variables and two output variables. The two input variables selected include customer deposits and balances due to banks and other institutions, while the selected output variables include operating profit and net income.

Table 2. List of input and output variables

No.	Inputs	No.	Outputs
1	Customer Deposits (CD)	1	Operating profit (OP)
2	Balances due to banks and other institutions (BAL)	2	Net Income (NI)

Table 3. Correlation analysis

Variables	Customer Deposits (CD)	Balances due to banks and other institutions (BAL)	Operating Profit (OP)	Net Income (NI)
Customer Deposits (CD)	1.0000	–	–	–
Balances due to banks and other institutions (BAL)	0.7033	1.0000	–	–
Operating Profit (OP)	0.9719	0.6371	1.0000	–
Net Income (NI)	0.9584	0.6442	0.9644	1.0000

2.2. Malmquist productive index

The Malmquist Productivity Index (MPI) was proposed by Caves et al. (1982) and is a significant efficiency measurement model, since it measures different units over several periods. Generally, this model calculates the technological efficiency of study units over different periods. The MPI model calculates the geometric mean of technological change (TCHCH) and efficiency change (EFCH). Further, technological efficiency is divided into scale efficiency and pure technical efficiency. The change in efficiency between the periods using MPI is calculated as follows:

$$MP^{s} = \frac{P_o^{s}\left(x^{s+1}, y^{s+1}\right)}{P_o^{s}\left(x^{s}, y^{s}\right)}, \tag{3}$$

$$MP^{s+1} = \frac{P_o^{s+1}\left(x^{s+1}, y^{s+1}\right)}{P_o^{s+1}\left(x^{s}, y^{s}\right)}, \tag{4}$$

where MP is the Malmquist Productivity Index, s and $s + 1$ is the time period, P is the efficiency change, x and y are observations, and o is the model's orientation.

The geometric mean of Eqns. (3) and (4) are given in Eq. 5

$$MP^g = \sqrt{\frac{P_o^s\left(x^{s+1}, y^{s+1}\right)}{P_o^s\left(x^s, y^s\right)} \cdot \frac{P_o^{s+1}\left(x^{s+1}, y^{s+1}\right)}{P_o^{s+1}\left(x^s, y^s\right)}}. \quad (5)$$

Eq. 6 can be used to calculate scale efficiency and pure efficiency:

$$MP^g = (EFCH) \cdot (TCHCH^g). \quad (6)$$

The change in efficiency, i.e., improvement or deterioration in efficiency for a particular DMU, is explained in terms of its improvement in relative efficiency. If the efficiency change is > 1, it shows that the relative efficiency of DMU is improving from one period to another. Similarly, if the efficiency change is < 1, it shows a deterioration in relative efficiency, and a change in efficiency = 1 shows no change in relative efficiency.

Table 4. MPI models with a combination of different inputs and outputs

MPI model	Inputs	Outputs
MP(1)	Customer Deposits	Operating Profit
MP(2)	Balance due to banks and other institutions	Operating Profit
MP(3)	Customer Deposits	Net Income
MP(4)	Balance due to banks and other institutions	Net Income
MP(5)	Customer Deposits	Operating Profit
	Balance due to banks and other institutions	
MP(6)	Customer Deposits	Net Income
	Balance due to banks and other institutions	
MP(7)	Customer Deposits	Operating Profit
	Balance due to banks and other institutions	Net Income

3. RESULTS

The current study examines the efficiency of Saudi Arabian banks using the Malmquist DEA model. In this regard, the input and output variables should have a non-decreasing relationship. To test this relationship, the study has adopted the Pearson correlation test. A correlation coefficient nearer to 1 shows a solid and befitting linear relationship between the two variables. The correlation coefficient results reported in the Table of input and output variables show a higher positive relation with the value ranging from 0.63 to 0.97, demonstrating that the chosen input and output variables are qualified for DEA analysis.

The models of DEA estimate the efficiency of DMUs in terms of CRS and VRS for one period, but these models cannot be used to estimate multiple time periods. Therefore, the current study has employed the Malmquist model to measure the efficiency of DMUs. The results are presented in seven models (MP (1) to MP (7)), as shown in Table 4, with different combinations between input and output variables. Table 5 reports the efficiency results in terms of change in efficiency. The scores of change in the technology of Saudi Arabian banks are presented in Table 6 under different models. Further, the scores of change in total productivity of Saudi Arabian banks are presented in Table 7 under different models.

The results of change in efficiencies show that DMU-1 to DMU-7 evidenced considerably efficient in most of the iterated models except models 2 and 4, where the efficiency has marginally changed. Further, the results of DMU-8 to DMU-10 are in contrast to the results of former DMUs, where there was a gradual change in efficiency in

Table 5. The scores of changes in the efficiency of Saudi Arabian banks

DMUs	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7
DMU-1	0.99	0.68	1.03	0.69	1.02	1.04	0.99
DMU-2	1.01	0.99	1.05	0.99	1.01	1.05	1.01
DMU-3	1.02	1.05	1.06	1.05	1.02	1.06	1.03
DMU-4	1.00	0.87	1.01	0.85	1.01	1.01	0.98
DMU-5	1.07	0.86	1.07	0.84	1.07	1.07	1.03
DMU-6	0.98	0.72	0.98	0.70	1.01	0.99	0.94
DMU-7	0.94	1.19	0.91	1.12	0.94	0.91	0.95
DMU-8	0.65	1.14	0.68	1.15	0.65	0.65	0.81
DMU-9	0.70	1.24	0.72	1.23	0.70	0.71	0.97
DMU-10	0.67	1.45	0.71	1.49	0.65	0.67	1.05

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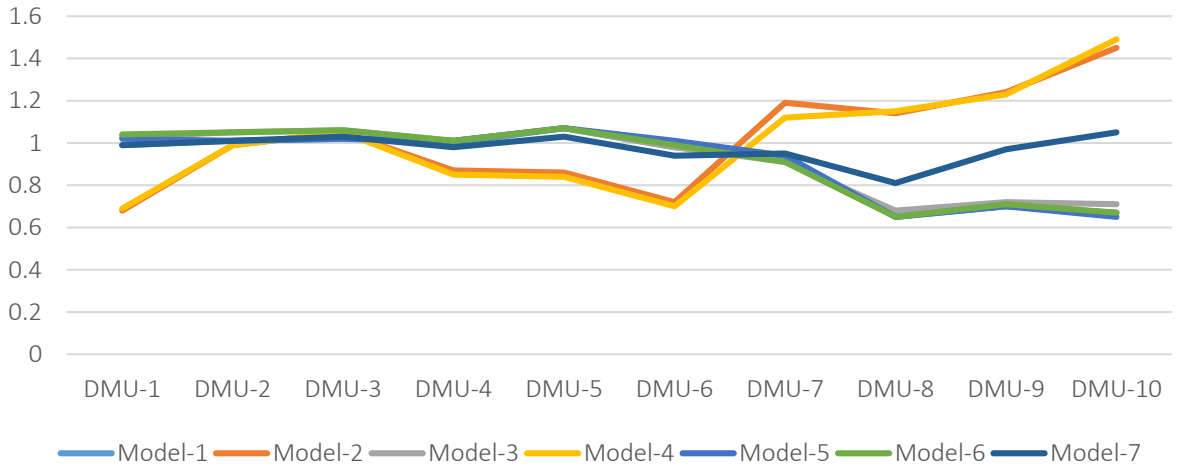

Figure 1. Change in efficiency of Saudi Arabian banks

Table 6. The scores of technical changes in the efficiency of Saudi Arabian banks

DMUs	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7
DMU-1	1.54	1.51	0.97	0.97	1.61	1.64	1.09
DMU-2	1.54	1.51	0.97	0.97	1.37	1.37	1.41
DMU-3	1.54	1.51	0.97	0.97	1.43	1.42	1.41
DMU-4	1.54	1.51	0.97	0.97	1.51	1.56	1.19
DMU-5	1.54	1.51	0.97	0.97	1.23	1.35	1.25
DMU-6	1.54	1.51	0.97	0.97	1.55	1.52	1.18
DMU-7	1.54	1.51	0.97	0.97	1.58	1.51	1.27
DMU-8	1.54	1.51	0.97	0.97	1.65	1.59	1.30
DMU-9	1.54	1.51	0.97	0.97	1.36	1.36	1.48
DMU-10	1.54	1.51	0.97	0.97	1.56	1.43	1.35

all the models except 2 and 4, where the efficiency has desperately changed. The results of the efficiency change of each DMU can be evidenced in Figure 1.

The technology change results show that DMU-1 to DMU-10 evidenced significant efficiency in all the iterated models. Further, the scores of technological change in models 1-4 are similar for all the DMUs; nevertheless, the scores have changed significantly. Moreover, models 5, 6, and 7 show that the DMUs are more active in bringing technological change. The results of technological change of each DMU can be evidenced in Figure 2.

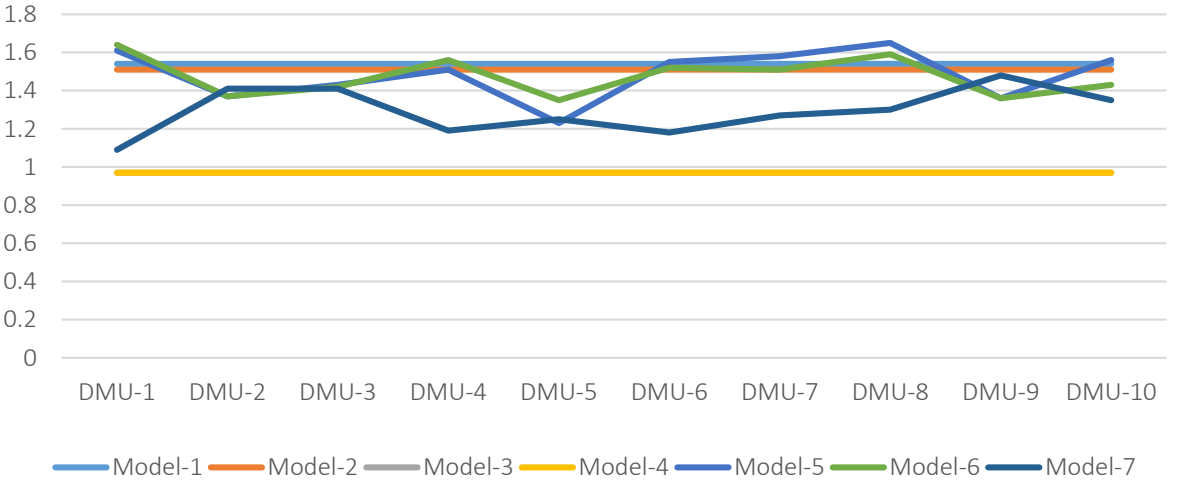

Figure 2. Change in technology of Saudi Arabian banks

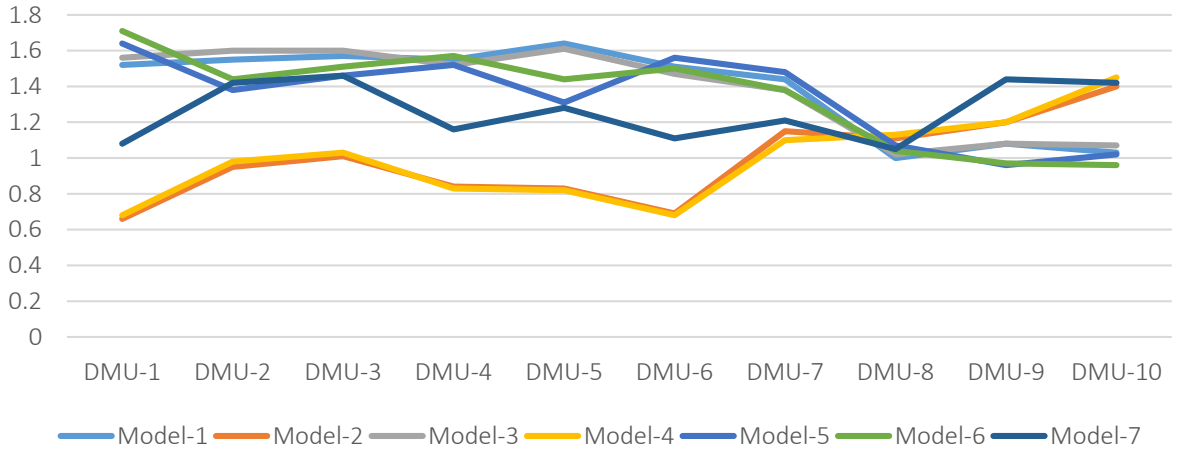

Figure 3. Change in total productivity of Saudi Arabian banks

Table 7. The scores of total productivity change of Saudi Arabian banks

DMUs	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7
DMU-1	1.52	0.66	1.56	0.68	1.64	1.71	1.08
DMU-2	1.55	0.95	1.60	0.98	1.38	1.44	1.42
DMU-3	1.57	1.01	1.60	1.03	1.46	1.51	1.46
DMU-4	1.55	0.84	1.52	0.83	1.52	1.57	1.16
DMU-5	1.64	0.83	1.61	0.82	1.31	1.44	1.28
DMU-6	1.51	0.69	1.47	0.68	1.56	1.50	1.11
DMU-7	1.44	1.15	1.38	1.10	1.48	1.38	1.21
DMU-8	1.00	1.11	1.02	1.13	1.07	1.04	1.05
DMU-9	1.08	1.20	1.08	1.20	0.96	0.97	1.44
DMU-10	1.03	1.40	1.07	1.45	1.02	0.96	1.42

The change in total productivity results shows that DMU-3, DMU-7, DMU-8, DMU-10, DMU-2, and DMU-9 evidenced significant efficiency in all the iterated models. Further, the scores of total productivity change in DMU-4, DMU-1, DMU-5, and DMU-6 are also efficient; nevertheless, the scores in models 2 and 4 have changed marginally. Moreover, models 1, 3, 5, 6, and 7 show that the DMUs are more active in bringing total productivity change. The resul ts of the change in total productivity of each DMU can be evidenced in Figure 3.

4. DISCUSSION

The study results are significant to the banking sector of Saudi Arabia. The results of the change in efficiency show that most Saudi Arabian banks are considerably efficient, while few are not quite efficient. Therefore, the efficiency change results confirm that DMU-3 is the best bank, followed by DMU-2, DMU-5, DMU-7, DMU-4, DMU-1, and DMU-6. Moreover, the remaining DMUs, such as DMU-8, DMU-9, and DMU-10, are found to be inconsiderably efficient. The results of the change in efficiency support the previous research works of Shahwan and Hassan (2013), Hassan et al. (2018), and Abidin et al. (2021). Further, the technical change results show that Saudi Arabia's banks are dynamic in contributing to technology. Therefore, technological change results confirm that DMU-8 is the best bank, followed by DMU-1, DMU-7, DMU-4, DMU-6, DMU-10, DMU-3, DMU-2, DMU-9, and DMU-5. The results of the change in technology support the studies of Worimegbe et al. (2018) and contrast with Khan et al. (2017) and Duho (2020). Finally, the total productivity change results show that all the Saudi Arabia's banks are efficient enough and efficacious in achieving total productivity. Therefore, the change in total productivity results confirms that DMU-3 is the best bank, followed by DMU-7, DMU-8, DMU-10, DMU-2, DMU-9, DMU-4, DMU-1, DMU-5, and DMU-6. The results of the change in total productivity confirm the past studies of S. Depren and Ö. Depren (2016) and Wanke et al. (2016). The reported results confirms the alternative hypothesis (H_1) that there is significant change in technical efficiency and total productivity of Saudi Arabian banks.

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CONCLUSION

The purpose of the study is to measure the efficiency of Saudi Arabian banks in terms of average change efficiency, technical change, and change in total productivity. The efficiency was measured by employing the Malmquist DEA model.

The results of the change in efficiency show that many banks in Saudi Arabia are efficient. At the same time, few are not entirely efficient, and Al Riyadh bank was ranked top in terms of change in efficiency, followed by the other banks. The results of technical change show that the banks of Saudi Arabia are interested to a large extent in technology adoption, and Bank Al Bilad was ranked top in terms of technical change, followed by the other banks. The results of total productivity change show that all the banks in Saudi Arabia put much effort into achieving total productivity, and Al Riyadh banks were ranked top in terms of change in total productivity, followed by other banks. Hence, the study results confirm that the banks of Saudi Arabia, nevertheless very few that are marginally efficient, are striving to achieve more outstanding performance.

The results of the current study confirm the 57th Annual Report 2020 of SAMA (SAMA, 2020), where the banking sector of Saudi Arabia was presented as efficient and stable during the pandemic. This was achieved through the bank's strong financial extent, where the CAR exceeded the international requirements and the deposits and assets were increased. However, the results show that few banks are marginally efficient. The government of Saudi Arabia has launched the Financial Sector Development Program, where a strategy has been drafted to preserve the efficiency and stability of the banking sector by identifying problems related to risk, capital, liquidity, and profitability.

Therefore, the present study supports the fact that the banks of Saudi Arabia are significant in achieving efficiency in terms of technology and total productivity. The study results help academic researchers to establish comparative efficiencies in the banking sector, and policymakers to concentrate on the growth of the banking sector. Future research should consider other dimensions of efficiency measurement, such as comparative efficiency measurement between banking sectors of different countries.

AUTHOR CONTRIBUTIONS

Conceptualization: Abdul Rahman Shaik.
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REFERENCES

1. Abidin, Z., Prabantarikso, R. M., Wardhani, R. A., & Endri, E. (2021). Analysis of Bank Efficiency between Conventional Banks and Regional Development Banks in Indonesia. *Journal of Asian Finance, Economics and Business, 8*(1), 741-750. https://doi.org/10.13106/jafeb.2021.vol8.no1.741
2. Alrafadi, K. M., Yusuf, M. M., & Kamaruddin, B. H. (2016). Measuring efficiency in banks: a brief survey on non–parametric technique (data envelopment analysis). *International Journal of Business, Economics and Management, 3*(5), 52-68. https://doi.org/10.18488/journal.62/2016.3.5/62.5.52.68
3. Altun Ada, A., & Dalkilic, N. (2014). Efficiency Analysis in Islamic Banks: A Study for Malaysia and Turkey. *BDDK Bankacılıkve Finansal Piyasalar, 8*(1), 9-33. Retrieved from https://www.bddk.org.tr/Content/docs/bddkDergiTr/dergi_0015_03.pdf
4. Andrieş, A. M., & Cocriş, V. (2010). A comparative analysis of the efficiency of Romanian banks. *Romanian Journal of Economic Forecasting, 13*(4), 54-75. Retrieved from https://ipe.ro/rjef/rjef4_10/rjef4_10_5.pdf
5. Bapat, D. (2012). Efficiency for Indian public sector and private sector banks in India: assessment of impact of global financial crisis. *International Journal of Business Performance Management, 13*(3-4), 330-340. https://doi.org/10.1504/IJBPM.2012.047299
6. Berger, A. N., Hunter, W. C., & Timme, S. G. (1993). The efficiency of financial institutions: A review and preview of research past, present and future. *Journal of Banking and Finance, 17*(2-3), 221-249. https://doi.org/10.1016/0378-4266(93)90030-H
7. Chaluvadi, S., Raut, R., & Gardas, B.B. (2018). Measuring the performance efficiency of banks in a developing economy. The case study of Indian public sector vs private sector. *Benchmarking: An International Journal, 25*(2), 575-606. https://doi.org/10.1108/BIJ-10-2016-0157
8. Depren, S. K., & Depren, Ö. (2016). Measuring efficiency and total factor productivity using data envelopment analysis: An empirical study from banks of Turkey. *International Journal of Economics and Financial Issues, 6*(2), 711-717. Retrieved from https://www.econjournals.com/index.php/ijefi/article/view/1780
9. Duho, K. C. T. (2020). Intellectual capital and technical efficiency of banks in an emerging market: a slack-based measure. *Journal of Economic Studies, 47*(7), 1711-1732. https://doi.org/10.1108/JES-06-2019-0295
10. Fethi, M. D., & Pasiouras, F. (2010). Assessing bank efficiency and performance with operational research and artificial intelligence techniques: A survey. *European Journal of Operational Research, 204*(2), 189-198. https://doi.org/10.1016/j.ejor.2009.08.003
11. Golany, B., & Roll, Y. (1989). An application procedure for DEA. *Omega, 17*(3), 237-250. https://doi.org/10.1016/0305-0483(89)90029-7
12. Haque, A., & Tariq, A. (2012). Efficiency of Banks in Pakistan: A Non Parametric Approach. *Business and Economic Research, 2*(1), 1-12. https://doi.org/10.5296/ber.v2i1.1711
13. Hassan, M., Khan, M. N., Amin, M. F. B., & Khokhar, I. (2018). Measuring the Performance of Islamic Banks in Saudi Arabia. *International Journal of Economics and Management, 12*(1), 99-115. Retrieved from http://www.ijem.upm.edu.my/vol12no1/5)%20Measuring%20the%20Performance%20of%20Islamic%20Banks%20in%20Saudi%20Arabia.pdf
14. Iqbal, M., & Molyneux, P. (2005). *Thirty years of Islamic banking: History, performance, and prospects.* New York: Palgrave Macmillan. Retrieved from https://link.springer.com/book/10.1007/978-0-230-50322-9
15. Jiang, H., & He, Y. (2018). Applying data envelopment analysis in measuring the efficiency of Chinese listed banks in the context of macroprudential framework. *Mathematics, 6*(10), 184. https://doi.org/10.3390/math6100184
16. Kasim, M. M., Ramli, R., Baten, A., Jamil, J. M., & Taleb, M. (2019). Efficiency of Banks in Malaysia: A Super Efficiency Approach. *Inzinerine Ekonomika – Engineering Economics, 30*(4), 442-450. https://doi.org/10.5755/j01.ee.30.4.19291
17. Ke, T.-Y., Li, Y., & Chiu, Y.-H. (2011). Analyzing for profit efficiency of banks with undesirable output. *African Journal of Business Management, 5*(20), 8141-8149. https://doi.org/10.5897/AJBM11.176
18. Khan, S. J. M., Samsudin, S., & Islam, R. (2017). Efficiency of banks in Southeast Asia: Indonesia, Malaysia, Philippines and Thailand. *International Journal of Social Economics, 44*(12), 2302-2312. https://doi.org/10.1108/IJSE-01-2016-0020
19. KPMG. (2021). *Saudi Arabia 2021 Budget Report*. Retrieved from https://assets.kpmg/content/dam/kpmg/sa/pdf/2021/ksa-budget-report-2021.pdf
20. Kumar, N., & Singh, A. (2014). Efficiency Analysis of Banks using DEA: A Review. *International Journal of Advance Research and Innovation, 1,* 120-126. Retrieved from https://www.academia.edu/11604169/Efficiency_Analysis_of_Banks_using_DEA_A_Review
21. Ngo, T., & Tripe, D. (2017). Measuring efficiency of Vietnamese banks. *Pacific Accounting Review, 29*(2), 171-182. https://doi.org/10.1108/PAR-06-2016-0064
22. Nguyen, P. H., & Pham, D. T. B. (2020). The cost efficiency of Vietnamese banks – the difference

http://dx.doi.org/10.21511/bbs.17(4).2022.06

between DEA and SFA. *Journal of Economics and Development, 22*(2), 209-227. https://doi.org/10.1108/JED-12-2019-0075

23. Oral, M., & Yolalan, R. (1990). An empirical study on measuring operating efficiency and profitability of bank branches. *European Journal of Operational Research, 46*(3), 282-294. https://doi.org/10.1016/0377-2217(90)90002-S

24. Radojicic, M., Savic, G., & Jeremic, V. (2018). Measuring the Efficiency of Banks: The Bootstrapped I-Distance GAR DEA Approach. *Technological and Economic Development of Economy, 24*(4), 1581-1605. https://doi.org/10.3846/tede.2018.3699

25. Said, A. (2012). Efficiency in Islamic Banking during a Financial Crisis-an Empirical Analysis of Forty-Seven Banks. *Journal of Applied Finance & Banking, 2*(3), 163-197. Retrieved from https://www.scienpress.com/Upload/JAFB/Vol%202_3_7.pdf

26. SAMA. (2020). *57th Annual Report*. Retrieved from https://www.sama.gov.sa/en-us/news/pages/news-680.aspx

27. Sathye, S., & Sathye, M. (2017). Do ATMs Increase Technical Efficiency of Banks in a Developing Country? Evidence from Indian Banks. *Australian Accounting Review, 27*(1), 101-111. https://doi.org/10.1111/auar.12110

28. Shahwan, T. M., & Hassan, Y. M. (2013). Efficiency analysis of UAE banks using data envelopment analysis. *Journal of Economic and Administrative Sciences, 29*(1), 4-20. https://doi.org/10.1108/10264111311319204

29. Titko, J., Stankevičienė, J., & Lāce, N. (2014). Measuring bank efficiency: DEA application. *Technological and Economic Development of Economy, 20*(4), 739-757. https://doi.org/10.3846/20294913.2014.984255

30. Tyas, A. A., & Rusydiana, A. S. (2021). The Pre-Merger Efficiency of Banks: Evidence in Indonesia State-Owned Islamic Banks. *Jurnal Ekonomi dan Bisnis Islam, 7*(1), 1-13. https://doi.org/10.20473/jebis.v7i1.23319

31. Vegesna, S., & Dash, M. (2014). Efficiency of public and private sector banks in India. *Journal of Applied Management and Investments, 3*(3), 183-187. Retrieved from https://econpapers.repec.org/article/odsjournl/v_3a3_3ay_3a2014_3ai_3a3_3ap_3a183-187.htm

32. Wang, C.-N., Nguyen, N.-A.-T., Dang, T.-T., & Trinh, T.-T.-Q. (2021). A Decision Support Model for Measuring Technological Progress and Productivity Growth: The Case of Commercial Banks in Vietnam. *Axioms, 10*(3), 131. https://doi.org/10.3390/axioms10030131

33. Wanke, P., Barros, C. P., & Emrouznejad, A. (2016). Assessing productive efficiency of banks using integrated Fuzzy-DEA and bootstrapping: A case of Mozambican banks. *European Journal of Operational Research, 249*(1), 378-389. https://doi.org/10.1016/j.ejor.2015.10.018

34. Worimegbe, P. M., Abosede, A. J., & Worimegbe, T. M. (2018). Efficiency, customers' satisfaction and deposit money banks' performance in Nigeria. *Journal of Economics and Management, 31*(1), 134-148. https://doi.org/10.22367/jem.2018.31.07